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TRANSFORMING THE FUTURE

ETH Zurich and the Construction of Modern Switzerland 1855–2005

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INTRODUCTION

David Gugerli, Patrick Kupper, Daniel Speich

The Swiss Federal Institute of Technology, whose story unfolds in the following pages, has always been about innovation, with an eye to the future. From the outset, the people who were responsible for organizing, operating, and financing the school had a fondness for the word "future" in reflecting on the meaning and purpose of their efforts. An early example is a comment made in 1851 by the Swiss Federal Council regarding the planned national university. The institution would "bear the future of its country," the council said somewhat emotionally, three years after the federal state's founding.[1]

The discourse quickly took hold and even became a rhetorical leitmotif. In 1930, in the midst of the Depression, the ETH celebrated its seventy-fifth anniversary. Serene in the face of world events, and putting himself in the new freshmen's shoes, President Arthur Rohn again invoked the future: "The student who can devote the best of his early years to deepening his knowledge and world view" must "cast his wholesome, unclouded gaze to the future fully conscious of the responsibilities to the state and to his fellow citizens conferred on him by virtue of his mental strength."[2] Those educated at the ETH incurred a duty of future service to the political community.

The comments of the Federal Council, and Rohn's views need to be situated in their historical context. So does the talk of the future – again with emotional overtones – that took place at the one hundred and fiftieth jubilee celebrations of 2005, three quarters of a century later. Students, teachers, researchers, and administrative employees were encouraged to "welcome tomorrow" (the official motto) with an appropriate enthusiasm. Ultimately, they were the ones who would shape the current and future society. "No one can predict the future," stated Meinrad Eberle, project manager for the jubilee in explaining this official motto. "Yet it is up to us to deal with it. The right way to do that is to think in terms of scenarios."[3]

From the future of the nation, to the future as service to the community, to a future imagined as a series of scenarios and challenges – the future was the stuff of which the ETH was made and which it transformed repeatedly over the years into a tool first for providing legitimacy, then confidence. Moreover, the "tomorrow" of 2005 was different from that of 1855 and 1930, particularly as focusing on it no longer produced a clear picture of what to expect but rather a confusing multitude of possibilities, a cornucopia of opportunities and risks.

When the future is open-ended, the past takes on special meaning. But it isn't only in such times of heightened need for direction that the way forward and the way back converge. Sometimes a simultaneous perspective is compelled by social pressures, for example, those resulting from the modern university's jubilee-oriented celebratory and commemorative culture. For the ETH Zurich's one hundred and fiftieth anniversary in

2005, the school's Executive Board asked its Corporate Communications Department to come up with a forward-looking publicity strategy. At the same time, the Institute for History was commissioned to explore the ETH's past. Delving into archives is not particularly convenient for the everyday business of professional corporate communications. No university jubilee is complete without its Festschrift, whose purpose is to document past activities and preserve memories. In 2005, in keeping with this tradition, the ETH took the novel step of creating a comprehensive and innovative hypertext Festschrift (www.ethistory.ethz.ch) that provides a guided tour of the history of the university and the evolution of individual departments, interviews with contemporary eyewitnesses, and extensive statistical documentation.[4]

The present volume, however, is not a Festschrift but rather a problem-centered, critical analysis of a highly complex and very interesting history. It was published in 2005 in German, and has been gently revised for the English edition. It intends to provide an interpretation that is both convincing and carefully documented. We do not consider the past a series of unambiguous crossroads but assume that everything, or at least much of the ETH's history, could have turned out quite differently. Consequently, we focus on what motivated people in the past, their perception of themselves and their environment, and the constraints under which they labored. We do not expect the past to dish up simple prescriptions for the future. Rather we wish to show that a journey into the past can serve as a useful detour along side roads, and with any luck provide a whole new basis for (self-)reflection and understanding of the present. The irritating as well as illuminating potential of historical thinking was articulated in 1985 by Martin Christoph Rotach, ETH professor of transportation engineering: "In 1984," he said, "our planning commission tried to peer into the year 2001. Now, 17 years is not really that long a time to forecast, and consequently many were unwilling to believe that fundamental changes would take place or even any changes at all. But let us think back to the economic boom and high-tech enthusiasm of 1967. Who at the time would seriously have believed that the trend would be broken by an energy crisis, recession, debt, unemployment, and a hiring freeze? Who at the time would have questioned the "feasibility of the future" courtesy of modern science and technology? Who would really have considered that the earth and its resources might be finite? And who would have thought that within half a generation we would be contending with youth riots, dying forests, and polluted soil, but also worldwide mobility, the proliferation of personal computers, the ubiquity of plastic, and mountains of rubbish?"[5]

Taking this amazement into account in the historical analysis and turning the fascination of strangeness into reflection means temporarily suspending cherished conclusions. The concept of progress – which for an entire era was based on history as a future-oriented development – has to be rethought. This notion of an undetermined future, which can and must be shaped in the present with an eye to the past, coincides with the eigteenth-century Enlightenment sense of the term.[6] "Let us resolve that the future shall not rightly say of us that, in this domain too, we could have given spirit and life to a new federal government, only we lacked the will," declared parliament in 1854, in founding the ETH.[7] On the institution's seventy-fifth anniversary, the speakers still had sufficient confidence in the forward march of progress to overlook the historical improbability and the social contingency of their existence. But by the one hundred and fiftieth jubilee, the wall of certainty was showing a few cracks. The historical narratives no longer supported the progress model. Moreover, the making of the future had shifted to the realm of science and higher-education policy.

In the pages that follow, we analyze the Swiss Federal Institute of Technology as a machine that is very much focused on transforming the future. To our minds, it is best seen as a complex institution whose well-oiled production and dissemination of knowledge serves a federal, industrial and academic working elite and whose research and teaching effectively transform the future.[8] As long as this machinery seems to be working, it is supplied with sufficient resources to remain in operation. The metaphor of the machine reminds us that although machines are actually made by people, they also develop their own logic and in turn dictate human action.[9] This symbiosis also influenced the ETH.

The idea of a machine that transforms the future, understood as an ensemble of people, symbols, and things, metaphorically brings together two terms that are significant for modernism and for modernity. The metaphor is appropriate to the ETH because it is a typical modern university. It appeared in the last 150 years as both a modernizing agent of and a laboratory for society. This makes it a privileged field of observation for processes that reach far beyond the institution. Its working models make it possible to study modernization processes and modern practices relevant to everyday life, in particular with regard to power, knowledge, and identity. This triad gives rise to three areas of contemporary investigation, all borrowed from Michel Foucault. Management problems provide a lens into questions of governance; the scope of research is closely connected with the appearance and disappearance of specific stores of knowledge; and teaching is inextricably bound up with historical forms of (self-)discipline and of subjectification.[10]

The mediation, validation, and production of elite knowledge relies heavily on prior assumptions and changes over time. Although the ETH machinery has in the main functioned well, it has never run smoothly. Operating personnel and equipment turned over constantly. The machine and its parts perpetually needed service, and had to be re-coordinated time and time again. The machine's interactions with the environment also had to be renegotiated at more or less regular intervals. Selection and recruiting, demand and opportunity, control and freedom, boundaries and connectivity – all these dimensions repeatedly required delicate adjusting, without ever becoming permanently fixed parameters. The future orientation of the machine made these negotiations more difficult to carry out. There was always a time lag between intervention and result whose duration depended on many factors. The simultaneous working of different time constants meant that the interplay of components and various inputs and outputs followed cycles instead of a steady course. Science historian Hans-Jörg Rheinberger has pointed out that, in the laboratory as in the history, such cycles can lead to astonishing developments.[11]

The history of science has developed a variety of models to deal with the punctuated course of historical change. These range from Joseph Alois Schumpeter's business cycles to Hansjörg Siegenthaler's crisis theory to Reinhart Koselleck's analysis of the historical "time layers."[12] The ETH went through long periods of structural clarity, while at other times the institution would be entirely remade in fairly short order. Such fundamental restructuring happened with surprising regularity, every six decades from 1848 to 1908, and again after 1968. These short but eventful periods were followed by decades that were distinguished by the relative stability of structural development.

This categorization agrees well with the concept of a "long" nineteenth and a "short" twentieth century, as elaborated by social history.[13] It conforms less to the concept put forward by historians of science and knowledge of a "long" twentieth century beginning as early as the 1880s.[14] As the first stirrings of a new modus operandi were already perceptible at the ETH in the late nineteenth century, to adopt such a periodization would have been possible as well. However, a strong argument against using this temporal framework holds that the innovations only took momentum in the first decade of the twentieth century, when the ETH transformed from a polytechnic into a technical university. The following period of relative stability lasted until the end of the 1960s and hence encompasses the Second World War. For Switzerland, which was not directly involved in the warfare, such a continuity through 1945 is easier to argue for than for the warring countries and those devastated by war. In recent years, however, the attentiveness of continuities throughout the "age of extremes" has been amplified, and a similar time scheme has been proposed for Germany's infrastructural history.[15] It is not uncommon to see 1970 as a historical break point, although the depth of the break is contested. Concepts such as the post-industrial society, the information society, and the knowledge society all represent attempts to describe a new social order that crystallized following 1968.[16]

These considerations have guided us in organizing the present book and suggested the following periodization. Chapter 1 is devoted to the major academic debate that succeeded the founding of the state in 1848 and that in 1854 created the framework for establishing the federal polytechnic through the mechanism of a federal law. Nation, profession, and the middle class are the reference points for the development of the young school in the following decades (see Chapter 2). Although development proceeded successfully, shortly after the turn of the twentieth century it reached a point requiring a new orientation. Accordingly, the polytechnic transformed into a university complete with academic rights and practices (see Chapter 3). In the decades following the First World War, the academic self-confidence gained by the Swiss Federal Institute of Technology (as the polytechnic was renamed) through a process of complex debates and self-reform led to new modes of cooperation. Chapter 4 deals with the cycles of activity at the ETH that resulted from tensions between business, politics, and science. Chapter 5 explores the higher-education and social policy debates that took place around 1968 focusing on the university as a societal laboratory. The most recent major debate in the history of the ETH marks the ETH's reorientation to the post-industrial world. Applying science-oriented business management principles to the running of the university facilitated a flexible approach to the ETH's internal and external relationships (see Chapter 6).

1848–

1. *A fundamental* DEBATE: ANCHORING *the Swiss* VISION *post-1848*

David Gugerli

1855

The opening ceremony of the Swiss federal polytechnic on 15 October 1855 was an unspectacular affair. The general outline of the program of events could be guessed ahead of the daily newspaper. Indeed, the detailed reports published after the fact served largely to confirm expectations. The only real surprise was the abominable weather on that autumn day: “Nonetheless,” wrote the *Neue Zürcher Zeitung*, “the celebration can be called a success.”[1]

In terms of public ritual, the event constituted an exercise in republicanism for the still very young confederation. The participants appeared to be brimming with confidence, and to know their roles automatically. But this heightened poise is deceiving. For in the 1850s, the federal state – here, playing to the crowd – was still an abstract concept. No one knew exactly how it would turn out, and that made it worth observing closely.

“At two o’clock,” the newspaper reported, “the procession left the city hall, greeted by the bells of the Gross- and Fraumünster (at major celebrations provost and abbess ride to-

The cityscape of Zurich in 1859 was distinctly urban. Streets had replaced the medieval walls, railroads and steamships were operating, and the first factory buildings had appeared down on the Limmat. Within a few years, the main building of the federal polytechnic would be erected in an open area up the hill.

gether) and the thunder of 22-gun salute" – one shot for each canton. No doubt, bringing all the "people of the two and twenty sovereign cantons united by the current federation" under the regime of a constitution was the greatest political achievement of the state up to that point.[2] Having resolved the higher-education question to the point of being able to now officially celebrate the opening of the federal polytechnic proved one of the earliest milestones on the long road from constitutional intent to constitutional reality. This made the presence of government representatives all the more impressive: "The federation was represented by the presidents of the legislative bodies, the members of the Federal Council and the Swiss school board. Participants from Zurich included the cantonal government, the education council, the city government, representatives from the surrounding towns, teachers, and students from the university and the polytechnic."[3]

The conspicuous federal presence on 15 October 1855 and the deliberate absence of surprises were one of a piece. The state representatives epitomized normality – a central concern also of the Zurich government and the future officers of the polytechnic. For, having all gathered here, they were charged, as it were, with performing a duty that was unfamiliar. Lining up in the literal sense of the phrase – according to rank – they joined the procession, behind which followed (more tolerated than respected) the newly matriculated students of the polytechnic along with those from the cantonal university.

That the event was not really about the students was clear to everyone. Joseph Wolfgang von Deschwanden, the polytechnic's acting director, had barely three weeks before written in his diary with no little embarrassment and irritation, "The festivities seem to me to be everything but what a school celebration should be. The institute is supposed to be public, & no one seems to want to allow the parents whose sons will be educated there to take any part in the events. The institute was established for the young, the students, & it is precisely they who are being closed out of fully half of the festivities. Imagine, a school celebration without students!" In fact, what was being celebrated was not the school but politics. The political system had made the school possible, and now the intent was to bring the school in line with future organizational and social policy. The celebration had to be a political one, even if it that meant forcing the celebrants to the sidelines. "If teachers, not statesmen, had drafted the program, they would have reached more deeply into the real lifeblood of the school. This omission pains me also and especially on account of the students, who must fend for themselves under the most wretched of circumstances."[4]

Thus the procession heeded its federal calling – and reached the Fraumünster. "Inside the church a large audience had already gathered, clutching invitations, as the marchers filed in, greeted by the organ playing of Mr. Kirchner. Mr. Frei-Herosé presented the deed of foundation with a short but concise speech about the link between the new institute and our national life. It will move forward efficiently and straightforwardly, and at the same time resist developing in a purely material direction. The speaker was followed by a superb male choir (wind ensemble and city singing society). Then Dr. Kern


The high point of the opening festivities of the federal polytechnic took place on historically uncontroversial ground, in the Fraumünster. View from the main choir, 1900.

spoke. In the historical portion of his talk he emphasized the interesting fact that in 1798 the culture and education minister supported the founding of a Swiss polytechnic institute (this was shortly after the founding of the Ecole Polytechnique in Paris). The speaker went to great lengths to explain what the federal authorities hope for the institute, what the people expect of it, and how these desires are to be fulfilled. The organ wrapped up the ceremony."[5]

Putting together the program had required negotiating a number of hurdles. Among them was the unspoken problem of the placelessness of the polytechnic, which still had no building of its own. The only solution was to choose one of the two large cathedrals for the site of the inauguration. That the choice did not fall to the Grossmünster was certainly consistent with official protocol. The Zurich main cathedral had to be avoided because it was much too closely allied with the Carolinum, the Zwinglian school of theology of the Ancien Régime. Dedicating the Swiss polytechnic in the Grossmünster would further overly encroach on the relationship with the cantonal university forged a good 20 years before, which liked to think of itself as a liberal, enlightened successor to the Carolinum.[6] Theology, religion, Ancien Régime, and university – the polytechnic must have dreaded these spectres like the devil dreads holy water; the federal state, too, had to keep them all at a careful distance from its own "institution." When it came to promoting harmony and emblematizing tradition, it was not for nothing that, on this "joyous occasion," framed at the beginning and ended by the organ's playing, one harkened back not only to the ecclesiastical overtones of the celebration but also to the culturally entrenched social life of the city.

It was a rite marked by symbolic distinctions: the carefully prepared guest list, the clear marching order of the procession, the hierarchy of the speakers and the assumedly well-thought-out seating at the banquet. Moreover, at this zero hour, one wished to endow the polytechnic with its own prophets, its own reason for being, and its own program. The role of the prophet was assigned to Philipp Albert Stapfer. Naturally, both Johann Konrad Kern, the school board president, and the *Neue Zürcher Zeitung* managed in their accounts to avoid any explicit reference to the Helvetic Republic, whose centralist constitution was perceived as problematic by the radical and liberal state. Whereas, loosely interpreting Kern, the Zurich reporter made reference to the French Ecole Polytechnique in Paris as a model, thus countering fears of virulent Germanization, Kern in turn, loosely interpreted Stapfer's proposals as a longstanding dream and an urgent national need. "We owe it to our time, we owe it to our new federation to bring to life the seeds sown nearly 60 years ago."[7]

In addition to this "historic" link between the polytechnic and Stapfer's vision, there emerged at the founding ceremony a solid, and in some way fundamental justification for the polytechnic institute. The "polytechnic" project was by now a part of the Swiss landscape. The field of endeavor for which it had to prepare its students occupied precisely that terrain which the nineteenth century, by dint of scientific, technical, and aesthetic achievements, had begun to appropriate as a quasi-natural realm of possibility.[8]

A slew of rhetorical questions in Kern's speech paved the way for the project to lead from the nation's geographical bedrock to its industrial future: "Have not our Alps been the subject of research since time immemorial? Doesn't the very character of our country, with its ever-changing topographical and climatic features, its diverse cultural layers and cultural aspirations also call out for its own special attention in the classroom? Let the engineer look to our mountainous terrain and railroads, to our rushing rivers and waterworks; the architect to our construction materials and the buildings we make of them; the mechanic to the abundance of our water power; the chemist to our (carefully nurtured) technical-chemical industries; the forester to the critical forestation and deforestation of our hills and valleys – for the inspiration to make our country's most important scientific truths the constant object of their own research and teaching. Finally, should not knowledge of the political institutions and history of our own country, the knowledge of the teachings of economy, which currently are of practical importance for our people, be especially attractive for every Swiss, no matter which profession he wishes to apply himself to? And shouldn't our industries, in their wealth and continuing development, also have a place in education out of special consideration for our unique circumstances?"[9]

Before all that could be shaped into an academic program, however, Kern articulated what for the celebrants was obviously a political goal of the polytechnic, based on stated historical, geographical, and economic realities. "Our Swiss institute must … allow for the special situation and needs of our people and be a national institute in the best sense of the word."[10] One hundred and fifty years post-celebration, one can digest such a sentence only with great effort. Yet the attributes Swiss, patriotic, and national, attached to one and the same "institute," were at the time the expression of a future-making political agenda. It was precisely this agenda that was endorsed by the dedication of the federal polytechnic on 15 October 1855. The academic component was still far in the background.

Between infrastructural policy and customs regulations

Although the opening of the polytechnic was a carefully orchestrated political demonstration, the school's creation story can be characterized as a complex, often frankly confusing political process – a development that went hand in hand with the earlier development of the federal state beginning in 1848. Ultimately, it comes down to a very political history of the gradual achievement of the Swiss Federal Polytechnic by writing, conferring, reading, and arguing.

This creation story has been reconstructed several times. Among the relevant works is Wilhelm Oechsli's account of 1905. On the occasion of the fiftieth-year anniversary of the school, the ETH historian applied himself meticulously to reading minutes of meetings, newspaper reports, and official communiqués. He described in detail the progress and tenor of these negotiations. Admittedly, opinions were so varied, the bargaining chips so changeable, and the arguments so contradictory, that Oechsli's attempts at order in turn served only to increase the confusion.[11] Even efforts to promote people like Alfred Escher and Stefano Franscini, in order to enlist their aid in reducing the political complexity of the young federation to a tractable level, were unpersuasive, and understandably. Eliminating controversy in favor of a simple narrative of the kind crucial to creating the polytechnic obscures any learning effect or change of position. Instead, it fosters a kind of drama that proceeds according to the individual vision of the heroes and the collective surprise of their opponents.[12]

What follows here is intended neither as a meticulous reconstruction nor a mock-heroic trivialization, but rather a shift in narrative perspective. The polytechnic can be understood as both an effect and an implementation of the federal state, whose growth and development enabled the negotiations that led to the founding of the polytechnic. It is also likely that just before and immediately after 1848, the battle was not so much for the polytechnic that was inaugurated in 1855. Rather, it was about federal realities concerning higher education, testing parliamentary procedures, disseminating political opinions, refining public relations efforts, as well as introducing ideological, religious, and to some extent even academic arguments. All this became interwoven through the debate process into a dense political fabric.

The National Council as generator of endless speeches. No sooner had the federal parliament begun its work than it found itself accused of being a locus of unproductive talk. From the *Postheiri*, 1849.

It is hard to say when exactly the project began. But the federal constitution of 1848 was certainly an important milestone.[13] The state's power to organize a Swiss higher-education institution was enshrined there, in a position that reflected deliberate forethought. In its first 20 articles the constitution provided for the usual protective and representational functions of the federal government. Not until Article 21 did it focus attention on a concept for a new infrastructural competence and supplement it with a right of expropriation. This was massive fire protection for the government's intention to take direct control of major infrastructure projects such as the canalization of the Linth River. The federal state of 1848 claimed much greater freedom of legal arrangement than had

Article 22 of the federal constitution of 1848 granted the government the right to erect a polytechnical school. The memorial page shows a crowd symbolizing the sovereign nation, in both civil dress and uniform, hailing a triumphant Helvetia, crowned with laurel leaves.

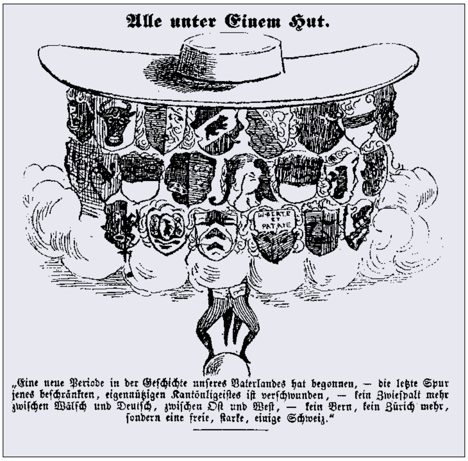
ever been granted to its predecessors.[14] No less significant was the content of the Article 23, namely the declaration of the customs regulations of the state. This guaranteed not only the state's right to design a unified, national economic area but also the means to finance its new function. Inserted between these two articles – almost as a simple consequence of the article concerning infrastructure and somehow as a transition to the

sober economic policy prerogatives of the article concerning customs – was the seemingly innocuous Article 22 on the university question: “The state is empowered to erect a University and a Polytechnic School.”[15]
The modesty of this sentence belies the hot temper of the schools debate among the constitutional committee, the different cantonal, religious, regional, political, and cultural groups, and, finally, the revisions committee of the Tagsatzung (legislative and executive council) right up to 1848. In the draft of the constitution, the article had looked quite different, and obviously had ruffled quite a few feathers. It read: “The Confederation will provide for the establishment of a Swiss University, a Polytechnic School, and teacher training colleges. The organization of these institutions, as well as the subsidies to the cantons in which the institutions will be located, are to be decided by federal law.”[16] This clear mandate must have fallen victim to power struggles, for the teacher training colleges were deleted, the “and” between university and polytechnic school became possible to interpret as “also,” and the subsidies to the hosting cantons simply not mentioned. All this was the result of constantly changing coalitions with a talent for repeatedly linking the schools question to totally unrelated religious, military, ideological, budgetary, and economically and politically sensitive topics.
In each case, the discussions were emotional, even or perhaps precisely because they had no empirical basis. For example, the bold declaration was made that only a school supported by the government could meet scientific requirements and accommodate national needs. In contrast, others insisted that it was neither useful nor important to finance a federal university. Such positions advocated, for example, protecting a cantonal university or compensating for the lack of one, or they catered to omnipresent religious fears. Moreover, the arguments intersected with beliefs and preferences regarding the appropriate organizational form of higher education. The choice before the government was whether to act as operational authority, political coordinator, or protector of a cantonal concordat. Finally, the significance of tactical positioning and “castling” in the negotiations should not be underestimated. The requirement by some for military-political centralization led of course immediately to a call by others also to centralize the country’s “spiritual armor” and in addition to support the universities and the teacher training colleagues. Such proposals in turn brought the defenders of cantonal educational sovereignty into the act and put on alert those who worried that their religious freedom was under threat. In the federal negotiating room, it was impossible to say anything without triggering an entire chain of explosive associations.[17]
Undoubtedly, a university belongs within the inventory of a public entity that is preparing for statehood.[18] In this case, the vague wording of the article enabled the federal state to acknowledge its educational and scientific mission without having to take any concrete steps.

Statistical excursions into the educational landscape

In 1848 the requirements of constitutional law and the realities of the federal state were still very far apart.[19] What was missing was what Alfred Escher as president of the National Council once called "the difficult work of implementing the laws of the federal constitution for the purpose of its full adoption in our lives."[20] Although the constitution defined potential areas of action, these had yet to be put into political practice. This was especially true of the sphere of competence of the Federal Council, which for the time being functioned more as a parliamentary committee than as a government. With only a meager infrastructure to draw on, it often struggled to hold its own against the power-brokers in the National Council.[21]

For example, Federal Councillor Stefano Franscini had to run the business of the Department of Home Affairs from his private residence in Bern, writing letters and minutes himself as well as trying to implement his (initially personal) plan to conduct a Swiss census for the government. He received little in the way of administrative support for either. Of the approximately 80 employees working for the central government in 1849, most were employed in the then important Department of Defense and in the state-owned factories, whereas home affairs was considered trifling.[22]



Switzerland, a single country? In 1849 the *Postheiri* illustrated its doubts that all the interests of all the cantons could be reconciled.

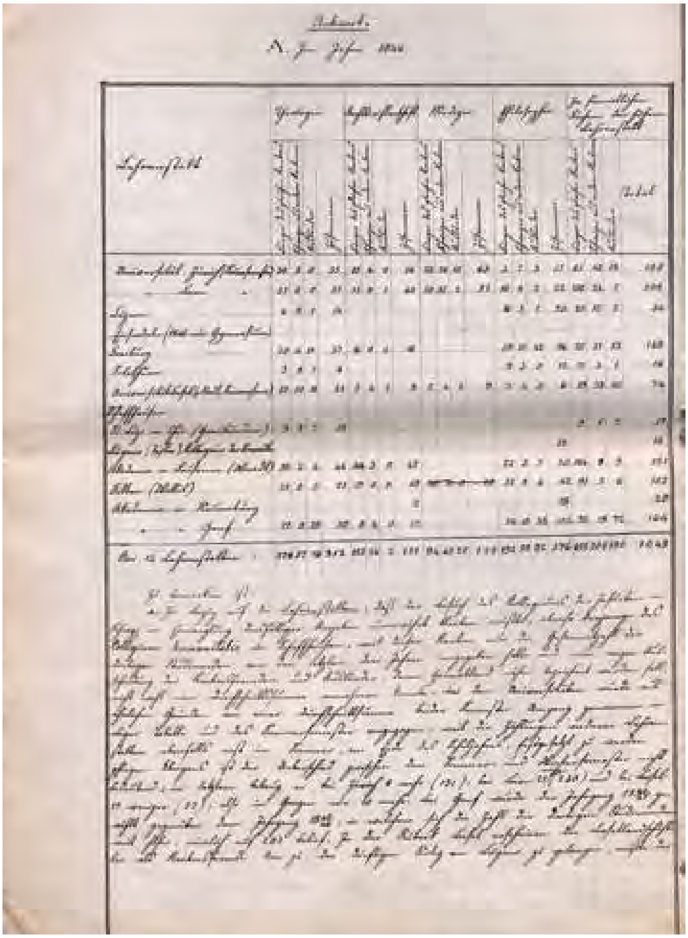
Barely two months in service, Franscini sought to escape this relative obscurity by more concretely formulating the article on higher education. This activity offered him the opportunity to massively expand the influence of his office. As a statistician, it was clear to Franscini that the future design of education required knowledge of current relations. He was also clear about how to obtain this knowledge. On 4 January 1849, he sent to all the cantonal governments a circular letter requesting information about existing educational structures, data on students broken down by origin and area of study, scholarships, and salaries and tuition. That it took a year for him to get feedback, that a second letter generated only a partial response, and that the questions were answered in a way that made comparison impossible – hardly surprised him. In any event, none of it kept Franscini from drawing up tables, calculating averages, and comparing values.[23] His description of the state of cantonal education was a statistical report specially compiled to address the higher-education question. In style it was totally consistent with the tradition of country profiles that emerged from the political economy studies of the late eighteenth and early nineteenth centuries. At the same time, it was a modern instrument of political opinion shaping, planning, and participation.[24]

The educational landscape described here was and remains difficult to grasp. It stretched from the Lyceum in Lucerne (which had its origins in a philosophical and theological faculty that was suspended in 1848), to the Benedictine Abbey in Einsiedeln, to the Academy of Geneva and the law school of the Lyceum in Fribourg, whose theological and philosophical faculties were likewise suspended by the cantonal government in 1848. The response from 13 of the 25 cantonal governments provided the numbers for five institutes of higher education, in which for the years 1846 and 1847 some one thousand students were enrolled: 628 philosophers, 93 lawyers, 320 theologians. "According to the calculated average, each of the five schools had a yearly enrollment of 69 students," stated Franscini, without explaining how he had arrived at his numbers.[25]

Even if Franscini had detailed his methods, the data would have been meaningless, though precise. For the cantons of Zurich, Bern, and Basel Stadt, which each boasted a university, had failed to respond. Nor had duplicate and triplicate entries been eliminated from the data. Moreover, the information was already outdated, because in the meanwhile not only had many Catholic institutions been closed for political reasons, but the Geneva Academy had reorganized one of its faculties. Franscini's survey was a long way away from delivering correct results. As a basis for decisions, the findings fulfilled their goal, however. Even when the figures were wrong, they nevertheless supported the decisions to be made.

No less varied than the institutional character of the country was the range of views and desires expressed: "The government of Appenzell met this interrogation with silence," recorded Franscini. Lucerne suggested "Zurich as the site of the federal university," but wished "at least as far as Catholic theology is concerned, two separate centers for the training of the clergy, one to be situated in Lucerne, the other in French Switzerland." Geneva in turn preferred "that the government erect a medical and a theological faculty," and declared that it did not wish to give up its own academy. Nidwalden "attached to the possible introduction of a Swiss educational institute a special request: that attendance not be declared obligatory." Freiburg, which not a year before had been threatened by Swiss troops in the Sonderbund War, now presented itself as a model Swiss canton and fervently recommended that it be the seat of a Swiss educational institute because it was "the capital of a canton that was part Catholic, part Reformed, part French, and part German," in which "these two main languages of Switzerland were spoken and substantial resources were available." "Substantial resources" meant the infrastructure of the Lyceum at Freiburg, which following the 1848 expulsion of the Jesuits had been accorded a new basis under constitutional law.[26]

The heterogeneity and multiplicity of the educational offerings as reflected in the Federal Council's survey was later characterized as "fragmentation of forces." "Higher education in Switzerland is therefore in a depressed, poor situation; its forces are fragmented, the



Doing politics with statistics. Extract of data describing the Swiss educational infrastructure, drawn up by Federal Councillor Franscini in 1851 based on feedback from the cantons.

results inadequate; one of the goals most satisfying to the country will not and, under these circumstances, cannot be reached,"[27] asserted an expert federal committee. However much admiration the academic richness and organisational diversity of the cantons could have inspired, it hardly translated into a need for government intervention. Instead, the image of "fragmentation" attested to a kind of emergency to be remedied, in the sense of restoring an original entity. Only the appeal to untenable conditions allowed the implementation of a new policy. The less "new" they appeared, the better.

Hunting for market niches

A little more than a year following the dispatch of the circular letter, the Federal Council appeared to have adequately completed the necessary documentation. It was now provisionally evaluated and analyzed to determine where exactly the higher-education system could be complemented by a federal institute, in other words, where there were gaps or suspected gaps to be filled.

In May 1851, the Federal Council appointed a committee of experts to consider the university question. This august group assessed the information provided by the cantons and processed by Franscini. The members of the committee included social and scientific luminaries such as Blanchet, Dufour, Escher, Federer, Merian, Moschard, Rauchenstein, Schweizer, and Troxler.[28] They were charged with pursuing the federal survey of 1849 through other means: “No special orders will be given to the committee, but its task will be to come to grips with and evaluate the issue straightforwardly from several points of view,” stated the Federal Council.[29] The invitation to the cantons to engage in – at least partial – self-evaluation had supplied the political legitimacy to create a university. In addition, the gathering of data on education enabled by the earlier “statistical” method had conferred on the undertaking a quasi-scientific procedural legitimacy. Now the enterprise was secured through a scientifically distinguished, socially highly networked, and politically influential educational elite, in the body of the committee members.[30] A whole series of meetings, interim- and partial reports, expert opinions and counter opinions, requests, petitions, and interventions focused on the higher-education question. Contrary to the proposal put forward in 1850 that fees for experts be eliminated, the councillors tripled the respective budget item. Every little detail was savored and used to political advantage. The more experts were involved, the better.[31]

The experts questioned whether a federal higher-education institution should actually be created, what type of educational entity was the right one, and what relationship the school would have to the state. The statement of the problem was reasonably clear. But the variety of opinions and the rules of combinatorics multiplied the options considerably. Soon after the committee began its work, the panel split into several factions. Possible coalitions were tested, more experts mobilized, and “subproblems” delegated to working groups. Alfred Escher appears increasingly to have taken control of the affair, although Stefano Franscini still led the process formally. Based on the reports of the working groups, the deliberations of the committee as a whole, Franscini’s survey, different opinions, and finally on the two draft bills that Escher had penned on the federal university and the federal polytechnic in June 1851, the committee issued a final report in July of the same year. It was hardly unanimous, and indeed, a minority dissenting opinion was sent to the Federal Council in a separate memorandum. Despite the elaborate proceedings, the gap in the educational system that a federal school was hoped to fill was neither found nor concocted.[32]

Realizing the university remained a problematic postulate of the national constitution. This was also due to the fact that for many it was not a practical issue but an ideological one. The goal of working toward "an alliance of amical fraternization among Swiss students from all parts of the confederation and thereby helping to contribute to the national unification of the entire Swiss people" was obviously consensual. Moreover, the reference to many previous projects in the first half of the nineteenth century also gave the committee instant "national patriotic reasons" for promoting a federal university. But no compelling rationale derived from that, merely "the provisional assumption that essential and irrefutable need demanded the building of such an institution."[33]

And here another imbalance emerged. The reports of the majority and minority of the Federal Council's committee diverged greatly, but only in relation to the university. In contrast, Escher's bill on the polytechnic and the explanatory notes regarding it were approved by the entire committee with very little fuss. That did not, however, lead to the conclusion that the university should be dropped and instead the obviously less contentious polytechnic erected.[34] Rather, the Federal Council simply stated that the opinions regarding the "substantial benefits" that a polytechnic institute "could bring to the country [might be] less divisive ... than would be the case with a federal university."[35]

In retrospect, to say that the polytechnic would obviously be the "correct" solution would be to miss a crucial point. The popularity of the university as a bargaining chip was due precisely to the fact that the primary issue in this transaction was not the university but the federal state. The negotiation process itself proved politically beneficial. Politically speaking, the issue of the university served to positively bind so many opposing positions that one would have been hard put to strike it from the government agenda. Indeed, in subsequent discussions, the plan for a polytechnical school was usually presented as a federal barter transaction. Thus, for example, in the summer of 1853, a National Council committee voiced the following: "While we would like to have the university be seated in German-speaking Switzerland, with respect to the polytechnical school, we suggest that it be located in the part of Switzerland where the French language prevails."[36] Whichever of the two major language areas did not end up with the university, either should or would have to accept the polytechnic. Few, however, were paying any attention to the polytechnical school. The hot issues concerned the university.[37] Consequently, the opinion-making process that followed the release to the general public of the Federal Council's memorandum in August 1851 served to further damage the federal university project, whereas the idea of a polytechnic remained relatively intact.

The public policy debate free-for-all

Fundamentally, there was a huge discrepancy between the consensus that reigned over the ideological usefulness of the university to the nation-state, and the dissent that every concrete proposal immediately provoked. This debate was structurally similar to the discussion on railway legislation that arose at the end of 1849 through a motion of Alfred

Escher that carried in the Federal Assembly. Like the higher-education issue, the railway question was also marked by political positioning and certain claims on the part of the federal government. In both instances, the councillors were negotiating which federal infrastructure to provide the newly industrializing Switzerland with. In both cases, the undeniable utility of the proposals also ran up against criticism on cost grounds and aversion to liberal ideas of social order. Thus, if the federal parliament wished to legislate productively, it had to find some way to bridge fundamentally divergent concepts of statehood.[38]

In August 1851, the new committee established by the National Council to prepare a higher-education law requested adjournment to the next session owing to the accelerating debate over regulation of the railway system. As the never-ending schools debate could be revisited at any time, the parliament granted the request.[39] During the parliamentary lull the project managed to avoid falling into oblivion. In fact, the interval made it possible to organize petitions. Whereas some called on the federal authorities to abandon the higher-education projects, others urged that at least one of the two plans be brought to fruition.[40]

Topping the list of potential fields of activity for the federal government in 1850 were the railways. As with higher education, the debate over the railroads centered on federal responsibility for national infrastructure. The photograph shows a train from the company Ouest-Suisse arriving in Lausanne, around 1860.

Opponents of the university made especially good use of the time, differentiating themselves and attracting new adherents. "In this way, the French-speaking Swiss who, dreading the loss of their traditions, now battled as fiercely against the federal institutions as they had earlier desired them. They consorted with the ultramontanes, who smelled in the plan for the university a threat to religion; with conservatives and particularists of every stripe who saw only a clever means for "federal barons" to consolidate their control and to train a compliant bureaucracy; with the Baslers, who feared for their own university. Moreover, because the university was perceived as a personal opportunity for Alfred Escher as a logical first president of the new university, the French Swiss cultivated all Escher's enemies, namely everyone who was offended by his railway policy, such as the St. Gallers, who could not forgive him for having planned a Bodensee railway through Thurgau that bypassed their town."[41] Higher education was obviously a delicate issue for all who increasingly saw their worst fears confirmed, that the federal government was ultimately a German Swiss protestant establishment. Thus, in February 1852, following a long-drawn-out debate in the regional executive, the Cantonal Council of Vaud called for "every effort to thwart the building of a federal university, and if the project should be adopted, to delay its implementation as long as possible."[42]

At the end of 1851, the federal government was authorized to build its own network of telegraph lines, whereby the national infrastructure policy took shape and materialized, so to speak. However, in summer of 1852 the government's ambitions for the railway were scaled back. Led by Escher, the economic liberals were able to push through their proposals in parliament with the full support of the federalists. The Federal Assembly rejected state construction of the railways, and decided instead to leave development of new transport to private investors and the cantonal legislatures. The railways disappeared from the federal policy scene, but not without clouding the air in parliament. Treatment of the higher-education agenda item was delayed by further requests for postponement, which could be interpreted not least as a knock-on effect of the railway debate. The matter only got rolling again in August 1853, when a detailed special report by National Councillor Jakob Stämpfli specified that the federal budget was anticipating a regular surplus of 1.1 million francs and therefore would have sufficient resources available not only for unforeseen events, but also for a university, a polytechnic, and to support other public works.[43]

This surprising result of the government's customs regime made one thing clear: despite all the doomsday prophecies that had cast doubt on the financial viability of the government, five years after its founding, the confederation was awash in money. The government not only had to embark on projects to realize and implement the federal constitution, at least on the drawing board. It also could, indeed, it must also realize such projects, because the funds they required were available contrary to expectations. "If, given such favorable financial circumstances, one does not proceed with bringing such national institutions to life," argued the National Council committee, "when will it happen? Let us resolve that the future shall not rightly say of us that, in this domain too, we could have given spirit and life to the new federal government, only we lacked the will.[44]

Now both opponents and supporters looked to coordinate their voices. A particularly successful initiative was that launched at the end of September 1853 by the Catholic priest and member of the university committee, Josef Federer, at the annual celebration of the *Schweizerische Gemeinnützige Gesellschaft* (Swiss Society for the Public Good). Federer presented the society members with a petition recommending the university to be sent to the federal authorities. Moreover, he secured the aid of the Aargau seminary director Augustin Keller, who was known nationwide as the eloquent leader of the radical-liberal Catholics.[45] Suddenly, the university project had another kind of support that at least in part neutralized religious differences – the remnants of an enlightened society and public culture.[46] The charity's petition was printed and, together with the majority and minority opinions of the National Committee, was distributed to the councillors in December 1853. The matter was now ready for consideration by parliament.[47]

In January 1854 the newpapers prepared the ground for the parliamentary debate by restating positions. The *Augsburger Allgemeine* made the biting but apt observation that a federal university was purely politically motivated and was intended to compensate Zurich not being chosen as seat of the federal capital. The *Basler Zeitung* was annoyed that the matter had even come before the councillors again. The conservative *Berner Presse* complained that the federal university was "a breeding ground for federal barons," while the Vaud newspaper *Le Pays* referred to a "Tower of Babel" and a "keystone of Unitarianism." That this university meant the end of French culture was not doubted by the Vaud contingent of the *Gemeinnützige Gesellschaft,* which launched a counterpetition to the opinion of its national parent society.[48]

The parliamentary debate

When parliament convened in the middle of January 1854 to discuss the university question, it foresaw no surprises. The cards had been dealt long ago, and positions taken. "We hear from Bern that the mood is good. Even the most hardened of the opponents are believed to be for the institute," reported the *Neue Zürcher Zeitung*.[49] Yet the opening arguments of the National Assembly disintegrated into a rhetorical free-for-all, in which the prior year's line of reasoning once again prevailed. The liberals and radicals of eastern, central, and southern Switzerland were mostly (and not unexpectedly) for the university; the ultramontanes, conservatives, and western Switzerland were against. One speech followed the other, documented and commented minutely in the press. As the *Neue Zürcher Zeitung* predicted, the supporters maintained the upper hand. At the end of the fourth day, the National Council decided to start discussion of the bill. That night, in the pubs of Bern, students celebrated the breakthrough for the university and organized a torchlight procession in gratitude.[50]

Had the opening debate developed as anticipated, the detailed deliberations that followed would have been extremely confusing. Very different versions were formulated and discussed in rapid succession, rejected again, only to be reconsidered. Indeed, people ended up championing causes that shortly before they had violently opposed.[51] What at first blush appeared hardly productive, unimportant, or even wrongheaded, on closer inspection turned out to be a painstaking, collective learning process, in the course of which positions were tested, tinkered, and adapted with the goal of creating majorities in both Councils.

A perfect example is a proposal made by Joseph Hoffman during the opening debate on 18 January: "One could even begin gradually with the polytechnic at Zurich, as foreseen," argued the representative from St. Gallen. Hoffman, a Catholic radical who in the 1840s had championed the

Too many cooks spoil the broth. The parliamentary debate on the university question was one of most protracted in the history of the young federation. From the *Postheiri*, 1854.

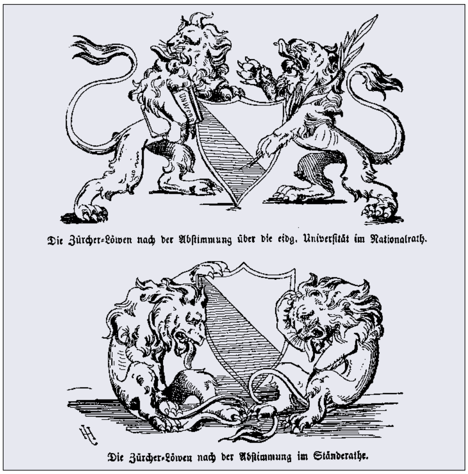
separation of church and school and had no interest in building a university on the traditional model. He favored instead a forward-looking, centralized institution oriented toward practical knowledge. "We do not propose a 'trade school'; it should have a different character altogether, and perhaps also be linked to the school of philosophy."[52] That Hoffmann's proposal was rejected in the National Council (despite its resemblance to the final bill adopted after three weeks of intense discussion) is hardly an indication of the inefficiency of parliamentary procedure or the unwillingness of the players to compromise. Rather, it primarily shows how parliament developed the ability to revise majority positions and to come back to earlier decisions.

On Friday, 20 January, the National Assembly began deliberating the committee's proposals for the university bill, article by article. But the circumstances of the deliberations were not optimal, and parliament made little progress. Already by the third article, the Council began sending bits of the text back to the working committee.[53] The list of faculties was controversial in several respects. In addition, the issue of where to locate the university and polytechnic was confusing, especially since the discussion had not resolved the question of which disciplines to combine and how. As none of the contending parties wished to establish a Catholic theology in Zwingli's Zurich, the two issues could not be decoupled. Moreover, the spatial separation of the planned institutions contradicted in principle the declared objective of concentrating the country's scientific power. By the same token, bringing it all together in a single place would provoke increasing resistance from federalists.

Over the weekend, the committee revised the rejected draft of the bill, and on Monday presented a new version to the National Assembly. As assessed by the *Neue Zürcher Zeitung*, the gist of the new version was "to have the two institutions in the same place, both to maximize sharing of teaching and educational resources and to make the general sciences available to the engineering students. The practical advantage of the proposal is that, in the event that French Switzerland is awarded neither school, the damage will be limited."[54] The ideal place for the institutions, which the newspaper did not name, was Zurich. The committee sought to address the religious and regional language issues, first, by leaving open the possibility of relocating the Catholic theology faculty to another city, and second, by stipulating that French be the language of the philosophy faculty. Following frequently heated discussion and much nitpicking, at the end of the week the National Council approved a bill for passage to the Council of States. Article 1 now read: "A federal university shall be erected that shall contain within it a polytechnic school."[55] This solution seemed appealing. Of course, the bill now had to be agreed by the Council of States. But in five years' of experience with the federal legislature, the smaller parliamentary chamber hardly ever ventured to change in any major way the decisions of the National Council.[56] However, the opposition to the federal university that had been building in the canton of Vaud had taken on the character of a genuine mass movement. On 31 January 1854, a petition against the university, bearing over 15,000 signatures from 220 towns, was sent to the Federal Assembly in Bern.[57] There, the states' councillors had been busy with the draft since the day before. The discussion again failed to get beyond the general debate, which in itself was already a bad sign for the advocates of the university. Departing from its traditional role, the Council of States declined to rubber-stamp the decision of the National Council as written. Whereas public positions were hardening, opinion in the Council of States once more ran the gamut, but in an overall more conservative, Catholic, and federalist tone. After a full three days, the general debate concluded on 1 February with a devastating decision for the university project: the Council of States voted 27 to 15 to reject the National Council's bill.[58]

Still, the decision was not entirely negative. At the same meeting, the Council agreed "in principle" to build "a federal polytechnical school in connection with a school for higher study of the natural, political, and humanistic sciences in Zurich," and tasked its committee on higher education with working out a concrete proposal. In so doing, the Council of States shifted the focus of the bill irrevocably. The polytechnic, which up to then had served primarily as a bargaining chip, now moved to the center. The federal university, for so many years the subject of controversy, was reduced to a philosophical extension of the polytechnic, comprising only a few academic subjects.[59]

To exploit the surprise of this configuration to maximum political advantage, quick progress would have to be made. Only by keeping a few steps ahead of the newspapers could parliament resolve the university question. The alternative, as recent years had shown, was to continually be dodging shots from the press, which could at any time reverse positions long believed to be won. Furthermore, parliament was already in the third week of its session, and adjournment was looming.



The federal university, which the National Council had previously awarded to Zurich, came to an abrupt end with the debate in the upper house of parliament. From the *Postheiri*, 1854.

Karl Kappeler, rapporteur for the Council of States committee, and later president of the federal school board, appears to have played a leading role in the short final act of the parliamentary drama. His success shows the effectiveness of clever agenda setting and targeted kowtowing in guiding the still unpracticed parliament, with its unwieldy bicameral system, to a binding decision. Through informal agreements and working the graveyard shift, Kappeler managed to speed the process up considerably. Even as the general debate was running in the Council of States, Kappeler transformed the draft university bill through additions and deletions into a proposal for an expanded polytechnic.

"Then he had Escher and Kern called out of the National Council to tell them about the modified draft." Kapeller forged a small intercouncil alliance by placing his confidence not only in national councillors Escher and Kern but also his Council of States colleague Johann Rüttimann. His achievement was twofold. First, immediately following the meeting, the Council of States' higher-education committee was able to confer with its members about a draft bill for an expanded polytechnic and (as it was supported by Rüttimann) promptly forward it to the Council of States. Second, Kappeler ensured that the opinion leaders of the National Council promoted his approach among the supporters of the university.[60]

Late in the night of 2 February, Kappeler copied out the committee's draft, had it translated the next day into fairly bad French governmentalese, and then lithographed. This enabled the item to be placed on the agenda for 3 February. This move by Kappeler and the National Council president took the opponents by surprise. Kappeler also won the recap of the general debate with an argument that benefited from the time pressure that he himself had created. According to this argument, there was no point in postponing



The heroes of Bern, 1854: National Councillors Alfred Escher, Johann Konrad Kern, and States' Councillor Kappeler. Prints from Wilhelm Oechsli's 50th-anniversary Festschrift.

the business to the next session; the decision was purely a question of being willing or not, that is, of political preference. Based on this calculation, no states' councillor would wish to be accused of lacking political will.[61]

The bill would have to be heard. During deliberation of the articles, the opponents of the university had little else to attack but the school for humanistic and political sciences. They succeeded in reducing the faculty of philosophy to an ancillary sciences division. Now the relevant passage read, "The polytechnic will be linked to the disciplines of philosophy and economic policy, insofar as they constitute ancillary sciences for higher technical training, namely modern languages, mathematics, natural science, political and art history, Swiss constitutional law, and economics." The downsizing benefited forestry which, at the request of Friedrich Schenker of Solothurn, was removed from the ancillary sciences division and installed alongside building construction; road, railway, waterworks, and bridge construction; industrial mechanics; and industrial chemistry as the fifth educational task of the polytechnic.[62]

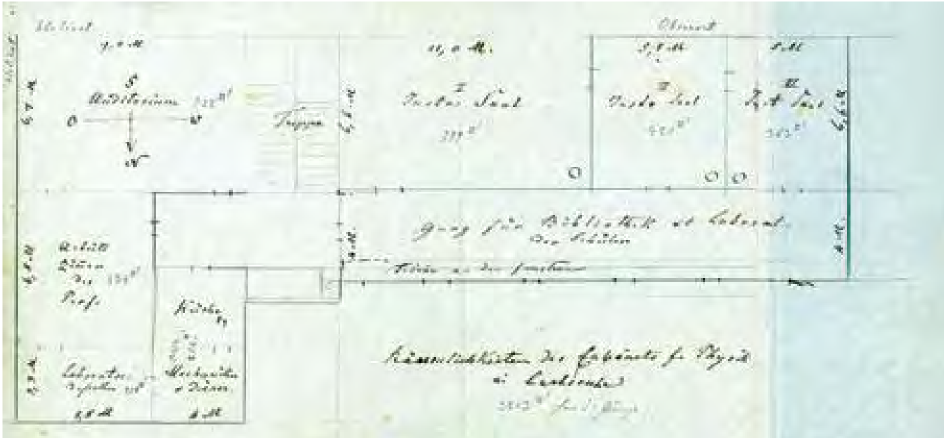
The remainder of the bill was approved with minor changes. The following week it went back to the National Council, and there, on 7 February, was passed into law. The strenuous debate over education had taken up almost the entire session from 16 January to 7 February 1854. Wilhelm Oechsli described it aptly as "one of the most memorable events in the annals of Swiss parliamentarianism." Already in the first week of 1854, the newspaper *Der Bund* had commented: "The major question of the week was the federal higher-education institutions, about which both friends and foes say that, among all the new federal projects, none had been discussed by the General Assembly with such depth or with such persistent attention."[63]

From Bern to Zurich: nailing it down

Of course, anyone who thought that the debate over the creation of the federal polytechnic was really over was going to be disappointed. Still, in February 1854, at three separate sites, closely related efforts were under way to come up with a concrete design for the newly decided law.

In Bern, the Federal Council was requested to provide an overview of foreign polytechnics. Franscini applied himself to the task and managed – mostly through diplomatic channels – to collect relevant syllabi and annual reports from Paris, Vienna, Karlsruhe, Stuttgart, Berlin, and Turin. The idea was to establish in Zurich a polytechnic that was cutting-edge yet whose offerings could be differentiated from those of its counterparts in neighboring countries. Alfred Escher also compiled a whole series of brief descriptions of foreign polytechnics. Together they served to provide models as well as to identify possibilities for setting Zurich apart. To evaluate the material and to draw up regulations, the Federal Council appointed a nine-member committee of experts. Over the course of many meetings up to the summer of 1854, it developed a ninety-page report, "Regulations for the Federal Polytechnic School."[64]

The commission was not merely a drafting committee, but had considerable leeway in designing the content of the institution-to-be. This was underscored by the fact that, in addition to the academics Joseph Wolfgang von Deschwanden and Pompejus Alexander Bolley (the rectors of the *Zürcher Industrieschule* and the *Aarauer Gewerbeschule,* respectively), the political heavyweights Alfred Escher and Johann Konrad Kern were also on board.[65] The gentlemen interpreted their statutory mandate with a greater or lesser degree of partisanship, as testified by their handling of the disciplines of pharmacy and military science. The chemist Bolley succeeded in getting pharmacy into the curriculum of the chemical engineering school at the polytechnic, although no mention had been made in parliament of there being a school of pharmacy. This expansion was based on the legitimate fear that the chemical engineering school, if limited only to chemistry,



The Karlsruhe model. The Zurich expert committee procured a sketch of the "physics laboratories" at Karlsruhe, simultaneously pointing out in procedural rules that the Karlsruhe polytechnic would not be easy to copy. Whereas in Karlsruhe, future students attended preparatory schools, in Switzerland the industrial schools would have to fulfill that function.

might draw too few students to justify the ample facilities with teachers and laboratories that Bolley envisaged. At this time, the Swiss chemical industry was still in its infancy, its subsequent growth still in the offing.[66] On the other hand, the proposal of the Swiss Military Association to establish a professor of military studies at the polytechnic was rejected on the grounds that the law did not provide for it. The initiators were told that they would need to apply to parliament for a change in the law. Given what it had taken to get the legislation through, this was a cynical proviso that could also have been applied to pharmacy.[67]

The deliberations were hardly limited to professors. They covered everything that a polytechnic school in the mid-nineteenth century could possibly need to function. Careful attention was paid to tools for teaching, from plaster figures and ornaments for drawing classes, to collections of tools, machinery, and building materials, to zoological, botanical, mineralogical, geological, and paleontological collections. Forests, gardens, and laboratories for mechanical and chemical engineering, and pharmaceuticals even came under discussion. The minimum age for students and the annual fees were also fixed. Finally, the committee produced a preliminary code of conduct, established rules for exams and the awarding of diplomas and certificates, and specified the salaries of professors, instructors, and teaching assistants.[68]

In Zurich, meanwhile, journalistic waves were swelling, as the canton had only three months to notify the federal authorities whether it wished to house the polytechnic and also to fund it in part. "Aut Caesar, aut nihil" – all or nothing challenged the headline of the *Eidgenössischen Zeitung* the day following the parliamentary vote. The conservative newspaper found it below the dignity of the canton to have a simple polytechnic fobbed off on it instead of a federal university. It is most likely thanks to Alfred Escher's rhetorical powers of persuasion that this position did not sway the cantonal council. With a surprisingly credible appeal to pragmatism, Escher had the courage (or the self-assurance) to bring to a close in Zurich the nailbiting event he had begun in Bern. Ultimately, it was arch-rival Basel that stood to replace Zurich as the national "center of the industrial sciences." Such a turn of events would have been all the more painful to Escher and his comrades-in-arms given that, at the national level, Zurich was an uncontroversial location. The university would compensate the city on the Limmat for the defeat it suffered six years earlier, in the 1848 negotiations over where to locate the country's capital. The Zurich cantonal council followed Escher and on 20 April 1854 voted with a clear majority to accept the federal polytechnic institute.[69]

The third selling point was Joseph Wolfgang von Deschwanden's desk. Deschwanden was an expert contributor to the editorial subcommittee of the Council of States' committee, and later served as the long-suffering director designate of the polytechnic. He was the obligatory gatekeeper for all business relating to the building of the school. Not only did he decide the fate of future relationships with other institutions; he also balanced the aspirations of the polytechnic against what was actually possible, established and monitored criteria for entry and expulsion, and set standards for control and freedom.

"They are so sensitive! If I make even the slightest reproach to an unfit student, you can bet Federal Councillor Franscini hears about it, and not just once, either. That's what they think is important!" Diary entry of Joseph Wolfgang von Deschwanden, first director of the polytechnic, on 1 June 1855.

The full burden of these efforts Deschwanden confided only to his diary. On 24 April 1855, for instance, he noted: "It has been a long time since I returned home as tired as I did today. All morning and afternoon, until 4 o'clock, exams for registrants to the polytechnic; afterwards, transporting models from the cantonal school to the polytechnic building, then goading people to get the business of exams rolling & especially those who took offense at having to do their bit: all this totally sapped my strength for today. And yet it revived me somewhat to be with the young people. Seeing them fills me with more joyfulness at the prospect of teaching again & to be involved with classes & science rather than these dry administrative matters; for me as an instructor, having been away from those halcyon days of teaching & working for over a year, this desire is not unreasonable."[70]

Two of the first professors of the federal polytechnic: the architect Gottfried Semper and the chemist Georg Staedeler. Semper was chosen first professor of the new institution in February 1855 by the Federal Council.

Even before the institute had opened, Staedeler had taken up his post to teach a preparatory course together with the mathematician Ludwig Raabe and Joseph Wolfgang von Deschwanden.

The niche in the academic market that the federation had sought since the beginning of the 1850s – and finally created by law on 7 February 1854 – Deschwanden now furnished with staff, equipment, and operating guidelines. The process was one of continual confrontation with the Swiss school board, a five-member panel that the Federal Council had appointed at the beginning of August 1854 as a managerial and supervisory body for the polytechnic. The board had its first meeting at the end of September. The members prepared the roster of professors, decided the budget, and set rules and the academic calendar. Compared with the universities, however, the degree of autonomy was modest. Decision-making power in important matters, for example, in the choice of professors, rested with the Federal Council.

The first school board was manned mostly with deserving university supporters from parliament. Kern assumed the presidency – the only full-time position on the board – and Escher was made vice-president. The board's authority was therefore not academic, but political. The fact that the politicians frequently drove Deschwanden to distraction illustrates the painful transition from a polytechnic of politicians to a polytechnic of engineers. This is not to say that post-1855 the polytechnic would not have been a political project. It means only that, having made its contribution to the creation of the federation, it now had to get down to the business of training engineers.

Accordingly, in October 1854, advertisements for thirty-two professors and nine to twelve teaching assistants at the federal polytechnic appeared in the *Bundesblatt* as well as in Swiss, German, and one Belgian and one French newspaper. By the end of the year there were 189 applications. More than half came from Germany, just under one-third from Switzerland, and a scattering from France, Belgium, and England. At the same

Before the polytechnic was inaugurated in Semper's main building, classes were held in temporary quarters, among others in the rooms of the high school in Zurich. Engraving from 1850.

time, board president Kern began contacting suitable candidates on his own. Established scholars were difficult to attract because the terms of appointment that Kern could offer gave little incentive to move to Zurich. In some cases, such as the architect Gottfried Semper, who was living in London as a refugee, the board benefited from the repressive political climate that had prevailed over most of Europe since the Revolution of 1848. By the time the polytechnic opened in autumn, thirty professors had been hired.[71]

The carefully staged inaugural ceremony of 15 October 1855 was the culmination of a fundamental, years-long political debate and, as such, represented nothing less than the physical embodiment of a political system's institutional rite of passage. Way in the back, almost forgotten and in less regimented formation, came the students. They had no real place in the proceedings, and yet their presence was essential. "Inaugural celebration of the polytechnic at noon, and by evening most of the students drunk," remarked Deschwanden in his diary. "Truly a tiresome, annoying beginning." The students had obviously grasped more quickly than their director that the festivities belonged not to them but primarily to the federal government, which was priding itself on having finally realized the nationalistic dreams of two generations of education policy makers. The long road to their own academic rite of passage was one the engineers (slightly inebriated) would have to face the following day.

1855–

2. *Nation, profession, middle class:* EDUCATING *nineteenth-century engineers*

Patrick Kupper

In July 1862 Carl Koristka, geodecist and professor at the Czech Technical University in Prague, embarked on a three-month tour of Europe that took him to Germany, Switzerland, France, Belgium, and England. His destinations were "the polytechnical schools of Munich, Augsburg, Stuttgart, Karlsruhe, Zurich, Hannover, Berlin, and Dresden, as well as the engineering colleges in Paris, Lyon, Liège, and Ghent, and finally what little England had to offer of this ilk in London." On behalf of the Czech National Committee, he made clear at each site "to what extent the local facilities would be emulated and adopted in the imminent reorganization of the Prague polytechnic." In a reported published in 1863, he reserved special praise for the federal polytechnic in Zurich: "We have described this young but strong and growing school more extensively than we intended at the outset of our study for the simple reason that, although it has far lower enrollment than other schools, we believe it to be one of the most important and promising of our time. It is bound to produce excellent teachers and imaginative development appropriate to progress in industry and technology."[1]

Just a few years after its founding the federal polytechnic already had a good reputation in Europe, owing both to its design and its promise. In addition to outstanding personalities among the first wave of professors, the school's innovative concept of engineering education, which emphasized mathematical and scientific literacy, attracted attention. Especially in the German states, the polytechnic served as a model for many years. It strongly influenced the basic reforms instituted not only at the Prague polytechnic but also at other German institutes of technology in the 1860s and 1870s. According to a 1904 historic review of German technical higher education, the founding of the federal polytechnic was a "significant" event. Zurich was a peripheral player in the shaping of the "German approach," but it was an important one.[2]

For Switzerland, the German technical universities remained a benchmark beyond 1855. The founding year of the Zurich institute fell between the first wave of German polytechnics that spanned 1825 (Karlsruhe) to 1836 (Darmstadt), and a second wave that followed in the 1860s, which included new facilities (Aachen) as well as the transformation of polytechnics into technical universities.[3] Although developments in neighboring countries – especially in France – were followed from Zurich and referred to when opportune, it was Germany's institutes that provided the standards to which the Swiss school aspired – particularly following German unification in 1871. Switzerland shared

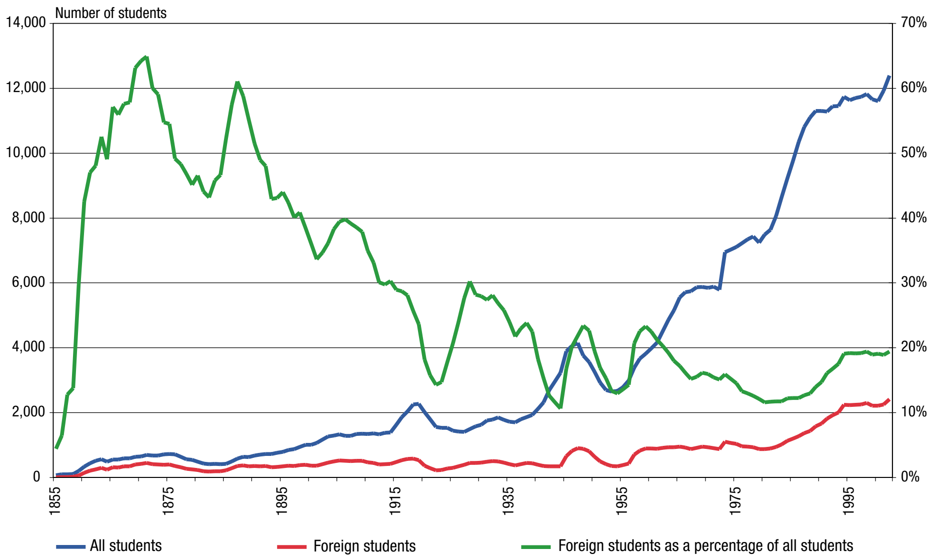
Zurich was a role model reflected in the architecture of technical universities elsewhere. Gottfried Semper's design for the main building of the federal polytechnic, completed in 1864, was copied many times in Germany, including in Aachen, Munich, Dresden, Braunschweig, and Berlin. Photograph from 1880.

with the German states a fundamental division of education into humanities and applied sciences that, at the higher-education level, was reflected in a separation into universities and polytechnics or technical universities, with education in the humanities at all levels enjoying greater societal appreciation.[4]

The strong external orientation of the polytechnic was reflected not only in the concept of the school but also in the background of the teachers and students. Well into the 1890s, roughly half of the professors came from abroad, of which the overwhelming majority were German. Similarly, during these decades many of the school's professors, lecturers (*Privatdozenten*), and teaching assistants left for German universities and technical universities. Until 1900, about half of all students also came from outside Switzerland. In many years foreigners outnumbered Swiss students, sometimes markedly. Germans and Austrians were strongly represented, often constituting more than a quarter of the entire student body.[5] In the 1890s, the first German university calendars acknowledged the high level of student mobility by listing all the German-language technical universities.[6]

In addition to its good reputation and modern facilities, Zurich itself contributed to the strong cross-border appeal of the polytechnic institute. That the city also possessed a university was especially significant. From the very beginning, the two higher-education institutions had cultivated a very close if not conflict-free relationship that helped make the site on the Limmat River internationally competitive. In addition, Zurich was man-

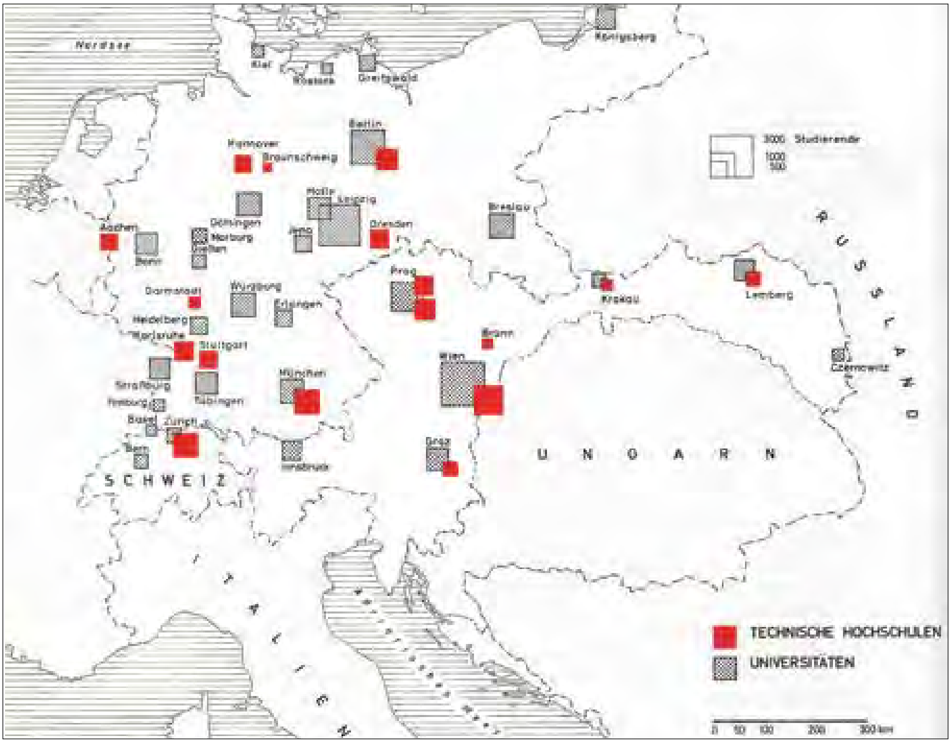
Figure 1: Students and the foreign student portion, 1855–2002



The proportion of foreign students at the ETH fluctuated wildly over the institution's 150-year history. At high point, in the early 1870s, two of every three pupils came from abroad. Over the hundred years that followed, this proportion declined steadily, dipping even more strongly in times of crisis and war. The rise since the end of the 1970s is due mostly to PhD students, who began to be tracked in 1973. The reasons for student migration are complex and cannot simply be explained by the attractiveness of the academic offerings in Zurich. Other factors that influenced students' decisions include conditions in the home country (lack of universities, political situation, and so on) as well as at possible alternate locations (quality of education, cost of living), plus travel, housing accommodation, and possibilities for return. Data: Leemann and Speich 2005b.

ageable and possessed of a politically liberal turn of mind, which mitigated the somewhat unsophisticated, petit-bourgeois aspects of the city of Zwingli.[7] The cost of living was relatively low, as were the school fees. The yearly tuition of 100 francs was, in the eyes of Frenchman Charles de Comberousse, "a trifle … Add to that the simple life, the affordability, the superbly equipped establishment." To enable Parisian readers of his 1879 book to picture Zurich, de Comberousse quoted a colleague at the Ecole Centrale: "Take Luxembourg, situate it on the hills of Montmartre, replace Paris with the lake, and you will have the school in Zurich."[8]

From the moment of its creation, the Swiss federal polytechnic was clearly a product both of German-speaking higher education and the specific social conditions of its location. The brisk activity of the institute unfolded against the backdrop of this dynamically evolving network of relations. It served to gather and store knowledge and make it available for a variety of purposes. The school's development was marked by the interac-



The Zurich polytechnic was an integral component of the German-speaking technical university landscape. In addition to the polytechnical schools and mining academies in Germany this included the Austrian polytechnics and the Russian polytechnic in Riga. The map shows the situation following the unification of Germany in 1871.

tion with the dynamically evolving spheres of federal policy, industry, and civil society. The remarks that follow below approach these relationships and their evolution along three axes of development that are central to the history of both Swiss and European society in the nineteenth century: the rise of the nation-state, of industrialization, and of the middle class.

FEDERAL CODES OF BEHAVIOR

Without the state, the development of higher education in the 1800s would have been inconceivable. Whether in Paris, Prague, Vienna, or the German states – polytechnics were top-down initiatives. In most cases the key role fell to the senior civil service. The state was not only the exclusive provider of technical education but also the major purchaser of trained engineers. The justification for the institutions varied little from place to place. With the exception of France, where the Ecole Polytechnique was erected in 1794 explicitly to prepare the future civil and military establishment elite, the main objective was always to encourage the domestic industry. In practice, however, as in France, training for the civil service came first.[9]

The Swiss federal polytechnic, too, was a state institution, though the state's founding and maintaining it was quite different from that of its counterparts. This difference profoundly influenced both the organization of engineering education and the young nation's symbolic inventory.

Federal education policy

At the time the Zurich polytechnic was founded, the institution of the Swiss federal state had only just emerged from the Sonderbund War of 1847. It was a republican, democratic, and federalist institution, imposed by the liberal, mostly Protestant victors of the civil conflict. Consequently, it continued to be rejected by the defeated Catholic conservative-dominated cantons even years later, and for a long time was also little admired in Protestant conservative milieus and, despite its federalist structure, anti-centralist circles of any kind.[10]

Unlike the foreign technical universities, senior civil servants played no role in establishing the Zurich polytechnic for the simple reason that they did not exist until well into the second half of the nineteenth century. In 1849 the federal government had 3,000 civil servants. Almost 90 percent were employed in the centralized national postal service, and a further 400 worked in customs.[11] The administration of the Department of Home Affairs, which had housed the polytechnic since 1854, consisted at the time of a single secretary.[12] The driving forces behind the school were not federal officials but leading federal parliamentarians, who because of their enormous influence on national policy were already ironically referred to as "federal barons."[13]

The scope of the federal government was initially quite limited. It was mainly responsible for foreign policy. Its domestic activities consisted in setting, implementing, and enforcing policy for the establishment of a single home market. Only when the constitution was overhauled in 1874 did the federal government gradually increase its reach and, as a result, begin to build a larger bureaucracy.[14] The Swiss federal state of 1848 was an inherently fragile and (in many regions and important political circles) a barely legitimate institution with meager competence or resources to offer. For this reason, creating a national polytechnic school implied a considerable expansion of the central government's sphere of activity. A glimpse at the federal budget in the 1800s shows that, for decades, the polytechnic constituted the third-largest line item. Whereas the greater share of federal government money – up to two-thirds – went to the military, only the allotments of the general administration and education (following the construction of the polytechnic in 1855) consistently exceeded 3 percent.[15]

Education and training assumed a central place in the self-image and worldview of the dominating liberals. A progressive education policy promised to emancipate the individual from ignorance and superstition and entitled him to lead a bourgeois life. Accordingly, as enlightened human beings, Swiss males would be responsible not only for themselves but naturally also for the well-being of society.[16] Yet from the outset, the founding fathers of the federal state met with fierce resistance from the cantons vis-à-vis education policy, to the extent that the 1848 constitution sharply curtailed national activity in the area. Only the abridged article on universities made it into basic law. General education remained the prerogative of the cantons. In this respect, the Swiss constitution clearly compared unfavorably with the German constitution, which was proclaimed shortly after, in March 1849, at Frankfurt's St. Paul's Church. The German statute provided not only for free primary school but also free instruction for the poor at all levels of education.[17]

In Switzerland, federal policy in the field of education remained a thorny issue. Regional powers perceived nationalized training to be a fundamental threat to their cultural and religious identity, and tenaciously defended the competence of the cantons to educate. Chief among these defenders were the Catholic minority, who in 1847/48 were dragged into the federation against their will. But linguistic minorities and Protestant conservative groups also were extremely wary of any centralizing of state authority. Progressive, liberal, and radical supporters of the federal state all saw a national education and training policy as a mechanism for eventually bringing all of Switzerland – even its most conservative and Catholic outposts – around to its way of thinking, and of nurturing younger generations of patriots. The complex debate in the spring of 1854, which ultimately led to the polytechnic's founding charter, gave a foretaste of the policy challenges ahead for the federal government.[18]

During the nineteenth century, federal policy succeeded in assigning a national supervisory function to federal authorities in certain areas. As early as 1849, a permanent inspectorate for public buildings was established. The constitution of 1874 marked an important turning point. Now, not only would the military be centralized, but new civilian opportunities opened up as well. Accordingly, a federal inspectorate of waterworks and forestry was created, followed by a factory inspectorate in 1878. On the other hand, the government's attempt to influence general education failed miserably. The introduction of an inspector of schools equipped with modest powers stood no chance with voters. Branded by its detractors as a *Schulvogt* (a derogatory term rooted in the Wilhelm Tell legend), the bill was roundly rejected by referendum in 1882. "Leave the guns to the national government, and culture to the cantons" went a slogan from the campaign for constitutional reform of 1874 that echoed long after.[19]

The position of the polytechnic as a federal institute was politically delicate. The close ties to the nation-state – itself still crystallizing – had several consequences. Not least, to some extent, the national government shaped itself through the polytechnic. The school became the nation-state's flagship both at home, and abroad, in a Europe dominated by monarchies. It was both a political object and an instrument of the federal authorities; it had to obey the federal norms and was, simultaneously, critical to its design process. It was at once a national school and a school for the nation.

National visibility

In his final work, *Die Schweiz seit 1848* (Switzerland since 1848), which appeared in 1928, the same year he died, the historian Eduard Fueter counted the establishment of the polytechnic among the greatest achievements of the national government constituted in 1848. Indeed, the school demonstrated that under the new national state lay the potential "to do more" than in the preceding period of Restoration.[20] In so stating, Fueter linked the destinies of the nation-state and its national school. His conclusion was not unjustified. Shaping the polytechnic enabled the Swiss nation builders to translate their political and societal ideals into practice relatively intact, while simultaneously making it possible for the institute to appear progressive, scientific, forward-looking, and patriotic. Through the polytechnic, the young federal state, which had few means of shoring up its own symbolic status, could portray itself in the right light.

In 1864 the main building of the polytechnic, designed by Gottfried Semper, was completed. The monumental structure, looming over the old city of Zurich, was the second federally mandated construction project after the Federal Council House in Bern.[21] With this "castle for teaching and the quest for truth," as Federal School Council president Karl Kappeler put it on the occasion of the institute's twenty-fifth anniversary, the involvement of the central government in the largest, and economically and politically most powerful city in the country could no longer be ignored.[22]

The polytechnic also had a visible role in shaping the government's scientific and technical infrastructure. In 1881 a Council of States committee called the institute a "creation that ranks among the greatest blessings of the period of the federal constitution of '48: productive in every area of life, it has directly and indirectly helped Switzerland to create a number of historic inventions. It has sowed a wealth of knowledge far and wide, and trained the intellectual forces of its own country in impressive numbers, in order to assume the engineering and commercial tasks of Switzerland, which formerly we had no choice but to confide to foreign talents."[23] The Council of States lauded not only the achievements of the polytechnic in educating engineering professionals, but also its "direct and indirect" contribution to building a national infrastructure.

In the early decades this consisted mainly in the consulting activities of the school and its professors, practiced in the service of the Federal Council, other political institutions, or even private companies. In correcting and improving waterways, building railways and roads, managing forests, and applying for patents, professors represented the polytechnic as experts.[24] Beginning in the late 1870s, some of these service functions for government and industry were organized into so-called annex institutions attached to the polytechnic.

The polytechnic represented the federal state not only domestically but also internationally, taking part in sundry world's fairs. In the second half of the nineteenth century,

Following its completion in 1864, the striking main building of the polytechnic sat regally over Zurich, which at the time had grown to around twenty thousand residents. The little house in the foreground is the then brand-new chemistry building. Engraving, 1875.

these fairs increasingly resembled national industrial exhibitions, and dating from the Vienna World's Fair of 1872, education had a regular place in them.[25] Above all, however, it was individuals who acted as ambassadors for liberal Switzerland. "As Swiss soldiers and officers once did, so today do Swiss engineers and businessmen fan out the world over, doing credit to the name of Switzerland even in the mountains of Abyssinia,"[26] wrote Wilhelm Oechsli solemnly in the 1905 Festschrift, enshrining the Swiss engineer in the formerly denigrated but now rehabilitated tradition of mercenary service. A sizable proportion of the individual advertising of the polytechnic and, by association, the Swiss liberal republic, however, was done by the school's foreign professors and students. Throughout the 1800s, for both categories, the number of Swiss and foreigners remained roughly in balance.[27]

This genuinely international character of the school gave rise to marked, increasingly aggressive nationalistic tensions.[28] This happened especially when foreign professors or student groups were negatively conspicuous, for example, in 1871, when the German community in Zurich raised the roof of the concert hall in celebrating the defeat of France and the unification of Germany, and in 1889, when Polish and Russian anarchists used the institute's chemistry laboratories as a bomb factory. As a result, identity checks of foreigners were made more stringent. The anarchist incident contributed to the rapid deployment of a federal secret police force that very year.[29] By the twentieth century, however, such emotional responses were unnecessary. Now the subject of

The civil engineering division's third-year class of 1862, portrayed in front of the newly constructed Wipkinger railway viaduct. In the background are the city of Zurich, the Lake of Zurich, and the Alpine foothills.

foreign students was more likely to come up in the context of "overfilled lecture halls," "overproduction" of engineers, or "creation of a proletariat of engineering disciplines"; when fears of competition from abroad arose; or when plans for improvement put pressure on perennially scarce financial resources.[30] The same arguments were put forth in Germany, in some cases leading technical universities there to double fees for foreign students in the early 1900s.[31] In 1908, the Federal Assembly's finance committee advocated a similar step for the polytechnic "on fiscal grounds." At the same time, the committee hoped to be able to "prevent too great a rush of troublesome foreign elements."[32] "It is obvious that, in view of the growing needs of the polytechnic on the one hand, and the increased services for students on the other, we might contemplate raising revenues by charging foreigners. Foreign – especially German – universities have set a good example," opined the Federal School Council in response to the proposal of the parliamentary committee before rejecting it out of hand: "We are unanimous in the view that the federal polytechnic should not follow." Compared with the substantial disadvantages of such a measure, the fiscal benefits would be marginal. "Among the foreigners there are always elements to be discovered whose influence on teaching and academic success is beneficial. We would not want to miss them." On returning home, they would spread the word about Switzerland. "What we gave them will flow back to us abundantly in manifold ways in the form of assets both material and intangible." It was a question of "sticking to our tradition, as we have done since the founding of the polytechnic, of treat-

Ethnic representation of the proportion of foreigners in a 1907 issue of the "beer newspaper" *Academie*. Of the nearly 1,300 students in the 1906/07 academic year, 40 percent came from abroad.

ing all students the same, regardless of nationality." Ultimately, such a practice would also be in the "political and economic interests" of Switzerland.[33]

The Federal School Council defended the institute's internationalism on the grounds of patriotism, the fertilizing effect of exchanges with foreign countries for their own country, and the gain in political capital abroad. As happened in selecting the academic canon and designing the curriculum, different nationalistic categories clashed on the foreign question. The relationship between the national roots of the federal polytechnic, the international standards of a top-flight technical university, and the universal ideal of science, which knows no boundaries, was and remained precarious.[34]

On being a federal institution

"An element of fundamental and essential complexity is the mixed racial composition of the Swiss Republic. German elements preponderate, but French and Italian must always be reckoned with; and this necessarily implies more than the obvious linguistic difficulties. Again, any federal institution must be influenced by mere considerations of locality; for example, in the choice of members of the federal School Council."[35] Thus did an American attempt to convey to his countrymen the singular aspects of the management structure of the federal polytechnic. As a national school, the polytechnic was subject to specific rules that, at the time, were designed and worked out to suit the federal political arena. This "federalism" became especially apparent in the administration of the school, but also left its traces in its multilingual instruction and course offerings.

As the highest authority under the government, the Federal School Council was inspired by the French "conseils de perfectionnement," but was sympathetic to the federal executive. Analogously to the Federal Council, the founding charter of the polytechnical school stipulated that every member of the School Council had to be from a different canton. Aside from this requirement, the rules for appointing the school councillors were the same informal ones that governed elections for the Federal Council. The federal government, which appointed the five (and, since 1881, seven) school councillors, had to ensure equitable representation of regions, religions, and languages. Also, beginning in 1881 there were the engineering disciplines to consider.[36]

The Federal Council chose the head of the federal court, Johann Konrad Kern, to be president of the first School Council. His vice president was probably the most influential politician of the time, National Councillor Alfred Escher, of Zurich, who (together with Kern) had played a key role in establishing the institution. The three remaining seats went to Geneva National Councillor Abraham Louis Tourte, Bernhard Studer of Bern, a mathematician – and friend of Alfred Escher – and physician Jakob Robert Steiger of Lucerne, a former national councillor and president of the Helvetic Society.[37] Tourte was a native French speaker, and Steiger was Catholic. When Steiger resigned in late 1854, he was replaced by another Catholic, National Councillor Augustin Keller of Aargau.

However, neither Steiger nor Keller was a representative of the Catholic conservative camp that held political dominion over the Catholic regions of Switzerland, especially the former Sonderbund cantons. Rather, both men were prominent politicians of radical tendencies and liberal Catholics who took a pronounced anticlerical and anti-Rome stance. On the eve of the Sonderbund War they had been among the most avid radical agitators.[38] The same was true of the Federal Council at the time. Two of the seven federal councillors were Catholics, yet staunch supporters of political and religious liberalism. In the 1860s the Federal Assembly diverged from electing liberal Catholics to the Federal Council, as it was only too obvious that the majority of politically active Catholics did not accept these men as their representatives. "We totally fail to see why two Catholics have to be elected, which makes nobody happy, since they are only so-called baptism-certificate Catholics," acknowledged the liberal *Neue Zürcher Zeitung* in 1863.[39] In the decades that followed, the liberals, who controlled the national government, concerned themselves less with religion in the distribution of political offices, a tendency that was reinforced in the "culture wars" *(Kulturkampf)*, which further accentuated the segregation between liberals and Catholic conservatives. Significantly, after the resignation of Augustin Keller in 1881, it would be a long time before another Catholic sat on the Federal School Council.

However, over the course of the 1880s, the Catholic conservative opposition at the federal level gained in strength. By frequently and successfully resorting to referenda, which ironically had been introduced to the constitutional revision of 1874 at the insistence of the radical democrats (left-wing liberals), the opposition managed to thwart liberal policy, the aim of which was to develop the federal state. In December 1891, the liberals, who held an absolute majority in both houses of parliament, decided to include the opposition in the government by electing Catholic conservative Joseph Zemp to the Federal Council.[40] Seven years later, in 1898, Lucerne cantonal councillor Josef Düring was named to the School Council, whereupon the Catholic conservatives had their first hand in directing the polytechnic. In another half a century, the scenario would repeat. The election of Ernst Nobs to the Federal Council in 1943 brought the social democrats into the national government for the first time. Two years later, the first socialist, Zurich city president Adolf Lüchinger, was appointed to the School Council.

As with the Federal Council, the School Council was headed by a president. But the position was much stronger than that on the federal executive.[41] Whereas the president of the Federal Council changed each year, the head of the School Council and his vice-president were appointed long term. The president was the sole member of the School Council who devoted himself fulltime to his duties, assisted by a fulltime secretary. He led the day-to-day business and chaired the meetings of the School Council. He was obliged to reside in Zurich, whereas his colleagues were generally in town only during meetings.[42] "This dispersion of the members naturally militates against frequent meetings or intimate knowledge of the school on the part of its members," criticized the American observer cited earlier.[43] In fact, his officially granted authority and the informal access to resources and knowledge gave the president of the polytechnic unprecedented power. Moreover, the tenure of the office was typically long. The five successors to Johann Konrad Kern, who left the institute in 1857 after three years to serve as the Swiss ambassador to Paris, remained for 16 years and more: Karl Kappeler (president 1857–1888), Hermann Bleuler (1888–1905), Robert Gnehm (1905–1926), Arthur Rohn (1926–1948), and Hans Pallmann (1949–1965). Each left his mark on the school. In comparison with the universities, academic self-governance and participation were de-emphasized. Kappeler was said to have presided "almost like a king in an intellectual kingdom," and Karl Schmid, professor of German literature and rector of the ETH in the 1950s, still characterized Rohn's time in office as an "enlightened monarchy."[44]

The School Council was not the only place where the polytechnic exercised its national duties. In the realm of teaching, an article on language in the founding charter of February 1854 already took into account the multilingual character of the country. Article 4 of the charter read: "The choice of German, French, or Italian as the language of instruction is left freely to the instructor." The commitment to linguistic federalism was an accommodation to the opposition, particularly of French-speaking western Switzerland, to centralized education. In contrast, the religious question so critical to Switzerland in the nineteenth century played hardly any role in shaping teaching at the polytechnic. Presumably the political and denominational "neutrality" of engineering made the institute unattractive for this debate.[45]

The actual implementation of multilingualism in the first national university left something to be desired, however. In the first academic year, instruction in French was given only in the division of general studies, in the offerings on French literature, economics, and business law. In addition, the course in differential and integral calculus, which in most schools was part of the first-year curriculum, was offered in German and French. The *Neue Zürcher Zeitung* showed its francophilic side: "We willingly admit that we would have liked to have seen more French among the instructors, not only to accommodate our French-speaking compatriots, but (and especially) because the French character better suits our nation than the German."[46]

Semper's magnificent building framed by escutcheons. The large emblems are those of Zurich and Switzerland, the smaller ones those of the other cantons. The integration of the institute in the federal political structure of Switzerland was much less organic than the image suggests. Postcard, stamped 1902.

In any event, 5 of the first 25 professors were native French speakers, 2 from the French-speaking part of Switzerland and 3 from France. In the following decades, however, the representation of French speakers among the faculty declined. Although the total number of professors continued to rise over time, with small fluctuations, and by the 1890s would exceed 50, both the number and percentage of French speakers diminished.[47] The year 1869 brought the death of Antoine-Elisée Cherbuliez, professor of economics, and in 1871 legal scholar Marc-Etienne Dufraisse left. Neither was replaced. After their departure, a mathematician and a French literature professor were the only two francophone instructors left.

During the institute's first years, the opponents of centralization, who had repeatedly warned of the "Germanization" of the polytechnic, felt both vindicated and betrayed by the faculty developments. As the 1860s opened, National Councillor Alfred Escher's casual mention of the old idea of a Swiss university sufficed to trigger a publicity campaign against the "Zurich railway barons" acting as "prospectors for German professors." "There is no major subject that a Swiss from the French-speaking part can study in his mother tongue. Indeed, it is even said that the few French instructors appointed earlier were quietly replaced by Germans," reported the Geneva press, and was supported by the Catholic conservative press. The *Schwyzer-Zeitung* referred to the "omnipotent Germandom at the polytechnic," and saw Zurich sinking "in the haze of the German refugee system," the university filled "with dreamers evicted from Germany."[48]

This perception was correct inasmuch as the two Zurich institutions, the university and the polytechnic, profited from the effects of the Restoration in the German states, which drove scientific brains such as Gottfried Semper and Friedrich Theodor Vischer into exile and raised an out-of-the-way, small town like Zurich to an attractive center of teaching and study. However, the dominance of "German" science at the polytechnic was also explained by the German academic system being open to scientists at Swiss universities. The French system, in contrast, was strongly nationalist and engaged in few activities abroad. Consequently, sabbaticals at foreign institutions appealed little to French scientists. Only defeat in the Franco-Prussian War, attributed by many contemporary observers to the substantially inferior French education and research system, made the country cautiously receptive to the idea of international exchange.[49]

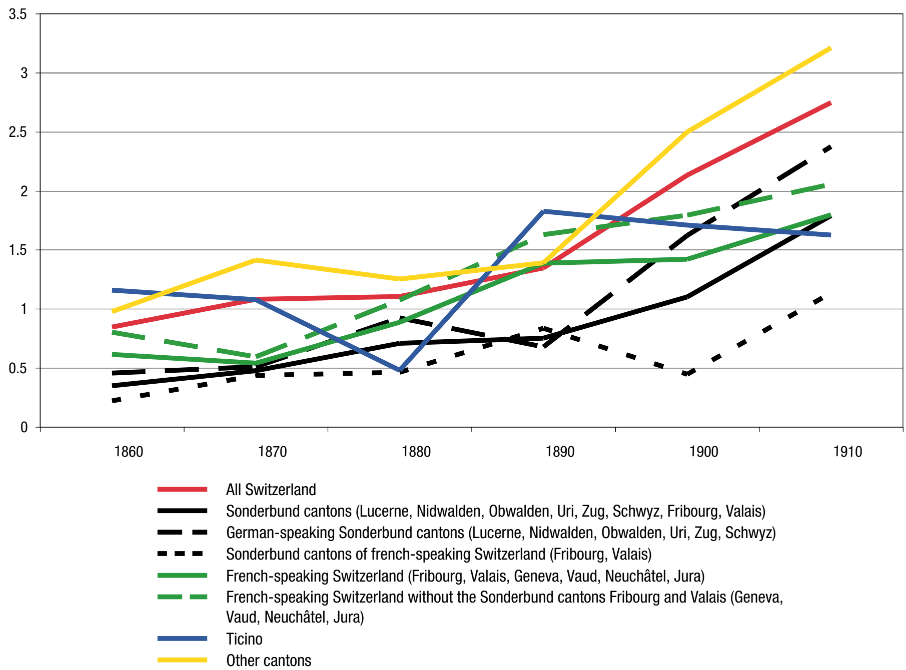
In 1869, polytechnic pupils from French-speaking Switzerland formed the Studentenverein Suisses Romands. In 1911, students from Italian-speaking Switzerland united to found the *Società Studenti Ticinesi*. During the same time period, the polytechnic also had eight foreign national clubs.

When, in the 1880s, the polytechnic was pressured from various sides to finally do something about the underrepresentation of the French, the school administration began to seek French teachers and students. In 1887 the Federal Assembly supported these efforts by raising the regular school budget by 20,000 francs, or nearly 5 percent, for the purpose of employing French teachers.[50]

The money from this dedicated fund made it possible to create two French-speaking professorships, as envisaged already in 1855: one in history and geography and also one in economics. Both were initially occupied by French scholars. However, after two French professors remained in Zurich for only a few years, the history professorship soon fell into Swiss hands. The French-speaking professorship targeted for engineering, on the other hand, was never realized.[51]

"Through its talented representatives", the polytechnic was eager to "encourage an invigorating exchange of French spirit, methods, and science with German spirit and science to complement the existing beneficial influence of the latter," wrote the School Council in its report for the Paris World's Fair in 1889.[52] It was unable to fulfill this promise. Right up to the twentieth century, the polytechnic remained an institute shaped by German science and German scientists. In the period between the two world wars, the school became increasingly nationalist. In the name of *Geistige Landesverteidigung* ("intellectual defense of the nation") patriotism, ideology, and the

Figure 2: Origins of Swiss ETH students, 1860–1910



Number of students at the polytechnic per 1,000 residents in the 20- to 24-year-old age group. In the first decade, pupils from the former Sonderbund cantons and the French-speaking part of Switzerland (especially) were underrepresented. Freiburg and Valais, both French, former Sonderbund cantons, accounted for the fewest pupils at the polytechnic. Data: Leemann and Kupper 2005.

"race" of teachers and students became a political issue even at the ETH, which in the 1800s had been so proud of its liberality and internationalism.[53]

Ultimately, the federal government's commitment to the polytechnic was reflected in its course offerings. Most of the costs of the institution, generally between 80 and 85 percent of the expenditures, were borne by the state. Because the financial needs of the school were steadily growing, every few years the board had to approach the Federal Council for an increase in the annual budget. This amount grew in several steps from an initial 150,000 Swiss francs to over a half million toward the end of the 1880s.[54] In 1892, the School Council asked the Federal Council to raise the government's regular yearly subsidy to the polytechnic by half as much again, to 800,000 Swiss francs. The board justified a portion of the request as being required to fund six new professorships, which required some explanation. With the 51 permanent professorial chairs it held at the beginning of the 1892/93 school year, the polytechnic was already the leader among its German counterparts. For example, in the same year, the technical university in Berlin had to make do with 37 professors, although its enrollment of over

Card celebrating the fiftieth anniversary of the polytechnic in 1905. The "discipline tree" growing out of the main building and festooned with divisional emblems had an unusually large number of branches for a technical university.

2,000 students and auditors was twice as high as that of the Zurich polytechnic. "The number of professors may appear large compared with that of technical universities of the same rank. But direct comparison is unfair, as our school has a much wider and more diverse range of facilities, which necessitates a larger faculty. The foreign universities have no divisions of agriculture, nor any division of teacher training of such breadth or so well equipped, to make it equal to a university faculty of mathematics and science; no outside school can claim a philosophy and economics division of the same rank as the VIIth division of our polytechnic; and none has to be concerned about teaching in two national languages," explained the School Council in its petition on the matter. In terms of staffing the engineering division, the Zurich polytechnic was said to lag behind the leading foreign technical universities. The situation would have to be remedied if Zurich wished to maintain its rank among top-flight schools internationally.[55]

The evidence the School Council gave for the diversity of its academic offerings was hardly exhaustive. Among the Germanic states, only Karlsruhe offered a course in forestry, and very few German schools of technology trained rural engineers and pharmacists. Zurich was unique in offering military science at the university level.[56] In short, within the German-speaking university landscape, the Zurich polytechnic was a standout. Together with the four core engineering disciplines – structural, civil, mechanical, and chemical engineering – it offered a colorful palette of other fields. Some of these divisions were part of the school from the outset: forestry, pharmacy, and philosophy and political science. Others were introduced in subsequent decades. In 1866, mathematics and science were upgraded to a single "division of teacher training." In 1871 the polytechnic added a division of agriculture, in 1878 a military division, and in 1888 a division of rural engineering.[57]

The traditional impetus for the development of the polytechnic institute was the interest of professional organizations, the Swiss teachers' association, agricultural organizations, and the military, who addressed their concerns directly to the Federal Council. The school administration was not always sympathetic to such concerns. The board rejected the initial proposal for military and agricultural divisions. Both eventually came about only after a number of failed attempts. Agriculture finally won acceptance as an appropriate and worthy field of university study in the wake of the contributions of Justus von Liebig to agricultural chemistry in the 1860s. The military division, on the other hand, had its origins in the revised federal constitution and the reorganization of the military that took effect in 1874, after the institute had repeatedly refused to expand its courses beyond voluntary offerings within the division of general studies. Military instruction was thought to be poorly compatible with the international orientation and academic culture of the polytechnic. The first professor of the military division, General Staff Colonel Emil Rothpletz, experienced this attitude firsthand. In his memoirs, he complained about the "hostile mood of the professors."[58]

For the increasingly nationally organized professional organizations, the polytechnic, the only federal higher-education institution, was an attractive address to which job-specific training needs could be directed. Inasmuch as the polytechnic accommodated these needs, and to some extent had to, as in the case of military sciences, it simultaneously strengthened its position as a national school. However, the institute had to be careful that in rounding out the canon of academic disciplines, it did not degrade its own standards for teaching and, increasingly, research – especially in view of its aim to compete internationally, especially with the leading German technical universities. When, in 1882, the Swiss parliament sought to clarify the question of "whether the agricultural school at the polytechnic couldn't be made more useful to the country's farmers," the School Council replied: "According to the founding charter the agricultural division is a distinctive scientific institution without a farm attached. This structure must be maintained in the future."[59]

A school for the nation

The significance of the polytechnic lay not only in its power to make its influence felt throughout the state as the only national school. By initiating, supporting, and strengthening practical nation-building projects, it also functioned as a school in the art of confederation. The design of admission requirements, programs of study, and degree certificates were the channels through which the polytechnic had an integrating and homogenizing effect throughout Switzerland. Admittance and curricula will be treated here, and certification will be covered in a later section.

In autumn 1855, the first school year opened with 68 students. Most of them had completed a 19-week preparatory course during the summer. A few had qualified directly through the entrance exam, which was held in October 1855 under the direction of Director Deschwanden in Bern, Lausanne, and Zurich. The regular students were joined by 101 auditors. These enrollment numbers were considered a success; certainly they exceeded the expectations of the federal authorities and committees prior to the institute's founding.[60]

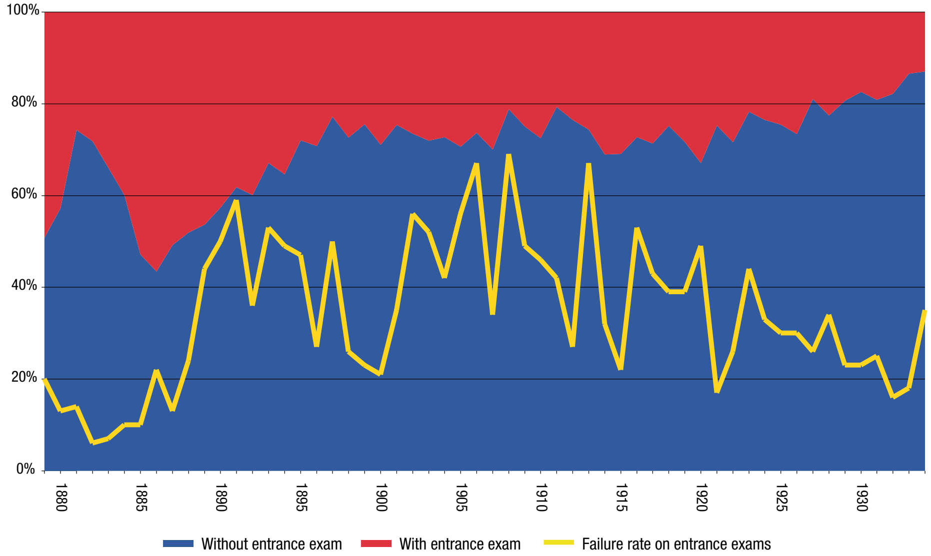
In the following year, advanced courses were added, thus nearly completing the full offering of planned programs; however, growth remained modest. The number of students rose only by 25, to 93, which did not augur well for further development. In 1857, enrollment stagnated at 94, and in 1858 increased only slightly to 109. Coming so soon after the initial expansion, this turn of events was worrisome. The ratio of tenured professors to official students, of financial outlay to yield in terms of education policy was obviously a situation that over time became harder to justify as initial start-up difficulties.[61]

The School Council was accordingly alarmed. It blamed the trouble on the polytechnic's overly strict admissions policy.[62] The school's determination to provide engineering education competitive with that of any comparable university, and to require its entering students to have the appropriate background, collided with the realities of Swiss education. The many young people who were or could be interested in such a university were inadequately prepared for it. The tension between recruiting, selection, and level of instruction was to haunt the polytechnic throughout its history, and now and again to flare up. How could existing or additionally available means best be used to recruit an appropriate number of pupils or students, and to select candidates, to reach and maintain a desired level of instruction? This, then as later, was the core question.

By the end of the 1850s, it became clear that enrollment had to increase. The School Council took measures at several levels. First, it revised the barely three-year-old admissions policy. These regulations stipulated the prerequisites for acceptance to the polytechnic separately for each division. In 1859, the number of examination subjects was reduced from between ten and twelve, to between six and seven.[63] The remaining requisites included "good oral and written expression in one of the three national languages (German, French, or Italian) and the ability to follow instruction in the two other national languages, to the extent that compulsory education is taught in them. In addition, … an all-around knowledge of elementary mathematics and geometry, trigonometry, and the elements of analytic geometry and analytical algebra, the fundamentals of descriptive and solid geometry, basic physics, chemistry, mechanics, and natural history, as well as skill in line and freehand drawing." Additional requirements included "age greater than 17, a satisfactory certificate of previous studies, and good manners."[64]

The entrance exams were a welcome tool for managing enrollment. Not only would the admissions regulations be repeatedly tightened beginning in 1867, but as the number of candidates increased, so did the rejection rate. "In terms of admission, the practices of the early years must be distinguished from current ones," wrote the School Council in 1879. "As the rate increased … greater rigor was applied." In international comparison, the Zurich polytechnic's qualifying exams were recognized as demanding. Indeed, in 1906, fear of the exam led future ETH professor and Nobel prize winner Leopold Ruzicka to enroll not in Zurich, but in Karlsruhe.[65]

Figure 3: New matriculation, with and without entrance examination, 1879–1934



By 1900, with the gradual recognition of credentials from Swiss and foreign secondary schools, the proportion of students spared entrance exams to the polytechnic had risen to 60–70 percent. Failures on the entrance exams kept pace with the number of applications. Data: ETH annual report.

As a second measure, in 1859 a preparatory course was re-introduced whose previous one-time implementation in 1855 had resulted in numerous registrations. The new course was year-long and focused on fundamental mathematics and science as well as German and French. Owing to the dominance of mathematical subjects in the curriculum, it was known as the "mathematical prelim" and quickly became popular. The course was attended by a total of 1,734 pupils before it was discontinued in 1880. Around two-thirds of them came from abroad. In its heyday at the beginning of the 1870s, the course had over 120 enrollees. One out of three pupils spent at least a year cramming in mathematics and other basic subjects.[66]

The third measure, introduced by the School Council at the end of 1858, had the greatest long-term effect. In 1859, the board president made a deal with the ministers of education of selected cantons with their own secondary schools – i.e., gymnasiums, industrial, or vocational schools. From then on, the diplomas from these institutions would guarantee exam-free entry to the federal polytechnic. In return, the schools would have to fulfill several conditions. First, they would be required to adapt their curricula to the requirements of the polytechnic; second, to schedule their school-leaving qualification as close as possible to the start of the school year in Zurich; and finally, to allow members of the polytechnic to participate as experts in their exams. The intention of the School Council in setting this third condition was to ensure that the secondary schools complied with the prerequisites of the polytechnic. In 1860 the first of these agreements were concluded with the *Kantonsschulen* in Frauenfeld and Aarau, the *Realschule* in the city of Bern, and the Academy of Geneva.[67]

These measures were the polytechnic's way of exerting indirect pressure on the cantonal secondary schools by suggesting which technical subjects should be taught. The introduction of the preparatory course was hotly debated in the national parliamentary chambers. It was labeled as interfering with cantonal autonomy in school matters and was approved by only a narrow majority.[68] As a network of participating schools became established, the polytechnic was increasingly involved directly in the design of secondary school education, and by extension encroached upon the domain of the cantonal authorities. Some of them were none too pleased. Zurich, Basel-Stadt, and St. Gallen indignantly rubuffed the advances of the polytechnic in 1860 as "*Bevogtigung*" (an Ancien Régime kind of paternalism).[69]

The polytechnic launched a whole series of often tough negotiations that dragged on over half a century. "Many roads lead to Rome," asserted School Council president Kappeler in 1872: "Advanced engineering studies should not strictly be contingent on unbroken school attendance beginning at the age of 6 or 7 and ending at the polytechnic."[70] However, the secondary school-leaving certificate (*Matura*) did increasingly serve as an admission ticket. Indeed, the proportion of pupils granted free access sank again in the 1880s after admission requirements were increased in 1881 and, concomittantly, existing agreements with secondary schools were suspended.[71] Subsequently, however, as new agreements were made, and equivalent French, German, and Austrian qualifications were recognized, the quota shot up quickly until the 1890s, before plateauing for a long time. During these decades, two-thirds of aspirants were able to make it into the polytechnic without having to pass exams.

Dealing with the cantonal school system proved an enduring challenge for the federal institute. It was well worth the trouble, however, as the polytechnic managed to bring an increasing variety of secondary schools in line with its needs. At the same time, the exertions also had a major homogenizing effect on cantonal schools all over the country. The upshot was a veritable invasion of federal educational policy into the strongly protectionist cantonal school system. By the end of the century, bolstered by a provision for a standard medical school entrance test incorporated into the federal regulations governing the *Matura*, the School Council managed to establish at least a few binding norms within the "almost chaotic diversity" of the Swiss school system.[72]

In the training of teachers, beginning in 1866, the polytechnic disposed of an additional mechanism for imposing its vision of education in mathematics and science on the cantonal schools. How effective it was at turning the products of those schools into engineering graduates is hard to discern. Still, as with the polytechnic's admissions policy, its centralized training of no small number of secondary school teachers may also have had a homogenizing effect that ultimately worked to its advantage.

In the winter semester 1895/96, 209 students were granted exam-free entry to the polytechnic, 81 successfully passed the tests, and 47 failed. One of these 47 was Albert Einstein. Although at 16 he had not yet attained legal age, a special permit arranged by a family friend enabled him to take the exam, but he failed languages and history. He then attended the *Kantonsschule Aarau*, one of the polytechnic's contract schools, where he passed the leaving exam (*Matura*), which enabled him to transfer to Zurich the following year without having to go through the exam process again. In 1900 he completed his studies with a teaching certificate in mathematics. In 1912, he returned to his alma mater as professor of physics, only to leave two years later for Berlin.

Similar practical difficulties arise in dealing with the question of whether the polytechnic was a breeding ground for a nineteenth-century national elite. Did the institute populate the emerging federal institutions with leaders? A comprehensive analysis would require systematically evaluating the biographies of graduates and reconstructing the recruiting policies of government institutions. However, even a cursory perusal of the collected biographies of federal councillors and parliamentarians along with a study of contemporary reports suggests a number of interesting conclusions.

Study at the polytechnic appears to have led relatively rarely to a political career at the national level. In 1908, Josef Anton Schobinger (1849–1911) was the school's first graduate to become federal councillor.[73] Of the nearly 1,400 federal members of parliament elected between 1848 and 1919, only 40 had attended the polytechnic. In order of rank as a place to study, Zurich came first, with 239 former students (199 from the university plus the 40 from the polytechnic), followed by Heidelberg (222) and Munich (170), and finally Bern, with 164 former students. Eight hundred and ninety of the nearly 1,500 parliamentarians had completed higher education. Two-thirds of them (607) were lawyers, followed by physicians (86). Up to 1919, engineers and natural scientists together numbered 90: 38 engineers and surveyors, 18 foresters, 11 natural scientists, 10 agronomists, 9 architects, and 4 pharmacists. Theologians (25) and social scientists (16) were decidedly less well represented than engineers and scientists. However, they were all far outnumbered by the nonacademic entrepreneurs and businessmen (214), workers and craftsmen (108), and farmers (92).[74]

Only 2.7 percent of all the national councillors and states' councillors to sit in the Swiss parliament from 1848 to 1919 – and 4.5 percent of the academics – had attended the polytechnic and, later, ETH.[75] Thus, it can hardly be said that the polytechnic was a finishing school for the political leadership of the nation. On the other hand, clearly a growing number of Switzerland's engineering managerial elite were a product of the institute. For the time being, given its limited sphere of activity, the government itself had no huge demand for trained engineers. Nonetheless, in 1871 polytechnic graduates assumed two important posts in the military administration: Colonel Hermann Bleuler, later president of the School Council, became chief artillery instructor, and a captain named Gressli was employed in the military laboratory in Thun. In the same year, canton Solothurn had filled a number of positions with polytechnic graduates, including four of six foresters, an unspecified senior official, two professors at the cantonal school, the head of the teachers' college, the engineer for the canton and his assistant, the provisional cantonal architect, and the land registry surveyor.[76] However, this concentration of "polytechnicians" in a cantonal administration appears to have represented the exception rather than the rule, and was probably due not least to the influence of then Solothurn cantonal councillor Hermann Dietler, who had graduated from the institute in structural engineering in 1860. Indeed, two years later, the bulletin of a newly founded society for former polytechnic students lamented "that in Switzerland, in particular vis-à-vis the cantonal governments, the career education that can be acquired at the federal polytechnic is not yet accorded the respect it deserves, insofar as experienced old hands are often preferred for state jobs over capable, scientifically trained engineers armed with diplomas from the institute."[77]
Similar statements crop up repeatedly in the subsequent period. They are an expression of both the demands made by polytechnic students in ever-greater numbers and with growing self-confidence regarding their skills, and the resistance they encountered. The relationships between the polytechnic, industry, and society are the subject of the following sections.

INDUSTRIAL STANDARDS

Innovation, increased efficiency, optimization – these were the future-oriented concepts at the heart of the industrialization process that helped to define the "long" nineteenth century. In the wake of the Industrial Revolution, economies grew quickly and permanently, if not continually. Moreover, mechanization, greater division of labor, and increased investment led to ever-changing industrial forms of production. All these factors created a demand for practical knowledge.[78] Handicrafts and cottage industries began to lose ground to factories, and the industrial sector displaced agriculture as the main employer. Urbanization and new technical equipment changed day-to-day life

Sulzer Brothers, a Swiss locomotive and machine factory, and the Rieter company in Tössfeld, near Winterthur. The manufacturing family Sulzer cultivated contacts with the mechanical engineering school at the polytechnic.

rapidly, and forever.[79] The railroad, the telegraph, and the sewing machine became the symbols of a new age. The technical universities represented the future as well.

The apparently simple question of precisely what role the federal polytechnic played in the economic development of Switzerland is not so easily answered. It is, however, nonetheless clear that the polytechnic was conceived and perceived as a true engine of the economy. Myriad reciprocal relationships were set up between industry and the polytechnic that, in turn, influenced the rapid technological and organizational change taking place in both.

Technical training and industrial growth

The nineteenth century itself assigned the universities and technical universities a major role in the industrialization process. The hope was that a standardized, advanced system of engineering education would deliver the steady flow of expertise and experts required to fuel a similarly steady and progressive rise and improvement in production, ultimately laying the groundwork for better living conditions for all. From the very beginning, the conceptual blueprint for the federal polytechnic emphasized applied knowledge. Students should not only learn theory but also gain “practical professional” experience “keeping in mind the particular needs of Switzerland.”[80]

The high expectations placed on education derived from the powerful conviction (rooted in the Enlightenment and enshrined as liberal doctrine) that, in principle, any phenomenon in the universe could be grasped intellectually, investigated scientifically, and mastered technically. Related to this was the strong secular belief in the directed development of history that holds in store a more human future: a rationally organized world in which individuals would move freely and independently. In the nineteenth century, "progress" became a leitmotif and keyword for this worldview that also stood for world appropriation. Liberal ideology and interest in scientific knowledge were mutually beneficial. Nowhere, the argument went, could the progress of mankind be better asserted than through the achievements of technology and science. Scientific advances validated liberalism and, at the same time, justified the substantial sums that liberals were plowing into the sciences.[81]

Though expectations for science and technology in the first decades of the nineteenth century were grounded more in philosophical reflections than in real observations, by the end of the century, contemporaries considered them confirmed, based on developments that had occurred in the interim. In particular, the rise of Germany from 1870 to a leading military and industrial power in continental Europe was credited to its superior educational system. The Prussian model of instruction, the Humboldtian university, and the applied institutes of technology all attracted the interest of the industrial nations and became an international benchmark that other institutions imitated and measured themselves against.[82] The motto "Knowledge is power" became a mantra at the national level, and education was recognized as a critical factor in social-Darwinian competition. Support of domestic industry through public investment in engineering education could be justified nationally. At the end of the nineteenth century, the Prussian minister of state expressed the essence of the interrelationship concisely: "Economic power is the basis of political power, and no economic upswing is possible without engineering expertise."[83]

Until well into the twentieth century, researchers of history and sociology of science accepted more or less uncritically the attribution of Germany's military and industrial success to its school system.[84] At the beginning of the 1970s, Peter Lundgreen tried but failed to prove the connection empirically using a macroeconomic model.[85] Later efforts abandoned this methodologically unproductive approach and attempted to capture more concretely the relationship between the educational system and industrial growth at the level of training institutions and companies. Consequently, claims about the growth-promoting effect of educational institutions became more cautious. "It became increasingly difficult to conceive of education as having in any significant sense a direct causal effect on industrial performance," concluded the editor of a recent collection of essays titled *Education, Technology, and Industrial Performance in Europe, 1850–1919* regarding previous research.[86]

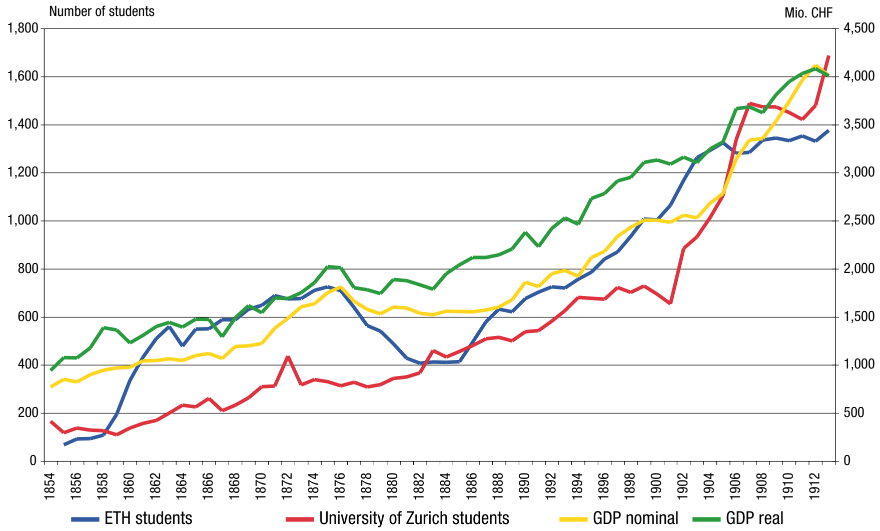
Indeed, the causal relationship is probably the reverse: then as now, economic growth stimulated the expansion of educational systems. On the one hand, increased gross national product and government revenues led to greater expenditures for schools and education. The education sector received not only more resources generally, but in the long term also increased its share of the national economy and state budgets. Statistical data even suggest that academic science institutions grew faster in the preceding two centuries than most other private and public institutions.[87] On the other hand, as wealth increased, so did the share of household budgets in excess of basic material needs. Even accepting that nineteenth-century gains in prosperity were unequally distributed, broad segments of the population – especially the lower middle-class – became increasingly willing to invest in their own education, and in particular that of their sons. The hope was that the educational capital acquired would pay off financially and socially.[88]

The economic boom-and-bust cycles of the nineteenth century affected the technical universities more than the general universities.[89] It is worth considering this difference in the context of the long depression of 1876–1884. The number of students attending Swiss universities grew over this period, but by the mid-1870s, enrollment at the federal polytechnic had slowed. The 1877/78 school year marked the start of a sharp downward trend that bottomed a decade later. In the mid-1880s, only 400 pupils registered for the regular program of study at the polytechnic, corresponding to slightly more than half the 1875 peak of 725. Thus the polytechnic lost the position it had held for two decades as by far the largest university in Switzerland. From 1880 until the outbreak of the First World War, its share of students remained relatively stable at around 20 percent.[90] The numbers reflect the fact that the decision to study at the polytechnic was more tightly tied to economic conditions and the job market than the decision to attend university. This judgment is supported by the breakdown of enrollment figures by division. The heavy industry- and trade-related faculties were especially hard hit, in particular the crisis-sensitive construction-oriented civil engineering school, whose enrollment tumbled from 300 in the winter semester of 1874/75 to under 100 in the years between 1882 and 1885.

Nor were the fluctuations purely a Swiss phenomenon. The "Long Depression" was the first global economic crisis; the subsequent recovery phase culminated in the first global boom in the 1890s.[91] This international and global networking of economies was also reflected in the domaine of the university. The ebb and flow of students to Switzerland and Germany was remarkably similar, with the same differences between universities and technical universities repeating across borders. If, during the depression years, the number of foreign enrollees to the federal polytechnic plummeted more quickly than did the native Swiss, it was because foreigners were overrepresented in the beleaguered civil engineering school. Indeed, in the winter semester of 1874/75, 42 percent of all polytechnic pupils were civil engineers (300, of which 195, or 65 percent, were foreigners). A decade later, the percentage had decreased to 22 (90 pupils, among whom 58, or 64 percent, came from abroad).[92]

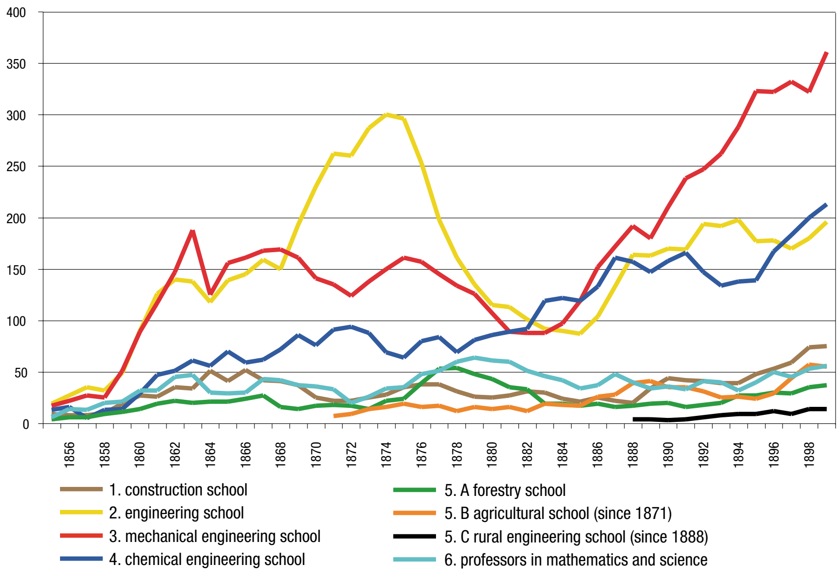
In the recovery that followed, enrollment at the polytechnic increased less rapidly than at the German technical universities. Between 1886 and 1900 the number in Zurich doubled, whereas in Germany in the same period it quadrupled. One cause of the slowed growth was that, in the 1890s, the number of foreigners at the polytechnic began to stagnate, and their proportion among the student body fell from 50 to 40 percent. The

Figure 4: General economic trends and enrollments at the University of Zurich and ETH, 1854–1913



The economic situation had a significant impact on enrollment at the polytechnic, which plummeted following the Long Depression of 1876 onwards. In contrast, during this period the University of Zurich gained students. Data: Siegenthaler 1996; Leemann and Speich 2005a.

Figure 5: Students by discipline, 1855–1899



The decline in enrollment during the Long Depression breaks down differently depending on the discipline. The engineering school, which obviously felt the effects of the collapse of the building sector, was hit hardest. Data: Leemann and Speich 2005a.

reasons for this change are difficult to determine. Improvements in engineering training in many European countries may have played an important role.[93]

All these developments can be summed up as follows: First, university education depended on economic growth: enrollment at the technical university was acutely sensitive to vacillations in the economic climate and the job market. Second, and by the same token, from the vantage of current research there is no proof that the expansion of technical education and scientific research in the nineteenth century had a generally positive effect on industrialization, though neither does it rule out that in certain areas and cases fruitful interactions may have resulted. Third, at any rate, the discourse was dominated by the view that precisely such a generally positive effect would result, or already existed. This conviction legitimized the continuously flowing and regularly increasing stream of public funds for the operation and expansion of educational institutions. Finally, and accordingly, industrial – and initially also commercial – production formed a gravitational nexus for debates over direction, content, and design of polytechnic education and research.

Employment and educational credentials

Owing to the strong dependence of enrollment on the job market, a successful technical educational institution had to be particularly attentive to the opportunities available to its graduates. What avenues did study at a polytechnic in the nineteenth century open? To what extent was it adequate preparation for a career in industry? What could one do with a certificate? How much did grades matter? And what was the polytechnic's diploma worth?

In the last quarter of the 1800s, the number of Swiss employed in the secondary sector (trade and industry) was slightly over half a million. During this period, the polytechnic was graduating between 100 and 300 students a year. A glance at the GEP (*Gesellschaft ehemaliger Polytechniker*, the alumni association) membership lists suggests that around half of them found jobs abroad. In contrast, a portion of those who remained in Switzerland went into public service as civil servants or teachers. A few are also likely to have found a livelihood in the primary sector – agriculture and forestry. As a result, rarely did the number of polytechnic graduates finding jobs in Swiss industry come close to or exceed 100 per year.[94]

Although competition among graduates was accordingly probably less than intense, the move from lecture hall to factory was not always easy. Among the first activities of the GEP was to establish a placement service for its members. This service was subsequently extended – at great expense – beyond the Swiss border. But the yield was modest, and the placement service remained "a perpetual headache" for the organization. In 1878, between 204 letters received and 241 sent, the service managed to achieve a mere twelve placements. Only after 1900 did the yearly average of successful placements reach over fifty.[95]

For its part, the labor market demanded a high level of mobility and career flexibility. For example, with the subsiding of the first railway boom in Switzerland in the mid-1860s, many structural engineers were forced to change jobs or to look for positions abroad. As Hermann Dietler reported in 1871, that meant accepting poorer working conditions and wage losses.[96]

Nonetheless, in the nineteenth century, unemployment was not an issue for graduates of the polytechnic. This, however, did nothing to alleviate the flow of complaints about the professional standing of engineers. The most significant communication of this nature – and one that triggered the most far-reaching reform of the polytechnic up to that point – was a petition that the GEP addressed to the Federal Council in 1877. In it, the association expressed its dissatisfaction with the treatment of trained engineers and declared that these grievances should be addressed by reforming the school.[97] In dealing with the proposals, the School Council cautioned against false hopes: "As a free and republican country, Switzerland of course wishes to provide the best facilities to enable its citizens in all areas of human activity to obtain the preparation required to perform to the utmost of their capabilities; but the republic is hardly equipped to postulate the rights of preference and exclusion of one well-recognized educational background over another … Indeed, what should be recognized is unfettered open competition. What matters is a person's ability to perform; how he came by this ability is a secondary question. The man, his talent, his energy, and his ability to choose are more important than their method of attainment. In principle, this is how it will remain in Switzerland, especially for engineers."[98]

From this perspective, the job placement difficulties encountered by the GEP appear in a different light. The most important qualification for an industrial job in the nineteenth century was practical experience; educational trappings and school credentials gained in significance only gradually. Career possibilities within a manufacturing company, and also in public service, were not rigidly defined. Technicians who had only attended a technical secondary school or who had no formal engineering training at all could still advance to a position of "engineer" or "chief engineer."[99] Even the *Schweizerischer Ingenieur- und Architektenverein* (Society of Swiss Engineers and Architects, SIA) founded in 1837 – barely twenty years before polytechnic – accepted them. Only in the slump of the early 1900s did the university engineers begin to draw a clear line between them and their less-educated colleagues.[100]

Tellingly, during the polytechnic's first fifty years, a diploma was just an enhancement to the *Matura*, and not a full-fledged degree.[101] Both within Switzerland as well as abroad, for those who earned it, the diploma was "only of indirect value. It is a recommendation," as Hermann Dietler put it in 1871.[102] Throughout the nineteenth century, less than a third of all graduates, or around 40 percent of pupils of the graduating class, obtained the diploma.[103] The difference was due to many pupils not completing the full course of study, quitting early either to carry on their education elsewhere or to enter or return to the working world.

Abgangs-Zeugniss.

Fächer.	Lehrer.	Noten.		Fächer.	Lehrer.	Noten.	
		Fleiss.	Fortschritt.			Fleiss.	Fortschritt.

Bemerkungen:

Expedirt den 6. August 1881.

DIPLOM als:

laut Beschluss des schweizerischen Schulrathes

dat.

The flawless transcript of Aurel Stodolas, dated 1881. Transcripts provided details of subjects, teachers, and grades for diligence and progress. They also included remarks on moral conduct and, for successfully passed final exams, the stamp "Diplom."

Courses leading to professions whose exercise required passing a government exam represented a special category. Although technical professions such as engineering, architecture, mechanics, and so on were not regulated, at the end of the 1860s, surveyors, foresters, and pharmacists were all required to have government permits whose acquisition and scope were determined by cantonal legislation or intercantonal concordats. During the First World War, the responsibilities of all three fields shifted in the direction of the federal government.[104] To support the shift, permits were coordinated with the courses at the polytechnic. Swiss students wishing to be licensed pharmacists would complete their training not with a diploma from the polytechnic but with the federal exam, whereas foreigners, who were denied the federal exam, could obtain a diploma. For surveyors and foresters, harmonization was a longer and more complicated process. In 1873, the Bern cantonal surveyor opined: “It happens not rarely that people who have graduated from the polytechnic still have very little experience in surveying and whatnot, so that it often seems a little risky to put them at the same level as certified government surveyors.”[105] Foresters as well as surveyors and rural engineers were thus required to supplement their academic work with field experience through a traineeship subsequent to their studies. With respect to teaching, the polytechnic and, later, the ETH soon developed a stellar reputation in these fields.[106]

The effectiveness of diplomas and certificates in opening career doors for their holders was a crucial factor in making the polytechnic an attractive place to train. For this reason, the school had to ensure that the educational capital accumulated through its courses was both exclusive and transferable to the factory.

Part university, part manufacturing plant

Curriculum design at the polytechnic should “preferably be based on the Swiss industrial sector, the needs of Swiss manufacturers, and the current requirements of mathematics and the natural sciences at such an institution,” read the report of the committee that drafted the first guidelines in 1854. The purpose of the polytechnic would thus be twofold: to prepare students for the real world while at the same time maintaining its character as a university.[107]

In other words, teaching at the polytechnic had to contend from the outset with the conflicting priorities of academy and factory. Since at mid-century these two poles (reflected in the terms “theory” and “practice” or “empiricism”) were far apart, fulfilling the polytechnic’s stated mission would prove a difficult balancing act. What was theoretically interesting was frequently irrelevant to manufacturing; moreover, the polytechnic’s lecture halls were ill-suited to training in applied industrial processes. The quest for appropriate forms and techniques of approaching and analyzing industrial practice has been a constant in the development of the federal polytechnic. Before the end of the 1800s, when the laboratory became established as a place for teaching the scientific method as well as industrial manufacturing, several generations of professors and lecturers, current and former students, and school councillors and politicians had struggled to resolve the dilemma. Going by the record of their efforts, the path to the laboratory was a tortuous one: they felt their way in fits and starts. Teaching alternated between theory and practice, whereas research only gradually became an integral feature of the polytechnic. The institution seemed to be heading in two directions at once.

The founders of the polytechnic and its first administration under School Council president Kern had always attached great importance to the idea of being a university. This bias was reflected in the relatively stringent entrance requirements, the importance placed on scientific subjects, and the emphasis on general education, as well as in the initial appointments. In making the latter, the polytechnic contracted an agreement with the two-decades-old University of Zurich. Joint professorships were established for several subjects. The arrangement was beneficial to both institutions since their respective strengths compensated for their shortcomings – the polytechnic's lack of academic reputation and the university's insufficient funds. The financially better off polytechnic assumed the greater portion of the costs, and the university shared its academic prestige. Between 1855 and 1857, fifteen professors were hired according to this scheme, primarily in the sciences.[108]

The marriage of mind and money was short-lived, however. Under Kern's successor, Karl Kappeler, the polytechnic began systematically to discard its ties to the university. In 1863, students of the university were restricted access to lectures at the polytechnic. Many of the joint professorships, once vacated, were left unfilled. The reason given by Kappeler was that the professors were too little involved with the affairs of the polytechnic. Specifically, they were more committed to science at the university than they were to teaching at the engineering school. Moreover, in chemistry, for instance, they ignored the link to industrial manufacturing.[109] By 1880, the number of joint professorships was cut in half; their share among all the professorships at the polytechnic dwindled from 40 to 15 percent.[110]

The break was particularly hard for the university, which trailed the polytechnic in mathematics and science.[111] Not only could the federal institution pay higher salaries, but, more important, it offered a much better teaching and research infrastructure. Accordingly, in the 1880s, after the polytechnic had constructed a new chemistry building, the university's chemistry division had to be satisfied with its neighbor's old facility. The polytechnic, on the other hand, could now gear the formerly joint professorships exclusively to its own needs. The one major disadvantage was the loss of the university's lustre. It was only well into the twentieth century that a chair at a technical university could claim the same academic and social cachet as its humanistic counterpart.[112] Mainly for this reason, during the last quarter of the nineteenth century and the beginning of the next, the polytechnic continued to have difficulty in attracting up-and-coming scientists and more especially, mathematicians. Chemist Victor Meyer, whom Kappeler had lured to Zurich from the Stuttgart polytechnic in 1872 and who defected in 1885 to the University of Göttingen, called the polytechnic "a first-class academic waiting room."[113]

The newly emergent technical universities in the German-speaking academic world of the 1800s had a status problem not only in that they harbored disreputable technical disciplines but also because they refused to surrender to the dominant Humboldtian ideal of pure science. On the other hand, they were accused by industrialists and politicians of lacking in practical relevance. This discourse had institutional consequences: Beginning in the 1870s, both Germany and Switzerland experienced the rise of technical secondary schools, also known as *Technika,* that required less training and were more responsive to the needs of the industrial workplace. Industrialist Johann Jakob Sulzer welcomed an early such effort in 1866: "God bless your project; it is a real boon for our young people who do not wish to become professors but able, well-trained foremen or chefs or building contractors or any other skilled professional."[114] The first, and for a long time the most important, *Technikum* in Switzerland was created a short decade later in 1874 in Winterthur.[115] With competition so nearby, the polytechnic was spurred to enhance its profile as a technical university.

Toward an engineering curriculum

All things considered, it should come as no surprise that, in the first decade, teaching at the federal polytechnic oscillated between standards of science set by the university faculty and practice developed in industry. Until the turn of the century, how to deal with these different requirements was the key problem of the technical universities, and nowhere more obvious than in mechanical engineering.

"If you want to be successful at teaching mechanical engineering, you must go about it methodically, and not fumble around trusting blind luck, as is the case with Escher and in other famous construction factories," scolded Jacob Ferdinand Redtenbacher in 1846. Before Redtenbacher was called to Karlsruhe, where he reorganized the way mechanical engineering was taught, he had spent seven years teaching mechanics and mechanical engineering at the *Zürcher Industrieschule.*[116] His ideas on curricular reform and his textbooks soon made Redtenbacher among the most renowned polytechnic professors in Germany. In his teaching, he incorporated French machine theory and British mechanical empiricism into an independent German school of mechanical engineering.[117]

Following the German model, the School Council was looking to fill the teaching positions in the mechanical engineering division with both theoretical and practical scholars. Initially, job offers were made to Redtenbacher and his no less well known colleague Julius Weisbach, professor of applied mathematics and mining engineering, in Saxon Freiberg. But "even a salary of 2,000 to 3,000 francs over the previously set maximum of 5,000 francs" was not enough to attract the two stars to Zurich. Instead, the School Council had to make do with two of their students. In 1855 Gustav Zeuner was appointed professor of mechanics and mechanical engineering, followed, one year later, by Franz

Reuleaux from Karlsruhe. “Just as Weisbach inclines more toward the theoretical side of things, and Redtenbacher more the practical, so do their students Zeuner and Reuleaux. Therefore, the latter should be able to unite the advantages of both orientations at our university,” stated the School Council in justifying its nomination of Reuleaux to the Federal Council.[118]

Initially, the separation of theory and practice was only gradual. Reuleaux, who epitomized practical experience and concentrated in his teaching at the polytechnic on designing, later on developed into the best-known machine theorist of Germany. His *Theoretische Kinematik* (*Outlines of a Theory of Machines*), published in 1875, claimed somewhat boldly to pave the way for the deductive science of invention. Gustav Zeuner worked on the application of thermodynamics to mechanical engineering. (This theory was established around the middle of the century by the physicist Rudolf Clausius, who himself was called to Zurich in 1855, and others.) Zeuner's papers on the subject, milestones in the development of the discipline of engineering thermodynamics, were essentially theoretical. But for generations of engineers, his name stood for practical tools that they routinely used in their work: tables that listed the properties of saturated steam, for example, and a slide-valve diagram that enabled one to determine the settings for steam engine controls.[119] In the course of devising these tools, Zeuner forged close ties with the machine works Sulzer Brothers, Winterthur. The relationship endured even after Zeuner moved to Dresden.[120]

In the 1870s and 1880s, the gap between theory and practice appeared to have widened. Rudolf Escher, professor of mechanical engineering, wrote in a 1903 obituary of his former division colleague George Veith, who had taught for a quarter of a century (1868–1893) at the polytechnic: “In the teaching of mechanical engineering, there used to be (as among engineers generally), two sorts of people: those who understood it, but couldn't do it, and those who could do it, but couldn't understand it. The result was a separation of lectures into mechanical engineering theory and applied mechanical engineering, in other words, part physical mathematics, part practice.”[121]

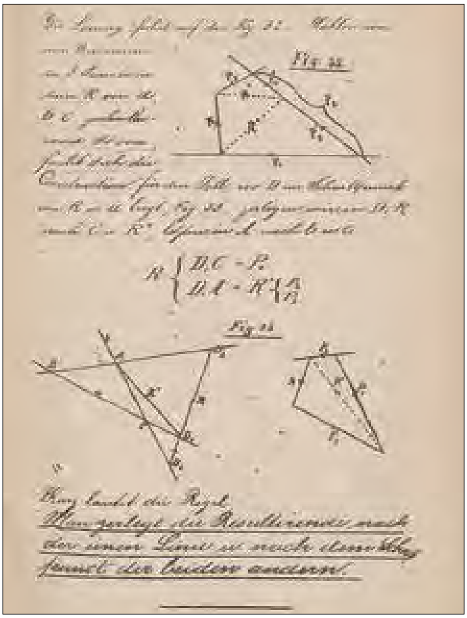
This separation into the impractical experts and the inexpert practitioners had a number of precipitating factors. First off, the leading German academic engineers, including Reuleaux and Zeuner, wished to inject theory into their field. In so doing, they distanced themselves even further from the everyday problems of mechanical engineering. The historian of technology Wolfgang König sees this development as “exclusively social” at core. “The technical universities were oriented, on the one hand, to the legal and social status of the universities, and on the other hand, theoretically and methodologically to the interests of the established university sciences.”[122]

The social motive was important; König's assessment, however, is exaggerated. Aside from wishing to follow the university model, the greater emphasis placed on the theoretical aspects of the discipline had at least two further rationales. First, the polytechnic had to differentiate itself from the industrial colleges and the new technical secondary schools. In 1866, Carl Culmann published his seminal *Graphische Statik* (Graphic statics), which he hoped would enable engineers to graphically approach and solve mathematical calculations on the statics of structures. Despite extensive training, engineers traditionally gave higher mathematics wide berth. By translating it into a visual language, Culmann not only made mathematics palatable to engineers but also adapted it to their needs. In the foreword to the second edition, published in 1875, he expressed annoyance at the popularity that "Graphic statics" had enjoyed since 1866: "Had such works been written for vocational schools and other such second-rate institutions, one might simply be pleased at the diffusion of the method. But *polytechnical* schools should aim higher. Here, an engineer who later will be working independently, who knows the importance of the rules and formulas that he uses, and who needs to consider his projects spatially, should not be satisfied with having digested a few building recipes. Rather, the goal should be above all to educate thinking men capable of rigorously applying spatial analysis to the projects they carry out."[123]

A second rationale was that the university classroom was well suited for theory lessons. In contrast, practical training was harder to organize in the engineering divisions. Indeed, for decades it took place mainly in the drafting halls, in which students carried out design exercises under the guidance of professors and assistants. Beginning in 1856, the polytechnic's efforts to connect with the outside world consisted at times of major excursions to construction sites, industrial plants, meetings, fields and forests, or mountains, depending on the division.[124] These excursions were considered an important "stimulus for young students." In addition, they helped to build contacts with industry while demonstrating to the public "how much trust and goodwill manufacturers and practitioners display toward our school."[125] Still, whereas field trips in architecture, and in certain of the natural sciences, for example, botany, zoology, and geology, were an integral component of the curricula, the benefit of the engineering pupils' outings was limited to their "motivating," illustrative character.[126]

Engineers also had access to shops for woodworking and metalworking, "an opportunity that is, however, little used," as the School Council remarked in its report for the 1889 Paris World's Fair.[127] Possibly related to the academic disdain for anything practical or applied was the fact that, for a long time, the problem of what do about the lack of practical training was ignored rather than addressed. In the same report of 1889, the School Council continued, "The school is convinced, through long experience, that intensive academic study and practical training for engineers cannot both be achieved simultaneously. And it is up to anyone who desires the latter to seek such training himself outside, in a workshop, either before or after attending the polytechnic. The school thus attaches little worth to such work, which is better practiced and learned at a factory."[128]

In 1885/86, the GEP asked its members what they thought workshop training for mechanical engineers was worth. The results showed that it was deemed necessary, ideally should last two years, and should best precede academic studies. For years, however,



“Divide a force into 3 components of given direction,” reads the assignment on page 40 of “Graph. statics based on lectures by Prof. Ritter,” printed in 1884 by the students’ *Verein der Polytechniker*. The figure shows the solution. Following the death of Carl Culmann, Karl Wilhelm Ritter carried on his legacy at the polytechnic.

In his forty years of teaching at the polytechnic and the University of Zurich, Albert Heim led over 300 excursions. The destinations were often barren landscapes requiring fitness, weather hardiness, and mountaineering gear. Moreover, Heim’s “Treasures ‘that the moths won’t eat’”, collected on these mountain trips or hammered from stone, were a heavy haul. The photograph is from an album belonging to Heim (with the long white beard) and was taken on an excursion to the Aar glacier in July 1904.

most students continued to shun practical training. Only after the Second World War was a compulsory internship introduced into the mechanical engineering division.[129] At the turn of the century, workshop training was quite expensive, and required the appropriate financial resources. For example, Sulzer Brothers demanded a thousand francs for the privilege of doing a two-year internship, payable up front.[130] This amount corresponded roughly to the fees charged by the polytechnic for a seven-semester diploma course.[131]

A further major reason for the sharpening divide between theory and practice at the polytechnic was the rapid gains in knowledge in both areas, which made it increasingly impossible to keep pace with developments in one's own field and still be on top of every aspect of theory and practice. Courses were expanded in several stages. They were initially designed to last four to six semesters, but by the end of the 1800s, most lasted for six to eight semesters. In addition, regulations were relaxed to make curriculum planning more flexible. Together with the academic freedom granted to advanced students in 1881, the new curricular flexibility made it possible to pursue optional interests in more depth.[132] Thus the second half of the nineteenth century marked not only the end of the universal scholar, but also the end of the universal engineer.

The increasing personal specialization and differentiation among fields in turn led to rapid changes in academic disciplines.[133] A frequently underestimated factor in this highly complex process was the institutional context in which science operated. Not least of these were the fluctuations in the personnel and material resources of universities, which played a major role in the local development of disciplines. At the time, and more so than today, science policy was tantamount to hiring policy. The creation of new professorships depended on mobilizing additional financial resources, for which growing enrollment provided compelling justification.

Carl Culmann taught the whole spectrum of civil engineering. After his death in 1881, his chair was split into separate subjects. Culmann's protégé Wilhelm Ritter was brought back from Riga to teach graphical statics and bridge building. Silesian-born Eduard Gerlich, co-chief engineer of the Gotthard railway, was appointed professor of railway construction and operation, and titular professor (lecturer) Karl Pestalozzi was made full professor of roads, canals, and waterworks. In 1889, when Johannes Wild stepped down, (in 1855 he had been appointed co-head instructor for topography and geodesy alongside Culmann at the engineering school), his teaching responsibilities were also divided among several professors.[134]

The mechanical engineering division experienced a similar differentiation in the 1890s when Georg Veith, yielding to heavy pressure from the School Council, retired, and longtime titular professor Hermann Fritz died. As a result, the dual professorships that had endured since the founding of the university – one for theoretical and the other for applied mechanical enginering science – could be dissolved and a paradigm shift initiated. The School Council proposed to the Federal Council that Veith's chair for machine design and construction be replaced by three new chairs for specific disciplines. "To properly meet the requirements of modern engineering we need three professors who are competent design engineers and capable of in-depth treatment of their subject matter from both a scientific and practical standpoint; basically, one chair for steam engines, a second for hydraulic motors and pumps, and a third for hoists, machine parts, and technical drawing," wrote the School Council in January 1894 in its report to the Federal Council justifying the appointment of Eugen Meyers.[135] The School Council was able to act on the proposals owing not least to soaring enrollments of the mid-1880s and resulting capacity constraints.[136] In addition to Meyer, positions were awarded to the Austro-Hungarians Aurel Stodola and Franz Prášil, who in subsequent decades helped to put mechanical engineering at the polytechnic, and later the ETH, on the map internationally. In 1895 the school also established its first chair in electrical engineering.[137] With this reorientation, the traditional professorship in theoretical mechanics and machine science, occupied since 1872 by Albert Fliegner, became a relic of a bygone age. After Fliegner retired in 1912, the chair was left vacant.[138] The new academic structure, which distinguished among areas of application, constituted one mechanism for bridging the gap between theoretical and applied mechanical engineering science. The construction of mechanical engineering laboratories constituted a second.

The laboratory as "idealized factory"

In the 1890s, the predominance of theoretical approaches to mechanical engineering at technical universities was roundly criticized. At the Technical University of Berlin, this struggle was personified by rivals Franz Reuleaux, a representative of the old school, and Alois Riedler, a practical reformer. The reformers were also labeled the "antimathematical movement" because they loudly called for less analytical mathematics in engineering courses.[139] When Aurel Stodola took the podium at the First International Congress of Mathematicians in Zurich in 1897 to speak as a mechanical engineer "about the relationship between engineering and mathematics," he entered a minefield, which he proceeded to negotiate with skill. "Thorough training in mathematics" was necessary, he said, but cautioned "against exaggeration" because "the vast majority of practicing engineers simply ignore advanced and especially pure analytical methods in favor of elementary or synthetic geometry ... Cases in point are graphical methods in construction engineering, speed calculations for building turbines, slide-valve diagrams for steam engines, and so-called vector diagrams for electrical engineering." Instruction in mathematics for the engineering disciplines had to take these factors into account and "[make] compromises not only regarding their expansion but also their methods." Stodola used the example of the diesel motor to explain the immense engineering effort required to "transform an idea into steel and iron." Such experiences no doubt gave rise to the engineering expression: "An ounce of practice is worth a pound of theory." The "kernel of truth" in this obvious exaggeration was the reference to "the need for experiment ...; the great push

As early as the nineteenth century, laboratory experimentation in physics had become very important. The laboratory in the physics building also served to train engineers in basic physics. Photograph from 1882.

for engineering laboratories is based on this guiding principle." Stodola pointed out that experimental research and metrology were becoming more important. "Making room for them in the curriculum will of necessity be at the cost of other disciplines, including mathematics."[140]

In fact, around 1900, the mechanical engineering laboratory was the nucleus of a new and growing self-confidence among engineering academics. Systematic experimentation with machines on a scale of 1:1 became the focus of an autonomous scientific engineering method. In an overview of the German technical universities, editor Wilhelm Lexis began confidently: "Not only does modern engineering make use of mathematics and science as auxiliary experimental tools, it also possesses its own scientific spirit, and its own scientific method of posing and solving problems. No doubt some engineering advances, and historically perhaps even most of them, can be credited to good intuition and empirical skill. But only the care and training of young scientific minds leads surely and consistently to the steady increase in engineering expertise that enables man to make the materials and forces of nature serve his goals and interests. The technical

“A factory in the best sense, a perfect factory” is how an 1894 publication of the GEP described the newly built chemistry building, as it looked in 1889. In the foreground are experimental fields belonging to the agricultural division.

universities thus have at their door a vast field that they must work as productively as their older sisters, the universities.”[141]

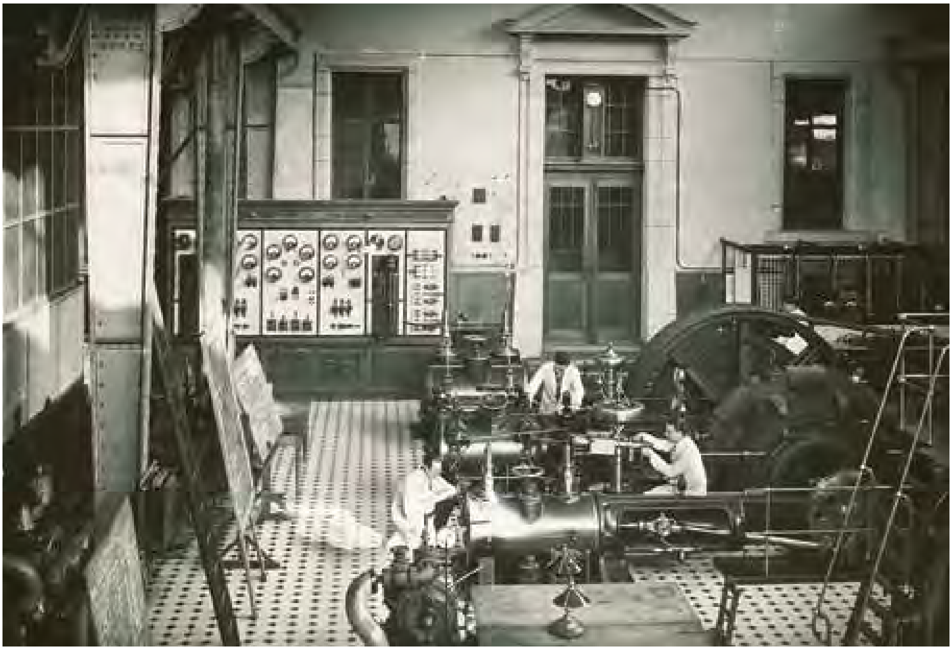
As Lexis’s comments make clear, the engineers saw in their “own scientific mind” not only an equal counterpart to the approach nurtured at universities, but also the independence of the engineering sciences vis-à-vis mathematics and the natural sciences. The distinction between the latter was delicate; controlled experimentation in the laboratory was also the beginning of modern natural sciences, though the origins of this “beginning” went back several decades earlier.

“In fact, everything has changed here. Physicists will no longer be trained in the lecture hall, as previously, but preferably in the laboratory,” the Federal Council told parliament in 1886. Like the new chemical building several years before, the construction of a new physics facility – raised by the Federal Council “without exaggeration, [to] a question of life or death for the existence and claim to rank of our technical university” – was accompanied by disputes between the federal authorities and the Zurich authorities over who would pay for what.[142] Between 1883 and 1889 parliament budgeted over 3 million francs – roughly as much as the national government provided that year for the general operation of the institute – for new chemistry and physics buildings and facilities. Consequently, in the 1890s chemistry and physics at the polytechnic were equipped with modern laboratories that were state-of-the-art. In contrast to most other technical institutes and universities in the German states, where "chalkboard physics" prevailed, the polytechnic offered experimental laboratory physics already in the nineteenth century.[143] For chemistry students the laboratory practicals were part of the standard curriculum from the first year. In addition to the analytical laboratory, there was also a chemical engineering laboratory. "Justification for the facility lies in the fact that it is basically here that students will learn how to prepare compounds and carry out chemical engineering analyses; moreover, since chemical engineering problems will be studied as well as purely scientific ones, insofar as possible facilities for manufacturing should be reproduced on site, albeit on a smaller scale."[144]

In the 1880s, in connection with the establishment of "testing institutes" (about which more later), mechanical engineers also suggested bringing the factory into the university.[145] This impulse was catalyzed by the Chicago World's Fair of 1893. German and Swiss visitors to the exhibition were deeply impressed by the mechanical engineering laboratories of the North American institutes of technology. In 1895, the Society of German Engineers (VDI) and prominent professors demanded that all the technical universities be outfitted with engineering laboratories. A short eight years later, this demand was met in full.[146] In 1896 the Federal School Council made a similar request for the polytechnic, and in the summer semester of 1900, teaching began in the mechanical engineering laboratory. Advanced mechanical engineering students then spent one day per week in the engine room, and half a day each in the thermal engineering and hydraulics rooms. The electrical division became involved only gradually in electrical engineering instruction. This field of study was still primarily based in the old electrical engineering laboratory facility in the physics building.[147]

In its machine laboratory, the polytechnic not only simulated the factory, but the laboratory itself became an industrial production facility. Following the Munich and Darmstadt model, the laboratory machines were used simultaneously to heat and ventilate the buildings and to generate power. Lighting for the entire university complex was converted from gas to electricity, to help promote the polytechnic as a sophisticated and modern institution. In addition to financial savings, there was the "further great advantage that the engine plant could be in continual service among the service personnel responsible for it, which is invaluable in maintaining discipline."[148] Nonetheless, several years later the polytechnic backed away from this concept and from then on obtained its power from the municipal power plant. Operating the factory put too many restrictions on teaching.[149]

As the new century dawned, the proponents of engineering sciences stopped referring to their disciplines as "applied" sciences, since engineers "do not 'apply' the laws of nature, but bend them to their will." Unlike "pure" scientists, engineering scientists were especially concerned with the "heavy 'constraints' involved in solving problems."[150] Whereas natural scientists eagerly isolated natural phenomena in the laboratory and



Interior and exterior views of the mechanical engineering laboratory, completed in 1900. Full-scale machines such as the piston steam engine shown here could be used for training and experimentation. At the left rear is the switch panel for the polytechnic's central lighting system. Photograph from 1904.

analyzed them in their "natural" form, the experimental methods of the engineering scientists simulated the hybrid relationships of technologized nature. But such distinctions also helped to shape the identity of the discipline. As far as the approach was concerned, the incorporation of engineering sciences into the laboratory had reinforced the common ground between science and engineering instruction. Both adhered to the principle of "giving scientific lectures based on exemplary laboratory-related exercises." Thus spoke Director Ulrich Grubenmann, professor of mineralogy and petrography at the two Zurich universities, in a joint speech to the engineering and science students at the start of the 1910 school year. Twenty years earlier, such an address wouldn't have been possible. "The appropriate selection of exercises provides teachers with the means of felicitously linking theory and practice, and thereby building a golden bridge between science and engineering."[151]

Launching into research

In this same speech, Grubenmann managed to segue from the direction of modern education to discussing the future. "Science can no longer be content with gathering, classifying, and summarizing knowledge already gained. Its most urgent task is to add to that knowledge and to lay the foundation for the future. The old science was concerned with what might be; modern knowledge strives to understand what will be! Accordingly, the emphasis of modern education at technical universities is not prescriptive lectures churned out for the masses but rather science-inspired exercises to be carried out in laboratories, institutes, and drawing halls, in colloquia and seminars, where students can also benefit from the personal attention of their teachers."[152] What Grubenmann's modern metaphor captured was the old Humboldtian unity of teaching and research. One year later on the same occasion, Grubenmann's successor, Theodor Vetter, explained that the goal was to "bring the Federal Institute of Technology ever closer to a real university, to a place of tireless work, diligent research, and solid teaching."[153]

Over the course of the twentieth century, research would become increasingly more important than teaching. In the nineteenth century, in contrast, research was still not the main priority of the polytechnic. In the institution's early reports, for instance, at the World's Fairs, research was shoved to the sidelines. This marginalization also had to do with the fact that the activities of research and invention were thought to be closely linked, and scientific innovations ascribed less to systematic endeavor than to the brainstorms of "lone geniuses" – analogous to the self-fashioning of famous inventors.[154] Yet individualization and spontaneity were not easily reconciled with the strict organization and rigid discipline that the School Council considered indispensable to making students into competent engineers. In 1879, it expressed its opposition to academic freedom thus: "Scientific research would not be adversely affected. Whoever receives this call has the drive and the talent for it from birth. Thus, fostering such talent shall not serve as a rule

"The school will educate students not simply in the lecture halls and demonstration rooms, but equally in the laboratory and experimental fields, where, using their eyes and hands to observe, measure, and test, they will familiarize themselves with the real world and as a result of such independent study of nature acquire the practical experience required to exercise their profession" (Federal Polytechnical School, 1889, 6). At that time, this declaration of intent mostly affected the natural scientists; until 1900, engineering exercises were chiefly carried out in the drawing hall. Above: Laboratory assistant Schmid in one of the agriculture and forestry laboratories in 1900. Right: The civil engineering drawing hall, 1890.

of school organization and discipline. The polytechnic's task first and foremost is to teach."[155]

Scientific research did gradually begin to take shape, even if under the guise of teaching. Once again, the natural sciences led the way. In the winter semester of 1871/72, Johannes Wislicenus taught a course titled "Introduction to independ[ent] chemical research." Offered daily, the course attracted only eight auditors – not a single student registered at the polytechnic.[156] Research was conducted with the scientific collections and increasingly in the laboratories. During the 1800s, both facilities were expanded,

Werder's universal testing machine represented a milestone in experimental engineering science. The photograph, from 1892, shows the machine inside the Federal Materials Testing Institute.

with the laboratories gaining in importance relative to the collections, as evidenced, for instance, in a switch in emphasis in the annual reports. Toward the end of the nineteenth century, the collections became equipped with their own laboratories. In the meantime, people realized that the natural science collections and laboratories could serve both teaching and research.[157]

For a long time, the engineering disciplines had no comparable research infrastructure. Most experimental work took place outside the polytechnic. Gustav Zeuner had machine blueprints delivered from Sulzer Brothers.[158] In the 1860s, Carl Culmann's experiments using a "universal testing machine" were carried out in the shop floors of the Central Railway in Olten. This apparatus, designed by Johann Ludwig Werder in the early 1850s, made it possible to test the strength of materials by bending them, compressing them, and pulling them apart. It was also employed in Munich, at the first mechanical engineering laboratory of a technical university in the German states, opened by Johann Bauschinger in 1871.[159]

In 1856, a group of professors had tried to purchase such an apparatus for the polytechnic, but in vain. Nearly ten years later, Culmann was more successful. He managed to

"On the other hand, our investigation has reassured us that the Münchenstein bridge did not fail owing to a general fault of iron bridges, but rather that our iron bridges still merit our confidence provided that they are correctly calculated, built with good-quality materials on solid foundations, and closely monitored," wrote polytechnic professors Ritter and Tetmajer in their expert report on the Münchenstein railway collapse (Ritter and Tetmajer 1891, 21), from which the image is taken.

get the Federal Council to agree to finance a universal testing machine that remained part of a permanent model exhibition on building materials in Olten sponsored by several railway companies. After a few years, the Central Railway abandoned the location, and for years the machine sat forgotten in the station of the Northeastern Railway in Zurich. At the end of the 1870s, it was temporarily set up in conjunction with the 1878 World's Fair in Paris to test Swiss building materials. In 1879 the provisional setup was transferred to the *Anstalt zur Prüfung von Baumaterialien*, a materials testing institute affiliated with the polytechnic and headed by Ludwig Tetmajer, professor of mechanical engineering and former assistant to Culmann.[160] In the previous year, a seed control station and an agricultural chemistry testing station had also become affiliated with the polytechnic, followed, in 1885, by a center for experimental forestry. These facilities were administered separately and were "intended not for educational purposes but to directly serve the economic interests of the country in the areas of construction, forestry, and agriculture."[161]

Under Tetmajer's energetic leadership, the testing institute quickly expanded its activities. For the national exhibition of 1883 in Zurich, the facility received a loan to buy new

machines, and in 1891 it was given a new building near the main university building. In the same year, the institute managed to make itself the focus of public attention. Tetmayer and his colleague Ritter, professor of graphical statics, and bridge and railway construction at the polytechnic, were appointed by the federal government to investigate a serious railway accident in Münchenstein. In June 1891, some 80 people had been killed when a railway bridge over the Birs River gave way under the weight of a train packed with passengers. The two academics concluded that the accident was due mainly to faulty bridge construction and to the poor quality of the iron used.[162]
This finding turned out to be good publicity for them, as it underscored the importance of standards for materials testing. Indeed, the number of evaluations performed by the Federal Materials Testing Institute (as it was named in 1895, later the Swiss Federal Laboratories for Materials Testing and Research, or Empa) skyrocketed, from merely 500 in 1880 to nearly 45,000 in 1899. At the turn of the century, the staff numbered 21, and operating expenses amounted to barely a tenth that of the polytechnic, with half of the amount easily covered by the 80,000 francs generated by the testing fees.[163]
The institute quickly gained an international reputation, as evidenced not least by the election in 1895 of Tetmajer as the first president of the International Association for Materials Testing.[164] In 1907 a center for testing fuels was established as an additional annex to the polytechnic; in 1927 it was incorporated into the Empa.[165]
It is significant that engineering research at the polytechnic initially unfolded largely independent of teaching. Research at the testing institute was clearly applied, business-oriented, yet also geared to public service. It catered especially to the construction industry, but also supported numerous efforts then ongoing to formulate materials standards at the governmental, nongovernmental, national, and international level.[166] By the turn of the century, following the creation of the mechanical engineering laboratory, engineering research was increasingly carried out at the polytechnic. The combining of teaching and research made it possible for the technical universities to fulfill their aspirations to achieve the status of traditional universities, and also – at least for the time being – to resolve the theory-practice debate. However, new boundary problems between disciplines arose and, couched in terms of basic versus applied research, were to persist throughout the twentieth century.

Collaborating with industry

As the scope of their research activities widened, so too did the appeal of the technical universities as collaborating partners for industry. The first contacts between industry and the polytechnic occurred shortly after its founding, and in those early days, primarily at the initiative of the latter. On the one hand, supplying industry with trained engineers legitimized the existence of the school. On the other hand, the links had practical advantages. The dye industry provided laboratory chemicals at low cost, and "real" machines could be studied in industrial engineering factories.[167] Whether these contacts would deepen over time depended on four factors: industrial demand for highly qualified engineers and technical expertise, the perceived importance of innovation, the practical relevance of the research and teaching offered by the polytechnic, and personal relationships between companies and university professors.

In the last quarter of the nineteenth century, Swiss industry – in particular the emerging industrial engineering and chemical dye industries – went from being imitative to quality- and niche-oriented. This shift was evident not only in the products generated but also in attitudes toward intellectual property. Switzerland was one of the last European countries to introduce patent protection. The first law on patents came into effect in 1888, twelve years after its German counterpart. Largely favored by the engineering industry, yet still rejected by the textile and dye sectors, the law was limited to discoveries that "could be represented by a model," which excluded textile and chemical products. The revised law of 1907 dropped this restriction (unique in Europe), in response to international pressure, and with the consent of the dye industry, which in the 1890s had changed its position on patent protection. Of course, clever copying of products takes engineering expertise, but with a move toward independent product development, demand for related know-how increased, and with it interest in the federal polytechnic.[168] Up until the new century, interactions between the polytechnic and industry remained generally at a modest level. But there were clear differences between individual disciplines, as a comparative look at engineering and chemistry shows.

For a long time, the construction and engineering industries were not much concerned with the goings-on at the polytechnic. Indeed, during the 1800s, the school had yet to fully bridge the gap between classroom teaching and industrial practice. Graduates in construction and industrial engineering did find jobs, in which the most prized of their skills proved to be graphical design methods. Consequently, Culmann's graphical statics became widespread in the building industry, and Zeuner's slide-valve diagram found use in the making of steam engines. As described above, factory-employed graduates not only had to learn the ropes and to work their way up the engineering career ladder, but also had to face competition from less-well-educated engineers, and from foreign specialists, whom they eventually replaced.[169] The industrial family Sulzer had a tradition of sending their oldest sons to polytechnics at home and abroad for training.[170]

More intense and regular exchanges had to await the first half of the twentieth century, when the laboratory infrastructure at the polytechnic was established and expanded, with teaching made more practically oriented and research strengthened. For their part, by the end of the nineteenth century, industrial companies had begun to differentiate their factory operations. With the advent of the First World War, they created their own research divisions, which became partners and research collaborators with the institutes and laboratories of the polytechnic. In 1909, the school gained the right to award doctorates, which meant it could then employ engineers as PhD candidates, a mechanism often exploited in collaborations with industry. In mechanical engineering, professors

As a longtime member of the School Council (1891–1927, vice president from 1898), Gustav Naville (1848–1929) was an important link between the polytechnic/ETH and industry. Born in Geneva, Naville managed the Escher-Wyss company, was a co-founder of Alluminium Industrie AG (1888), the Swiss Association of Engineering Industrialists (1883) and the Central Association of Employers (1908), on the board of directors of the Kreditanstalt (Credit Suisse) (1892–1900), and president of the GEP (1888–1902) and the SIA (1907–1912). Prior to starting as chief engineer at Escher-Wyss in 1873, Naville followed a typical engineering education trajectory: mechanical engineering study at the polytechnic (graduating in 1870 with a diploma), two-year internship at Sulzer, and finally a trip to England.

Stodola and Prášil were especially credited, during their decades-long tenure at the ETH, with having expanded the "close relationship with the nation's industry" as the division put it in characteristic fashion in 1955.[171]

Whereas the polytechnic appears only to have been modestly involved in the rise of the Swiss machine industry in the 1800s, it played a prominent role in the development of the national chemical industry: "Without this engineering education and research facility ... the chemical industry might have been lost again in the critical development phase of the 1870s and 1880s. The polytechnic functioned as a bridgehead for German chemistry professors, who brought the tried-and-true formula of the German model – practical training and industrial collaboration – to Switzerland. But it was exclusively Swiss graduates of the polytechnic who steered academic chemistry toward more industrially oriented organic chemistry, who established laboratories in the dye factories of Basel, and who supported close collaboration between industry and the university."[172]

In the 1870s, under pressure from the German chemical industry, Swiss dye makers, who were concentrated in Basel, began to specialize in high-quality niche products. The high costs of raw materials (in comparison with foreign competitors), most of which had to be imported, drove companies into refining, which in turn required investment in research and development. Graduates of the federal polytechnic played a key role in this successful specialization and increasingly scientific process. This became clear with the organization in 1882 of the Swiss Society of Chemical Industries. Four of the seven members of the founding board of the society were graduates of the polytechnic; another was a current professor. In the 1890s, the polytechnic massively expanded the chemical engineering division and oriented it even more strongly to chemistry in Basel.[173]

With the construction of new laboratories both in the chemical industry and at the polytechnic, collaborative research during these years intensified. There was, however, always a discordant element of these relations, for instance, when professors from the polytechnic grumbled in their publications about the “collusiveness” of industry. The academic tradition of publishing research results contrasted with the growing trend among chemical companies to contractually swear their workers to secrecy.[174] Typically, interactions between university and industry were not institutionally regulated, but conducted largely through “gentlemen’s agreements.” The network forged by these relationships was the basis for a fluid collaboration that, at the turn of the century, resulted in directors from industry taking up professorships and vice versa. For example, in chemistry, Robert Gnehm represented a pioneer of this order, as did Walter Wyssling in electrical engineering, and Conradin Zschokke in hydraulics.[175] Gnehm and Zschokke continued their careers on the School Council.

In 1881, after the federal government had fulfilled the demands of the GEP and the SIA and “with due regard to the needs of the engineering professions”[176] had increased its members from five to seven, the governing body of the polytechnic switched rapidly from a group of deserving federal politicians to one that was industry-oriented. In 1882, the “engineers” already comprised a majority, and with the addition of Gustav Naville in 1891, and for four decades thereafter, the School Council had probably the most influential Swiss businessman among its members.[177] When president Karl Kappeler died in office in 1888, Hermann Bleuler, an alumnus of the school, succeeded him. The transition from Kappeler, a lawyer, to Bleuler, a mechanical engineer, was a sure sign of the shift of power to the engineers, which raised them in the eyes of civil society.

CULTURAL NORMS

Over the course of the nineteenth century, the creation and development of the modern state bureaucracy and its civil service, along with the neohumanistic educational reform influenced by Humboldt, set the stage for the rise of an educated middle class. Within this far-reaching societal process, the state played a central role in its double function as educational institution and a major employer of the academically trained. The terms “education” and “middle class” “refer to acquirable attributes and the cachet they bring.” Their functional context arises from the “exploitation of educational patents for the benefit of middle-class existence.” Lawyers and doctors were traditionally regarded as the epitome of the educated middle class. Yet, the social position and value system of architects and engineers, chemists and pharmacists, foresters and teachers also entitled them to inclusion in that same category.[178]

The following section illustrates the role of the federal polytechnic in redefining the social categories of education and middle class. Graduates of the school aspired to social recognition. Attending the polytechnic meant more than acquiring specific knowledge and bringing it to the attention of potential employers. Studying was also associated with the adoption of certain social values. The transfer of knowledge and the molding of middle-class character were thus inextricably linked.

Climbing the bourgeois career ladder

In the 1800s, the middle class did not constitute a single social category but rather a fluid social milieu. "Middle class" was defined primarily by a set of values, a distinct lifestyle, and certain personal networks. The closeness of the connection between profession and class is evident in the contemporary term "middle-class profession."[179]

Throughout the long process of socioeconomic transformation that accompanied industrialization and the transition from a hierarchical to a middle-class society, old and new professions had to work out their positions in society. Educated professionals essentially had two strategies at their disposal for obtaining suitable employment: one social, and the other professional. The former required integrating broadly into the ruling class, and the latter involved choosing a narrow occupational specialization with the aim of distinguishing laypeople from experts and thus securing a certain degree of societal autonomy. Historically, the two strategies are not cleanly separable, but have tended to occur in combination.[180]

This mixture of social and professional strategies was the basis for the activities of Swiss special interest organizations such as the SIA, founded in 1837, and the GEP, which in 1869 was launched "with the goal ... of fostering friendly and colleagial relations between former graduates of the polytechnic."[181] As early as its founding year, the society counted 185 alumni among its members. In 1875, the list of members grew to nearly 700; in 1894, after 25 years of existence, around 1,600, of which half were resident abroad.[182] The GEP was thus able to claim half of all graduates among its members. The society organized regular social meetings for them, updated the list annually, and provided a job placement service. It soon developed a close association with the SIA. Beginning in 1876, the two organizations shared an organ: *Die Eisenbahn* (The railway), which in 1883 was rechristened *Schweizerische Bauzeitung* (The Swiss building journal). In 1888, the SIA and GEP decided to hold their annual meetings in alternate years.[183]

In the mid-1870s, the GEP redoubled its efforts to represent the professional interests of its members to their alma mater. In 1877, in a petition addressed to the Federal Council, the society requested far-reaching reforms at the polytechnic and in so doing triggered a prolonged debate on reorganization. The GEP diagnosed a "crisis among the engineering firms" owing to the fact that "almost no Swiss company would give an engineer a job deserving of his talents, such as would be offered to him abroad, especially in France."[184] According to the GEP, the reason for this disdain "was not least the way engineering was taught," especially in the neglect of general education. "Consider the merits and status engineers coming out of the fed. polytechnic. It is not unusual for us to find that though their mastery of specialized science is commendable, their general education is lacking, with the result that in their professional life these engineers never manage to advance to higher positions, let alone mention have any hope of a distinguished career in public service."[185]

On the basis of these deficiencies, the GEP called for a better general education and a higher age for admission. Both requests were taken up in the revised regulations of 1881. The division of general studies, which in 1855 was generously funded, was responsible for ensuring that students at the polytechnic received a broad education during their studies. "For technical colleges geared to providing an intensive technical education, which is the trend of our time, this 'division of general studies' will act as a countermeasure against an education too singlemindedly focused on practical goals. Youth dedicated to advanced engineering study will be steeped in the great ideas that uplift and ennoble the entire human species as such."[186] From 1863 on, students were required to take at least one general studies course per semester, choosing from a range of offerings including history, philosophy, art history, literature, economics, and public and administrative law. Although the initial enthusiasm for the division subsided, in the 1880s and 1890s it came back into favor, and indeed was held up as a model by German higher-education reformers of the time.[187]

Equipping students with a general education was one way to help polytechnic graduates be socially successful. Additional attempts, which were avidly supported especially in Germany, sought to emphasize the cultural achievements of engineering and thereby to put practical training on an equal footing with education in the humanities.[188] The undeniable incursion of technology into the real world helped to boost the self-confidence of engineers. As Eduard Gerlich, a railroad engineer at the polytechnic, intoned in 1900, "[We must show] the extent to which our accomplishments have furthered the well-being of mankind not only in terms of economic prosperity but also, and especially, by promoting culture. If we simply consider how the modern transport system has remade the world, there can be no doubt that engineers have the right to as high a place in society and in politics as the so-called humanists."[189]

Such appreciation was not lost on the academic engineers at the polytechnic, whose status was inferior to that of traditional university professors.[190] The societal assessment of educational institutions was reflected at the semantic level: the polytechnic was a school, not a university; it was attended by pupils, not students; and teachers, not professors, taught there. Finally, it was headed by a director, not a dean. This state of affairs remained unchanged until the First World War.[191]

On the surface, the social emancipation of engineers in Switzerland and Germany appeared to unfold in much the same way. Closer examination, however, reveals some interesting differences. For example, an article in *Die Eisenbahn* titled "Position and influence of engineers in social life," stated, "Conditions in Germany are apparently much less favorable than in Switzerland; there, the power of the old scientific disciplines and of equally entrenched officialdom has more firmly and unfairly barred the door to deserving engineers than could ever be the case in Switzerland."[192] Indeed, in Germany's more liberal and democratic neighbor, the borders between social strata and status groups appear to have been more permeable and the process of advancement more open than in the empire. Thus, Swiss society offered engineers good opportunities for moving into the middle class by acquiring a bourgeois life style. By the same token, in their attempts to gain privileged access to professional jobs and the civil service, Swiss engineers were rather at a disadvantage. In 1888, a professor from the Technical University of Charlottenburg traveled from Berlin to Zurich to brainstorm with his chemist colleague Georg Lunge over ways of enabling the technical universities to grant doctoral degrees. He had hoped, "in free Switzerland," to be able to make headway.[193] But his efforts there came to nought. In 1899, with the personal blessing of King Wilhelm II, Charlottenburg became the first technical university in the German-speaking countries to have the right to award doctorates. It took the federal polytechnic ten more years to achieve the same feat. Even the GEP's initiative, included in the petition of 1877, to get the polytechnic diploma accredited foundered. Unlike Germany, Switzerland had no strong state institutions to take on and defend demands of this kind. The disregard for degrees facilitated the social rise of the engineers, but at the same time made it difficult for them to protect their position in society.[194]

The uncertainty of their social situation was especially brought home to the engineers especially in times of crisis. It was no accident that the first efforts at professionalization occurred during the depression of the 1870s and 1880s, as well as shortly after the turn of the century. In 1877, the SIA – whose activities in the preceding years had ground nearly to a halt – revised its statutes. The political representation of the interests of the engineers and architects would now be a chief thrust of the organization.[195]

The GEP had similar concerns. In its petition of 1877, in addition to calling for increased preparatory training, the GEP had three further requests. In the first of these, the society noted that "a fundamental error of the existing regulation" was that no experts from industry participated in the planning of the curricula, nor were they represented on the school board. This complaint was taken up by Federal Councillor Schenk, who spent two days conferring with and listening attentively to members of the GEP. In 1881, the government determined that engineering professions needed to be represented on the School Council, a move that would lead to polytechnic engineers being in control. Soon, the GEP accounted for the majority of school councillors, and when Hermann Bleuler took over from Karl Kappeler in 1888, one of their own even occupied the presidency.[196]

The GEP's third demand – to increase the amount of French language instruction – was also agreed to. The fourth and last issue was to table discussion of academic freedom at the polytechnic. The polytechnic purported to educate independent men, "but we do not

see how that is possible in the face of requirements that crush self-esteem and of overly pedantic monitoring that often yields only superficially successful results."[197] The problem of required courses was partially addressed. Unlike the German technical universities, which were already introducing academic freedom, the polytechnic only went halfway, because in 1881 the right to choose courses was granted only to advanced classes.
The rules revision enacted that year skillfully mediated between academy and factory, school and university. The revised regulation relaxed course requirements, which also enabled a more flexible design for the advanced programs. In addition, it brought engineering instruction closer to university standards, while at the same time integrating representatives of engineering interests and industry into the management of the institution. This arrangement lasted through the next two decades and even into the early twentieth century, when it was overrun by international developments.[198]

Toeing the line

In 1855, like the foreign institutional models on which it was built, the polytechnic subscribed to a set of rules that embraced mandatory courses and strict discipline. This proved to be problematic for several reasons. The rules not only conflicted with academic freedom, which the students at the neighboring University of Zurich enjoyed, but they also contradicted core elements of middle-class identity. In the bourgeois-liberal image of what it was to be human, the enlightened, free, and autonomous individual was hard to reconcile with the disciplined, patronized pupil of the polytechnic.
Instruction was intended not only as preparation for an engineering career but also to help develop a constitutive, middle-class identity. In the eyes of the parliamentary committee that drafted the polytechnic's regulations in 1854, "the future position of our pupils in society" made a strong general education essential. Moreover, "a healthy knowledge of economics, political history, and constitutional law was probably the best antidote to "the socialist and communist nonsense that, unfortunately, was often promulgated or supported by former pupils of the polytechnical schools in Paris." At the same time, the committee had "no doubt ... that the nature and number of subjects in each of the first five divisions had to be precisely stipulated, and that pupils should have to take all these subjects." This was obvious "in the very nature of these fields of study" and was further confirmed by the excellent results obtained with this system "particularly in the French institutions."[199]
In this sense, the School Council, management, and faculty were all equipped with an arsenal of means for controlling and enforcing. In the course of an academic year, pupils were subject to a whole gamut of progress checks. "Every required course is accompanied by an obligatory tutorial on the basis of which the teachers' conference twice-yearly awards grades, from 1 to 6 in the individual subjects. At the end of each year, during the last 8 days of courses, final tutorials replace lectures. These consist of written assignments, graphics exercises in the drawing and construction halls, and experiments in

the laboratories and workshops. On the basis of all this work, a special conference of teachers decides promotions."[200] Promotion qualified a pupil to attend the next level of courses. In the school's first decade, between 4 and 21 percent of pupils on average failed to pass to the next level, though the numbers show no clear trend.[201] A special report card kept a record of each student's performance for the duration of their academic study. The collected reports constituted "the big school book" (Kappeler). On request, pupils and their parents or guardians could obtain transcripts; third parties, however, were denied access to the "book."[202]

According to the annual report of 1861, exams were the "best means of instilling the young men with a sense of discipline. The school has a right to demand that its pupils pursue their stated educational goals with seriousness and perseverance. Acceptance into a division must never be construed merely as a right to reside at the institute."[203] Enforcement of discipline was the responsibility of the director. The School Council president reserved the right to deal with cases of inadequate performance as well as "breach of morals and decency, and disobedience to the authorities or teachers." Punishment could take the form of a reprimand, a threat of expulsion, or ultimately actual removal from the school. The authorities made good use of these measures. The 1862/63 school year marked a milestone of sorts, when nearly one out of four pupils was subjected to disciplinary action. One hundred and sixteen pupils accounted for 154 reprimands, 35 warnings, and 16 expulsions.[204]

It didn't take long for rivalry to spring up between polytechnic and university students. Josef Wolfgang von Deschwanden, the first director, noted early on "with horror the total lack of any ideal or shared aspiration among the students ... Their sole commonality is their puerile insistence on mimicking each other's customs."[205] They also copied the German university tradition of fraternities along with their notion of "satisfaction" and penchant for dueling. In contrast to the university senate, which declined to intervene against dueling, the polytechnic took a firm stance from the outset and dismissed dueling students from the school.[206] To discourage "dueling mania," which "is inimical to the character of the country," the new school regulation of 1866 explicitly cited "night disturbance, fights, and dueling" as disciplinary offenses.[207]

In Deschwanden's view, "disciplinary leadership" was enormously complicated by the "fragmentation of space" that prevailed at the polytechnic in the early years and that made it impossible for the director to continually supervise the pupils.[208] This changed in 1863/64, when Semper's magnificently designed building gradually became operational. Soon after, however, authorities and pupils began to collide on the premises. As the summer semester of 1864 drew to an end, "repeated complaints" from professors, janitorial staff, and passers-by about students climbing on the window parapets led then director Pompejus Alexander Bolley to mount a "bulletin board" campaign appealing to the students' sense of honor and decency. Walls, furniture, and equipment "are so rapidly and thoroughly trashed that one would never know that we have recently moved into a brand-new building." The entire student body must unite to stop such "childishly willful or maliciously motivated individuals," said Bolley, and threatened to make the perpetrators personally liable for the damages.[209]

In the following days, events escalated.[210] The pupils reacted to the director's appeal with outrage. The first announcement was scribbled over with comments and graffiti; a second copy, behind glass, demolished after a blow to the glass. A renewed appeal by the director provoked "a riotous assembly in front of the bulletin board." The students organized themselves and put a six-member committee at their head. Despite a number of talks and attempts at meetings, the situation deteriorated. A crowd of pupils and Director Bolley clashed violently, after which, in a joint letter, 329 of the total 504 pupils declared their imminent withdrawal from the polytechnic. Only if Bolley resigned would they reconsider their decision. The School Council, assembled hastily by telegram, responded with an ultimatum: The rebellious pupils had twenty-four hours to disband their committee and return to classes. When they refused to give in, the members of the committee were expelled as "ringleaders." All the petitioners stood by their signatures and turned their backs on the school.

The crackdown on the refractory pupils was welcomed by the public and supported by politicians. Neither the Federal Council nor the Council of States nor the National Council was willing to consider the appeal lodged with the federal government and parliament by the pupils against their expulsion. Like the Council of States, the majority of the National Council committee approved the action of the school authorities, believing that "a very dangerous atmosphere [had] developed at our polytechnic," an "atmosphere of unaccountability and mischief." A minority of this five-member committee, comprising Philipp Anton von Segesser, leader of the Catholic conservatives, and – at the other end of the political spectrum – the radical Wilhelm Klein, of Basel Stadt, cited gaps and inconsistencies in the school authorities' report. Their observations bound these two ideological opposites in a similar uneasy conclusion: "An in and of itself not very important dispute would never have led to such a break between the pupils and the school authorities were not deeper problems lurking beneath the surface," they observed, asking whether "the school administration had perhaps already lost its moral upper hand before the hostilities began, its only remaining recourse being punitive and bureaucratic ... In all well-managed institutions of this kind," the administration primarily seeks indirect ways of "influencing the minds and attitudes of the pupils in their care ... Indeed, the self-government that one cannot yet expect of our young engineers is instead developed through a kind of self-censure that generally regulates public opinion among the pupils, discourages fashionable excesses, and avoids anything that could bring dishonor on the institution or its students. Unfortunately, the report is silent on whether and to what extent any steps were taken in this direction."[211]

Von Segesser and Klein had discerned that the barely ten-year-old polytechnic model of governance prevailing in mid-1864 was already fracturing. The program and exercise of guided and self-discipline at the school was out of kilter; "self-censure" was not working. In the end, what upset the balance of discourses and institutions, of actors and artefacts, of imputations and self-perceptions, and sundered the web that wove these elements together, was not Bolley's clumsily worded bulletin board attack. Rather, as the expelled pupils themselves put it, his response provided a spark "sufficient to ignite the long-simmering fire of discontent."[212]

The destabilization of the status quo had three main components. First, since Easter 1863, the concentration of the institution's activities in the Semper building had sharply increased interactions between pupils and administrators. The acts of vandalism were hardly just "childish" nonsense, but represented the discomfort of the pupils vis-à-vis the new spatial arrangement. Second, latent tensions contributed to the unequal treatment of polytechnic pupils and university students, as disciplinary issues generally and in particular duels made clear. Since 1864, when the university had moved into the south wing of the Semper building, different rules of conduct applied under the same roof. The third point of contention was the lack of academic freedom. An open choice of subjects was not a privilege enjoyed only by Zurich university students; the practice was also being increasingly adopted at the German polytechnics also introduced the practice. Academic freedom was a trend of the times. Since in day-to-day life at the university it primarily meant attending a course in, say, elementary mathematics voluntarily rather than being required to do so, it symbolized the status of the student as an independent social being. Ultimately, the ability to choose implied the freedom "to fail at the university," and to be punished for negligence not directly but indirectly through denial of academic success.[213]

In 1864, the expelled pupils celebrated their exit with a boat ride to Rapperswil at the other end of the Lake of Zurich.[214] The institute recovered from the departure of two-thirds of its pupils without too much difficulty. The crush to get into the school during these years was significant, so much so that by the winter semester of 1865/66 enrollment had again swelled to over 500.

Socialization

Academic freedom fit very nicely with the widely held middle-class ideal of self-determination. However, the federal polytechnic's president, Karl Kappeler, proved immune from the German tendency to greater liberty to choose. At the beginning of the 1870s, he wrote: "The question of the best way to organize a higher technical education institution is difficult and never-ending! Nor do we wish to rule out any alternative approaches in future. But our observations thus far recommend that we continue full speed ahead and unwaiveringly on our current course."[215] At the end of the 1880s, Kappeler had not changed his tune. "In Switzerland, we believe that expecting youth to fulfill their obligations is the right thing to do, and honors them, rather than oppresses them. If our sons wish to become independent men and citizens, they must learn early on to be responsible. Real work comes first; that's what brings real freedom,"[216] he wrote in an 1879 School Council argument on academic freedom.

At the opening of the engineering school pub, around the same time, a pupil at the polytechnic expressed himself quite differently: "Switzerland is free. Good Mother Helvetia provides diligently for any and all rights for her beloved citizens. Only the poor pupils of the polytechnic appear to require overzealous minding. How else to explain the unbearable requirements that destroy a student's right to self-determination among his professional peers, drain energy, quash all intellectual impulses, and through summonses and threats of expulsion nearly frighten to death the poor student who simply wishes not to sacrifice all his efforts to this or that subject area! Are not most of us voting citizens? Are not many of us Swiss soldiers, even officers? And yet our government wishes to deny us the ability to choose and to learn, and constrains our education with the tightest of shackles!" Nonetheless, he said, a sharp wind was making itself felt within the halls of the polytechnic, "that with piercing whistles whips about the basic pillars of our school, causing them to totter ... We live in turbulent times! Yet from the strife will emerge the ideal of every true polytechnician: academic freedom, a shining, beneficent star rising over our school and showering its students with the fruits of their labor. The system must fall; it does not tolerate joyful growth, and consequently, our recovering self-esteem cannot tolerate the system."[217]

In spring 1878, the *Verein der Polytechniker* (association of polytechnic students, rechristened *Verband der Polytechniker* in 1889) was founded. The motto inscribed on its banner read "Freedom and dignity for the student body." Rather than the scientific aspirations and social life promoted by earlier, mostly short-lived student associations, the newly formed association emphasized "energetic and successful representation of our overall interests." In the first year of its existence alone, 332 of the polytechnic's 480 pupils joined the society; 125 of them traveled together to the Paris World's Fair.[218]

As measured by the number of pupils in the 1880s and 1890s, the relatively low incidence of disciplinary cases indicates a thaw in relations between the school authorities and the student body. Apparently, notions of the proper balance between guided and self-leadership were slowly converging. Even the language of the administration changed. "Pupils" became "students," and the heading of the "Diligence and Discipline" section in the annual report was replaced in 1890 with "Student Conduct and Performance." Increasingly, the administration perceived members of the *Verein der Polytechniker* as proper student representatives. Formal recognition meant having the School Council approve new statutes in 1903, which required all polytechnic students to make an annual contribution to the association.[219]

In addition to this broad-based association, individual divisions gave rise to specialist societies as well as interdivisional associations based on national or regional criteria or a recreational activity such as the *Polytechniker-Ruderklub* (rowing club).[220] The few figures available indicate that in the decades before the First World War, about half of the stu-

Mass drinking on command and into the wee hours. The *Kneipen* (students' ceremonial drinking sessions) organized by the student associations, and sometimes frequented by professors, were places of ritualized consumption of beer. An invitation card for a Christmas drinking event. Around 1900.

dents were involved in these societies. Membership offered the opportunity to exchange knowledge, and more especially to participate in group leisure activities. A separate sphere of university life grew up around pubs, free from the pull of the "system." "While so much of what was formerly beautiful about student life has been destroyed by the system, these pubs have remained our refuge."[221]

Most of the student societies modeled themselves on German fraternities, with the wearing of the colors generally limited to the executive committee. The pub as meeting place was in many respects the center of social life. Here, the rules of the "beer state" were enshrined in "beer comments," which prescribed first and foremost ritual forms of excessive consumption of alcohol. The collective loss of control temporarily obliterated the large differences in geographical and social background of the members. In the nineteenth century, the character of the student body at the polytechnic was interregional and international: pupils came from all areas of Switzerland, from many parts of Europe, and even from America and Asia. We know much less about their social origins, although the distribution of scholarships and tuition fee waivers by the administration shows that pupils from poor backgrounds also came to the polytechnic. From 1855 to 1871, one in every ten pupils received a tuition waiver, and one in fifty received a scholarship.[222]

Leaving home behind was often accompanied by submitting to the rigid internal hierarchy of student associations. Social integration came at the price of ritual self-conquest to the point of self-sacrifice. The social discipline of clubs, societies, and associations extended the academic discipline of the tutorials and in the laboratory. Here, as there, one had to learn to get the better of oneself, to conform and submit to a program, be tested, and make one's way through the system.[223]

"The Polytech's the kind of place,
That holds you in a cold embrace,
You learn things theoretical
That to life are parenthetical
I do declare!

Pity the poor student,
At year's end he's barely sentient,
The devil himself designed the curric'
At the Po- Po-* Polytechnic.
I do declare!"

First and last stanzas of "At the polytechnic" from the fiftieth anniversary songbook. Pictured is the *Akademische Forstverein* (Academic Foresters' Club), 1905.

The beer state constituted not only a complementary alternative world to that of the university. It was also a parody of middle-class society. In the sheltered, socially tolerated space of the student society, one could dispel loneliness, drown one's academic sorrows in alcohol, test one's mental and physical limits, as well as (from a safe remove) practice the sincere insincerity of male sexual identity and the civic virtues of self-control and leadership. Almost incidentally, one also made valuable contacts for one's future professional career.[224] In their songs and beer newspapers, the students made fun of life at the polytechnic, all the while identifying with the school. In their social function, these student societies resembled another, more broadly inclusive instrument of socialization: the military.[225] Naturally, military and student societies were male fraternities; women were excluded.

* A play on the German slang for "rear end." [Trans.]

Assistants Georg Schudel and Eugen Wulkan, working in the chemistry laboratory, around 1917. Mandatory singing of the "Rules for Chemists," instituted in 1906, killed, as it were, the two birds of academic discipline and socialization with one stone:

You'll have to weigh out milligrams,
Until the scales are tipped just right,
Keep your filter spic and span,
Wash it every day and night.
If such tasks you wish to shun,
Find another job, son…

Cacodyl and other things
Are evil beyond all compare,
Chlorine, iodine have a sting,
While bromine lingers in the air.
If that's enough to make you run,
Find another job, son.

To keep from poisoning yourself,
(Though what a bore! I sympathize)
Read all those chem books on your shelf,
Or ignorance'll be your demise.
Cyanide! It's reason number one,
To find another job, son.

Gender and the polytechnic

The extent to which middle-class gender roles and their attendant inequalities were entrenched in nineteenth-century Switzerland is clear from the confidence with which the newly founded state denied women political rights. In contrast to the exclusion of Jews, the exclusion of women in shaping the political collective post-1848 entailed no discussion.[226] The state did not anticipate that girls and young women would attend cantonal secondary schools let alone complete higher education. As Federal Councillor Frey-Herosé said in his opening speech, the polytechnic should take into account "the requirements necessary for an educated *man,* and in particular a republican."[227]

When, as here, university training is linked to political participation, it was small step to intrinsically connecting the exclusion of women from both higher education and political rights. Taking into account the Swiss case, however, this connection is not as straightforward as it might seem at first glance. In Switzerland women's rights in these two spheres evolved rather differently over time than they did in other European countries. Whereas women in most industrialized states were granted political rights in the interwar period, in Switzerland women had to wait until 1971 for electoral and voting rights. In contrast, Switzerland was ahead of other countries in admitting women to higher education. In 1867, the University of Zurich became the first state-recognized university worldwide to grant a woman a degree. By the end of the 1870s, the federal polytechnic and all Swiss universities opened their courses to women (except for Basel, which followed in 1890), opened their courses to women. French universities allowed women in 1890. German universities remained closed to them until the turn of the century. Munich, Germany's first technical university, began to admit women in 1905.[228]

The early opening of Swiss universities to women students may be explained by the fact that the first entrants were nearly all exclusively foreign students, who were hardly integrated in their place of study and thus posed no threat to the middle-class gender order. Marie Vögtlin, the first Swiss woman to register at the University of Zurich in 1868 and to pass the state exam in medicine in 1873, was an exception. In the 1870s and again in the 1900s, enrollment of women at the University of Zurich increased sharply. The vast majority were still foreigners, especially Russians. A peak was reached in 1908, when 397 women were studying at the university, corresponding to 27 percent. Among this group, only 51 were Swiss nationals. In the following two decades, a diminishing number of foreign women students came to Zurich. Although within twenty years the number of Swiss women students increased fourfold, after the First World War the proportion of women sank to under 15 percent.[229]

Developments at the polytechnic unfurled in a similar manner, albeit with far fewer numbers. After several years of experience with individual women students from the university, who audited courses and used the shared collections, in winter of 1871/72 the Russian Nadina Smetzky became the first woman to enroll in one of the programs. The

Professor Eugen Bamberger teaching with his assistant Adolf Hill. Sitting in the second row are two young women, most likely Margarete von Uexküll and Marie Baum. The photograph was taken in 1896.

following year, the institute boasted four women, which moved School Council president Kappeler to include in his report for the 1873 Paris World's Fair a paragraph on the "admission of women to the divisions." "In the general studies courses (such as history, literature, and so on) ladies were not excluded as auditors … In recent times, however, we had to decide whether to accept ladies as regular pupils. The authorities have since answered the question in the affirmative. Of course, no special provision is made for acceptance. Ladies must pass all the entrance examinations. For this reason, and also because women prefer to study medicine, registration up to now has only been sporadic … So far there have been no problems. Naturally, if the numbers were to increase, or the school to be inconvenienced, teachers and administrators would reserve the right to reconsider the question."[230]

They never had to. The stream of women to the polytechnic remained narrow. In the 1870s and 1880s, the only attendees were Russian and German. In the mid-1880s, a woman was finally admitted to a degree program, and in 1877 a diploma was awarded to a woman for the first time.[231] The low enrollment alone was enough to lay to rest the imagined "inconveniences" or fear of risk occasioned by "females." In contrast to the university, women at the polytechnic could be treated as a negligible quantity or simply overlooked.

Sex differences in attendance at the university and the polytechnic reflected the strong association of technology with "male." Engineers viewed technology as a heroic male task of dominating nature. Nature in turn was ascribed female characteristics. Carrying

Obvious allocation of roles: The engineer as bridge builder for the "weaker sex." The postcard may have been drawn by later Federal Councillor Karl Kobelt (head of the Department of Defense from 1941 to 1954). Kobelt studied civil engineering at the ETH from 1910 to 1914, and in 1917 obtained his doctorate in engineering sciences. In 1913, he chaired the *Akademischer Ingenieur-Verein* (Association of Civil Engineering Students).

out engineering work required "male" virtues: rigorous and exact thinking, perseverance and will power, imagination and creativity.[232]

In the social perception and treatment of technology, in the imaginary worlds of men and women, these discursively produced gender characteristics were deeply engrained; they seemed "natural." Indeed, for decades, the small number of women students at the polytechnic – under 5 percent – was accepted "as a matter of course."[233] Just as "natural" was the fact that most of the women students opted for pharmacy: of the 51 Swiss women students who passed the diploma exam up to 1927, 37 were pharmacists.[234] Until recently, the gender segregation of technology has hampered efforts to increase the proportion of women in the engineering disciplines.

The long period of growth that began in the late 1880s and lasted up to the First World War, brought changes in gender roles. Women increasingly managed to obtained skilled professional positions. The middle-class women's movement was organized and addressed the social status of women. At the turn of the century, girls in the canton of Zurich were able, for the first time, to earn a *Matura*.[235] As a mark of growing class antagonism and incipient industrialization, but in parallel with the emancipatory aspirations of the middle-class gender discourse, the classification of the male and female sexual character crystallized. "In male-dominated fields such as politics, the military, and the university, a veritable virilism, i.e., a masculinization of models and practices,

Just one year after awarding its first doctorate, pharmacist Hedwig Delpy became the first woman to receive a doctorate, in 1910. The photograph, which dates from 1909, shows Delpy to the right of Professor Karl Hartwich in the pharmaceutical laboratory. Pharmacy was the field of study that attracted the highest number of women.

gained ground."[236] Forced "masculinity," as was common in the military and the student societies, was intended to immunize patriotic citizens and thus the social body against the imagined dangers of modernity, against degeneracy and nervous disorders, as well as to strengthen both the workforce and the defense capability of the country. [237]
Under these circumstances, women had a difficult time venturing into male domains. Such was the experience of Marie Baum, the first female assistant at the polytechnic.[238] In autumn 1897, chemist Eugen Bamberger's proposal to hire the 22-year-old German woman, who had obtained a diploma in natural sciences from the school, provoked serious consternation among the administration. The School Council president asked Bamberger whether perhaps "another qualified person among the graduating male students or at least of Swiss origin might not be found." Only when Albert Heim, professor of geology and the husband of the first Swiss woman doctor, Marie Vögtlin, lobbied energetically for Baum and chemistry students petitioned for her to stay, did the authorities definitively appoint her.[239] After obtaining her PhD in 1899 and armed with letters of recommendation from her professors, she applied to the Basel dye factories for a position. However, she was consistently told that in general "women are ill suited to the rough air of the factory." "Women" apparently referred only to middle-class women,

for in hiring female blue collar workers the bosses paid such considerations no mind. Shortly thereafter, Baum found a job in the patent department of a chemical firm in Berlin.[240]

The close associations between man, voter, and conscript soldier that existed both on a symbolic level as well as in the socialization of young people, effectively and enduringly kept women academics in Switzerland out of positions of leadership despite their early admission to the university. The association of "*Männerbund und Bundesstaat*" (male fraternities and federal authorities)[241] excluded women not only from politics but also steered them professionally to peripheral positions and traditionally female occupations. Even the faculty of the ETH Zurich long remained a male bastion. Although the first woman lecturer at the federal university worked with mineralogist Laura Hezner prior to the First World War already, it would be a good forty years before another appeared. The first female full professor at the ETH was appointed only in 1985.[242]

1905–

3. *Setting a* NEW COURSE: *The* POLYTECHNIC *becomes a* "REAL" *university after 1908*

Patrick Kupper

1911

"The ceremony was held at the end of the summer term. Its modest republican style and simple dignity took on a greater sheen in the glow of the participants, who included delegates from the federal parliament, the Federal Council, the federal court, the international agencies, the federal railways, the cantonal education authorities, the universities and secondary schools, and the officials of the city of Zurich. Scores of former students were on the scene, reaffirming, through their presence, their connection to the federal polytechnic, and together with the authorities, teachers, current students, and countless other friends rejoicing in the growth and prosperity of the Swiss institute (*Hochschule*)." Thus read the account of the polytechnic's jubilee celebration in the school's annual report of 1905.[1] The *Neue Zürcher Zeitung* called the ceremony dignified, and commented approvingly that no government money had been frittered away on fireworks for the amusement of spectators. In so doing, Zurich set itself apart from the lavish ceremonies exemplified by the Royal Technical University in Berlin only a few years before, on the occasion of its one hundredth anniversary in 1899.[2]

The student associations also issued invitations in connection with the fiftieth anniversary jubilee. An invitational postcard to the students' ritualized drinking session (*Kommers*) hosted by the *Verband der Polytechniker* on 30 July 1905.

Delegates from the divisional and national students' associations posing on the day of the celebration before the main door of the polytechnic. Photograph taken on 29 July 1905.

Whereas the event in Berlin was as much about imperial power and glory as it was about technological progress, Zurich's reflected "republican straightforwardness" and federal structure. Against this backdrop of modesty and austerity, the object of the commemoration was thrown into even sharper relief: "If Switzerland today has become a wonderland of technology, and boasts the most important developments on its home soil, it is in no small part due to its advanced engineering schools," gushed Wilhelm Oechsli in a Festschrift commissioned by the Federal School Council.[3] Weighing in at four hundred pages, Oechsli's *Geschichte der Gründung des Eidgenössischen Polytechnikums mit einer Übersicht seiner Entwicklung 1855–1905* sported a leather binding and gold trim. Together with a second, shorter volume documenting Zurich's architectural development, Oechsli's history was published to coincide with the July 1905 events. A portion of the government monies set aside for the festivities went toward making the Festschrift available to participants at a reduced price, in some cases even for free.[4]

In contrast to the awkward birthing of the institution fifty years earlier, the jubilee was carried off with great aplomb. Much had been learned in the five intervening decades about staging events and orchestrating the nation. The numerous guests were received on a Friday night in the Waldhaus Dolder. The "official day" followed on Saturday, 29 July.

The menu for the main banquet was printed in several versions. This one shows the emblem of the mechanical engineering division, in the center of which is a flywheel with a mechanical governor. To the left is a cog, and to the right a turbine.

It opened with a procession of 2,000 people. As canons thundered and bells clanged, the gay yet orderly parade – complete with marching band – made its way from the polytechnic down Leonhardstrasse and Weinbergstrasse, across the Bahnhofbrücke, along Bahnhofstrasse, and over the Quaibrücke to the festival hall, which it entered punctually at 11 o'clock.[5] "In view of the stage was a magnificent tableau; to the rear, against a backdrop of Alpine scenery, stood the members of the musical society and the men's chorus, whose performances opened and concluded the ceremony; in front, filling up the entire stage and extending off to the sides both left and right were the representatives of the student associations with their colorful flags, and below the picturesque rows of bailiffs."[6]
Robert Gnehm, president of the School Council; Jérôme Franel, director of the polytechnic; and Otto Sand, president of the GEP, gave speeches, after which the choral groups sang "*O mein Heimatland, o mein Vaterland* (Oh, my homeland, Oh my fatherland)." Among the 1,200 invited guests at the banquet in the *Tonhalle* (Zurich concert hall), spirits ran increasingly higher as the day wore on. Several speakers could hardly be heard. Toastmaster Colonel Naville's repeated calls of "*Silentium!*" failed to quiet the merriment of the student groups.[7] Toward evening, a concert took place in Belvoir Park, after which all the guests piled onto steamers and smaller boats for a ride into the twilight on the Lake of Zurich. On their return, the passengers were treated to a special lakeside light show and a gondola race. The dramatic climax of the evening came at the end: "As the delightful events slowly drew to a close, the bright lights illuminated the polytechnic, whereupon a cheer broke out on the steamships, then spread to the boats before dying away."[8]
The evening's elation was still palpable at the concluding "rendez-vous" in the *Tonhalle*. Nonetheless, participants and careful observers alike took away other, more ominous

Title page of the students’ fiftieth-anniversary issue of the *Bierzeitung*. The cats gathered at the base probably represent the “caterwaul” – the traditional singing of comic songs.

impressions. When the day was still bright and the guests still sober, a few cracks were perceptible in the neatly spruced-up, decked-out façade of the polytechnic. In unusually sharp words for such an occasion, the school’s leading representatives had themselves voiced concerns about the current situation of the institution. Newly elected school president Gnehm, for instance, began his commemorative speech as expected by recounting the history of the polytechnic in glowing terms but ended with a decidedly thoughtful “look at the present and the future”: “We must confess that we anticipate the coming days with serious concern. Questions of profound importance that will determine the course of our institute must be dealt with.”[9] Gnehm was followed by Franel, who used the podium to campaign for a fundamental reorganization of teaching methods. The audience might have wondered what compelled these speakers to abandon tributes befitting the occasion in favor of a lecture on the pressing issues of the moment.

The polytechnic in crisis

Gnehm and Franel had every reason to be concerned. Fifty years into its existence, the federal polytechnic was at a crossroads. Critical reforms had been blocked time and again. In the annual report of 1903, the School Council had written of pending issues “whose solution will greatly influence the course and future development of the federal polytechnic. At stake are the reorganization of the school and the question of space, as well as the matter of disentanglement from the canton and the city of Zurich.”[10]

Neither of these issues was new. Gnehm’s predecessor, Karl Kappeler, had labeled the quest for the ideal organization a “never-ending enterprise,” and complaints regarding the “shortage of space” were a perennial feature of the institution’s annual reports. At the turn of the century, however, these problems took on increasing seriousness and urgency. Among the catalysts of this intensification were two events that both occurred in the nineteenth century. The first was the School Council’s decision in 1898 to dissolve the joint scientific collections of the polytechnic and the university, a termination opportunity that came only once a decade. The second, external event was the German emperor’s decree in autumn 1899 that Prussian technical universities be allowed to award doctoral degrees. These events set in motion processes that called in question the appearance as well as the inner organization of the polytechnic, and both were to some extent contingent: the termination dates of the collections contracts had been set decades earlier, and the German emperor's decision resulted from the very intense and ultimately persuasive efforts of a small circle of people.[11] The processes unleashed, however, were not contingent, because the dates and events that triggered them had no intrinsic meaning: rather, it was projected onto them. In other words, the fact that these events opened up space for action, which the actors were able to translate into options, was preconditioned. The transformation of the polytechnic in the beginning of the twentieth century sparked several decades-long developments. Three closely intertwined processes were particularly significant: first, the development of engineering as a bundle of disciplines that were independent yet based on shared scientific standards; second, the increasingly academic nature of technical higher education and the adaptation of the structure of the polytechnic to the university model; and third, the widespread, increasing importance of engineering and science in the wake of industrialization and the concomitant higher social status and greater sense of entitlement on the part of engineers and technicians. These three developments combined with economic conditions to give rise to a chain of events that unfurled after 1900.

The polytechnic's growing appetite for space was further stimulated by the surge in demand for higher engineering studies as well as for classical university education. Following a low point in the 1880s, enrollment at the polytechnic regained its upward swing.[12] However, the greater number of students was only one reason for the space shortage and – despite the contemporary appeal lamenting "overproduction" and "the creation of a proletariat of engineering professions"[13] – not the most important.

The differentiation of disciplines, the opening of new fields of activity, the movement of science and engineering from the classroom into the experimental laboratory, as well as the greater emphasis on research and the scientific method in education substantially influenced space considerations. As the School Council wrote in a report to the Federal Council in 1898, "Along with the increase in space requirements, laboratories and workshops are proliferating which, as a consequence of the changes in teaching methods in the natural sciences, now must supplement work in the collections to a greater extent than ever before."[14] A few years later, then director Gnehm rejected suggestions that the space problem could be resolved by restricting admission. "The truth is that the future of our institute does not rest in trivial, inadequate, or even objectionable measures to reduce the number of students to a few dozen or perhaps 100, and thereby temporarily remedy the most urgent space needs and other defects. For it requires entirely other solutions if it is not to tumble from the honorable rank that it has claimed for a half century. The inexorable progress of science and engineering calls for new directions and new disciplines that we must find a hospitable place for."[15]

In the pursuit of the right to confer doctorates, all three streams of development mentioned above came together. The PhD symbolized at once scientific and academic equality, and social recognition. In April 1900, the *Schweizerische Bauzeitung* published a four-stanza poem in defense of the "Doktor-Ingenieur." Borrowing freely from Goethe's *Faust,* the author poured forth under the pseudonym "Biedermeier":[16]

Up to now only Philosophy
And Jurisprudence, Medicine,
And even, alas! Theology
Entitle one to a PhD –
As if somehow an engineer
Cannot be learned – oh, how queer!

I have to say, it tries my nerves
As it would anyone who observes
What our technical art and talent
Fetches on the open market!
I ask you, without the engineer
How would we get from there to here?

In the PhD debate as well as in the soon-to-erupt discussions regarding academic freedom, the engineer's new self-confidence played a major role. After the fiftieth anniversary celebration left the way forward on the issue unresolved, a polytechnic student wrote in the *Neue Zürcher Zeitung:* "And yet, the introduction of academic freedom is the crux, the factor that will decide whether the institution opts for another fifty years of productive development or whether, despite all the material resources it has invested, it prefers to atrophy. Because conditions are different than they were fifty years ago. The engineer is no longer forced to accept the humble role of servant whose work is dictated by his boss. He can summon on his own the creative power that fuels the inventions suited to the spirit of the times and its needs, and that is capable of seeing far beyond the obstacles of the present moment. He is the country's leader of the future."[17]

The polytechnic in its traditional form could not longer meet the scientific and social requirements expressed here and in many other texts. The widespread introduction of the right to confer doctorates (*Promotionsrecht*) in the technical universities of the German-speaking countries, which constituted both the high point and the formal resolution of their emancipation movement, only accentuated the inconsistent status of the Zurich polytechnic. In addition to its lack of a university degree and academic freedom, the institution also could not grant PhDs. Consequently, its well-established position as a leading technical university in the German-speaking world was threatened in two ways: the failure of internal reform was as detrimental to its international reputation as was the shortage of space to its claim to be one of the best-equipped technical universities.[18]

At the time, the full significance of these fateful developments was not lost on the polytechnic. However, the school was at very great pains to solve the problems. For years the reforms made no headway. A breakthrough in available space and in reorganization came only in 1908; three years later, in 1911, the polytechnic was renamed Eidgenössische Technische Hochschule.

What factors stood in the way of the long sought for and ultimately completed reforms, and how were they finally accomplished? The following section examines these questions, with regard first to the so-called disentangeling *(Aussonderung)*, and second the

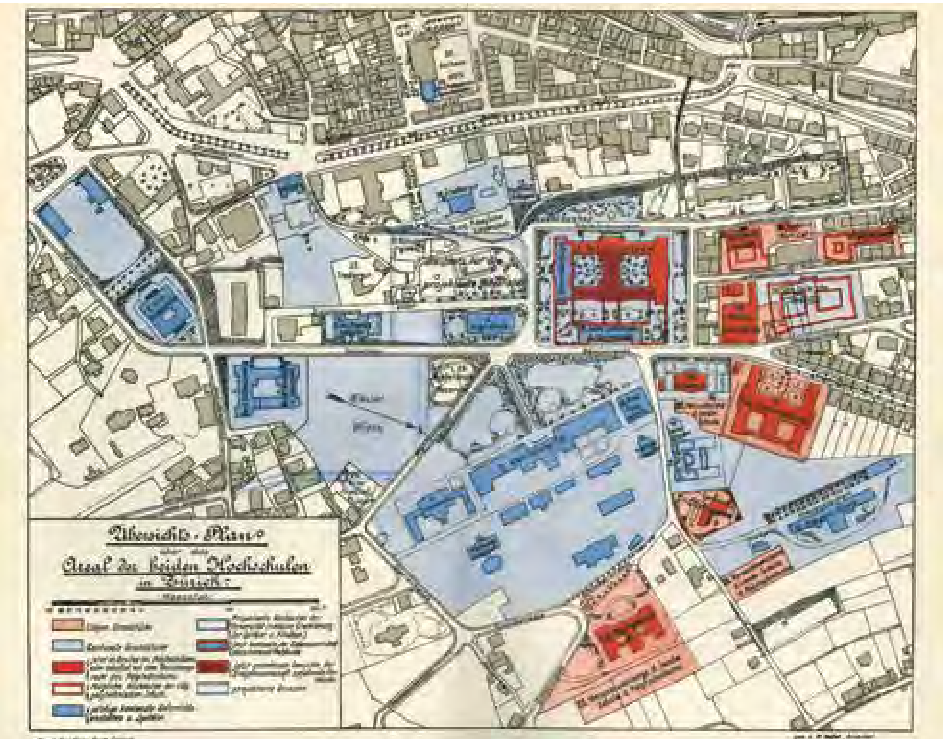
The buildings of the polytechnic at the beginning of the 1900s. The observatory is not shown. Undated postcard.

comprehensive institutional reorganization comprising the PhD, the reform of the school regulation, and the change of the school's name.

Disentangling

In 1906, the Federal Council submitted to parliament a proposal to terminate a 1905 agreement with the canton and the City of Zurich, "whose purpose was to fulfill the legal relationships created by Art. 40 of the federal law of 7 February 1854." The Council's rationale for the rearrangement was that the article had in short order become a shackle, frustrating any attempts to solve the problem of space shortage. "The current submission seeks to liberate the institute once and for all."[19]

The "space shortage" was thus not a new phenomenon, but a decades-old problem that despite the acquisition of additional buildings and extensive construction of new ones cropped up repeatedly in response to the growing needs of the school. However, certain periods stand out in which the chronic complaints about space reached a level of distress that appeared to threaten the future. At such times, attempts were made to change the statutory provisions. Article 40 of the founding charter of 1854 had stipulated the services that Zurich was to perform as the seat of the institute. These included, in particular, providing and maintaining the premises and making the university's exist-



"Survey map of the area occupied by the two Zurich universities" from 1907. Prior to the disentangling in 1908, the university and polytechnic facilities as well as cantonal and federal lands had many areas of overlap.

ing scientific facilities available to the federal institute. The rapidly growing demands of the polytechnic were accompanied by increasing differences between the federal and Zurich authorities about how to interpret the legal mandate and who was responsible for which extensions. An initial adjustment that allowed the canton of Zurich to buy its way out of future construction obligations was concluded in 1883 after clashes that had persisted over almost ten years. This agreement finally enabled the polytechnic to tackle a long-cherished expansion project: in the 1880s, physics and chemistry were given new buildings along with the materials-testing facility.[20]

Fifteen years later, in 1898, the School Council was again forced to seek a realignment of relations with the canton and the city of Zurich. In contrast to 1883, this time the School Council was not looking to remedy an unsatisfactory relationship through reform but rather to completely cut its institutional and infrastructural ties to the city, canton, and University of Zurich for the foreseeable future. Its first target was the scientific collections it shared with the university. After the new building for the mechanical engineering school became operational in 1897, the School Council considered the issue of the collections its most pressing priority. Although the polytechnic's annual report for that year referred to bottlenecks in different laboratories, genuine complaints appeared only under the heading “Collections.” “Many, in some cases significant, gifts have once again been contributed to their enrichment. On the other hand, the question of sufficient space has forced us to a definitive solution. The prevailing space considerations … also inhibit … the establishment and implementation of practical training for students, which is indispensable for instruction in the relevant sciences and with which less prestigious schools are better provided.”[21] By the same token, the time was ripe for seizing the initiative vis-à-vis the collections. The relevant contracts with the canton and the city of Zurich dated from 1859 and 1860. Both had a ten-year timeframe, after which they were automatically renewed for another ten years, as long as neither side had given notice, by prior year, that it would opt out. This meant that the cancellation period for the older of the two agreements was expiring.

In summer 1898, the School Council submitted to the Federal Council a four-point proposal that envisaged the stepwise decoupling of the polytechnic’s infrastructure from the University of Zurich as well as a clear allocation of responsibilities between the federal government, canton, and city of Zurich. First, the federal government would be asked to cancel the agreements from 1859 and 1860. In a second step, these would be replaced with new agreements dissolving the joint collections, with the geological-mineralogical collection being transferred to the polytechnic, and zoology to the university. Third, the university (and the zoological collection) would vacate the polytechnic’s main building; and finally, the entire main building, including the adjacent buildings, as well as the forestry and agriculture school would be taken over by the government for the exclusive use of the polytechnic.[22]

The Federal Council agreed to this scheme in September 1898, and annulled the collection agreements. In 1899, negotiations began between the School Council and the Federal Council on one side, and the canton and the city of Zurich on the other. The parties agreed quickly on the basic strategy for disentangling the institutions. The move was in the interest not only of the polytechnic but also the university, whose plans for expansion had been hindered by the existing regulations. Conversely, as year after year the two institutions fought over the increasingly untenable situation, a lengthy tug of war ensued over the implementation of the decoupling, in particular concerning distribution of the resulting financial burden. Much time passed before even a provisional arrangement could be hammered out, followed by countless rounds of negotiations over the separation agreement of 28 December 1905 cited in the Federal Council’s proposal mentioned above. It took roughly another two years before a polished version of the agreement went into effect in 1908. Several lingering points of contention were not resolved until 1914, and by arbitration.[23]

But the polytechnic’s perseverance had paid off. The objectives of 1898 were fully achieved. The separation agreement clearly allocated property rights as well as responsibility for construction, installation, and maintenance for buildings and collections.

As foreseen, the university took over the zoological collection, whereas the polytechnic acquired the mineralogical-petrographic collection. The main building, chemistry building, forest and agriculture building, as well as the former Seiler brewery and the surrounding areas became the federal property.[24]

The polytechnic's annual report of 1908 acknowledged the new agreement as a milestone in the school's development. "Difficult and lengthy negotiations over a full decade have come to an end; clarity has replaced confusion, and the barriers that for too long hampered development of the two universities can and now must fall. A new and important step in the battle for space has been reached; a bright future has opened for teaching and research."[25] Two decades later this assessment remained unchanged. "[The agreement] clarified matters in a way that, for the E.T.H. as for the university, made the long-awaited freedom of movement possible," wrote Robert Gnehm in the mid-1920s.[26] Actually, in the years following 1908, both the polytechnic and the University of Zurich were able to undertake major expansion projects. The "bright future" predicted by the annual report was thanks not only to the separation but also to the revamped rules and regulations that were introduced in that same year.

Few of the shared collections of the polytechnic and the University of Zurich were as carefully presented as the main geological collection, in this photograph from 1900. More often, the "impression was one of warehouses jammed to the rafters than purposefully arranged scientific display" (SR1: Schulratsmissiven 1898, No. 234, Schulrat an EDI, 241).

Reorganizing the polytechnic

Reform efforts at the polytechnic after the turn of the century came during a restless era. Just when researchers had concluded that everything worth discovering was already known, a series of pioneering developments caused the traditional scientific world view to collapse within the space of only a few years. Following the conclusion of his studies at the polytechnic, as he was eking out a living in Zurich giving private lessons, Albert Einstein received a 15-year-old book on ether theory from a friend and wrote his future wife Mileva Maric about it: "One has the impression that it was published in antiquity; the observations are that old-fashioned." Four years later, now a clerk at the federal patent office in Bern, Einstein revolutionized Newtonian physics with the publication of his theory of relativity. At the same time, he put paid to the then prevailing theory of the ether, which was believed to be an all-pervasive medium. Even before the outbreak of the First World War, the theory of relativity, along with Max Planck's introduction in 1900 of quantum theory and Ernest Rutherford and Niels Bohr's new atomic theories (based on the discovery of radioactivity by Antoine-Henri Becquerel, and Marie and Pierre Curie) became the cornerstone of a whole new body of science.[27]

But science had no monopoly on the dismantling of age-old ideas. Expressionism tapped into a profound malaise of modernity, an uneasiness that was not confined to art. Tension and haste, sensory overload and meaninglessness were all phenomena much lamented at the time. Fears of degeneration and neurasthenia were widespread. When, in his anniversary address of 1905, Otto Sand, president of the GEP and director-general of the federal railways spoke of "premature nervous conditions" among the young owing to excessive academic workloads at school, he gave voice to a topic of broad concern. For it was especially the young, looked to as a wellspring for society, who were believed to be most susceptible to the dangers of the time.[28]

The First World War constituted a major historical turning point, and certainly the breakdown of Western civilization that it evidenced proved a traumatic experience with far-reaching circumstances. Already in preceding decades, however, nineteenth-century faith in technology and progress had begun to give way to a more ambivalent view of modernity, according to which growth of material wealth was not an unqualified good, and rationalization brought not only efficiency gains but also dehumanization. Accordingly, in the early 1900s, mechanization and the "disenchantment of the world" (Max Weber) gave rise to movements to protect land and nature, and to promote new lifestyles and religions.[29] At the same time, the integrative capacity of Swiss liberalism reached its limits, and class conflicts bubbled out into the open. The Social Democratic party doubled its membership from barely 10 percent up to 20 percent between 1899 and 1911, and in 1904 included class conflict as part of its platform. Unions grew stronger, and the number of labor disputes increased. In the two years following the Russian revolution of 1905, which was followed with lively interest in Switzerland, Zurich alone experienced over 100 strikes.[30] Furthermore, the economy, which had

Expressionism reflected a widespread unease with modernity at the beginning of the twentieth century. "Die Wahnsinnige" (The madwoman), woodcut by the Zurich sculptor Eduard Bick, 1915.

already stalled briefly in 1900, showed new signs of weakness that were reflected in the Swiss job market. Up to the turn of the century, polytechnic graduates were always in demand, even when the jobs they found did not quite correspond to their plans. Now periods of temporary unemployment became a familiar experience.[31]

Such was the social context that at the end of 1907 led eight engineers and an architect to form an action committee and to place an advertisement in the *Schweizerische Bauzeitung* inviting "Swiss academically trained engineers and architects" to a meeting in Olten. The main purpose of the gathering would be "to gain better appreciation of their profession in public life and in society." In particular, the initiators decried the "lack of protection conferred by the professional titles 'engineer' and 'architect.'" The danger "that the image associated to date with the possessors of such titles would continue to degrade, to the point where any Tom, Dick, or Harry could claim to be an 'engineer' or 'architect,'" had to be combated through "energetic action of academically trained engineers and architects. There is also dissatisfaction with the way the reorganization of the fed. polytechnic is being carried out, especially given how important it is to the future of academically trained Swiss engineers."[32]

According to a brief report in the *Bauzeitung,* "the participation as well as the fresh air that blew through the meeting" exceeded "even the wildest expectations of the founders … From Graubünden and Ticino, Geneva and Lake Constance, the Lötschberg, St. Gallen, and (most numerous) from Bern and Zurich, colleagues heeded the call to discuss our issues." The more than 200 entries on the attendance list and the letters of support received included "many of the very best names."[33]

The following two issues of the *Bauzeitung* reported extensively on the gathering. It began with a presentation by the founding committee, during which the members reiterated the fundamental issue, "that the status of engineers and architects in public and social life does not receive the appreciation that its importance in contemporary culture merits … The primary cause of this lack of recognition of engineers and architects is their lopsided education at the fed. polytechnical school, which trains outstanding specialists but not men who can be called upon to wisely shape the destiny of our people." Chief among the obstacles barring the way of engineers to leadership positions were insufficient knowledge of economics and commerce. "And because our education cannot happen without the long-recognized need for reorganization at the polytechnic, we have put that, too, on the program." The committee also accused the polytechnic of creating "a scientific proletariat through its current overproduction" and pointed out the "social significance" (this passage of the presentation the *Bauzeitung* quoted verbatim) of this development, that is, its revolutionary potential. Finally, the committee requested measures to protect the job titles of engineers and architects and pleaded for "increased collegiality, esprit de corps in the best sense," which is "the most effective means of improving the economic situation especially of our younger colleagues."[34]

In the "very lively" discussion that ensued, it was obvious that the men present shared a common view of the situation. Each of the action committee's proposed ways of improving the unsatisfactory conditions – educational reform, protection of titles, and professional solidarity – were supported, even though priorities on the floor varied.[35] The question of the polytechnic received the greatest attention. It was well known that the School Council had tried years earlier to get the Federal Council to approve the granting of PhDs and to revise the institute's regulations but that these efforts had come to nought. A polytechnic professor at the Olten meeting announced that just the evening before, he had received a draft of a new set of regulations. Gustave Naville, who was both president of the SIA and vice president of the School Council, added – to loud applause – that the relevant resolution had been unanimously approved by the School Council "and that reorganization was now under way."[36]

The news was all the more welcome as many in the room had questioned who was responsible for the long delay in resolving such an important matter. Both Naville and Arnold Bertschinger, president of the GEP, felt obliged to defend their organizations, and put the blame squarely on the absent Federal Council. Although Bertschinger's argument did not go unchallenged in Olten (and thereafter), the impulse to clarify the question of guilt was contained.[37] At the time, the incentive for settling old scores was low, insofar as the crucial issue was to work together to lay the foundation for a better future. However, the pressure on certain individuals at the Olten meeting to explain themselves is a provocative starting point for examining more closely the long latency period of the polytechnic's reform efforts. Why were they blocked for so long? And what had to change to remove the blockages?

An unsuccessful debate over doctorates

These questions lead back to the turn of the century and the excitement caused by the decision, in 1899, to give the *Promotionsrecht* to Prussian technical universities. Previously, PhDs had been the prerogative of the universities. Following the reforms of the higher technical colleges in the German states in the 1860s and 1870s, which put them more or less on equal footing with the universities, the doctorate remained the last academic bastion. At the initial meeting of delegates from all the German technical universities, which took place in 1880 in Berlin with Zurich in attendance, the assembly agreed "to work toward ensuring that the technical universities receive the right to grant doctorates."[38] Over the next two decades, the technical sciences made several attempts to chip away at the symbolic privilege of academia. But they met with bitter resistance from the German universities, which were unwilling to give up their remaining token of distinction.[39]

The activities of this so-called engineers' movement focused on Germany, but their influence was felt at the federal polytechnic. Between 1884 and 1890, the School Council was confronted three times with initiatives from teachers wanting the polytechnic to obtain the *Promotionsrecht*. All three attempts came from the chemistry faculty, who like their counterparts in Germany played a pioneering role in the matter of PhDs. Because chemistry could be studied at both technical universities and regular universities, the chemistry faculty not only felt the disadvantage of their institution more keenly than their colleagues in other disciplines, but could also easily prove that they were equal to university chemists.[40]

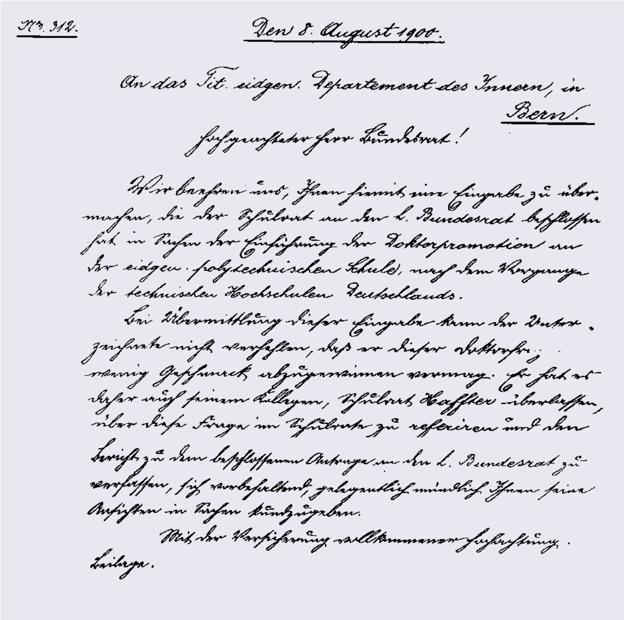
None of the three efforts came to much. The only tangible result was an 1890 report by School Councillor Konrad Haffter, which concluded that "the introduction of a doctoral examination at our institution is hardly urgent."[41] Whereas the German empire of the late nineteenth century debated the issue with increasing vehemence, in Zurich it was left to gather dust. The chemists stopped making demands, which presumably contributed to the new PhD policy of the University of Zurich of 1892. This put the polytechnic's diploma onto an equal footing with the university's, thereby allowing the polytechnic faculty to supervise doctoral theses, although not to participate in the final evaluation of them.[42]

The PhD question was revisited in 1900, in a public spat in the *Neue Zürcher Zeitung,* a turn of events that had everything to do with the surprising granting of the *Promotionsrecht* to the Prussian technical universities.[43] In October 1899, at a lavish anniversary celebration for the Technical University of Charlottenburg, the German emperor Wilhelm II announced that henceforth the university would be permitted to award the title "doctor of engineering" – "Dr. Ing." for short. This imperial decree had the effect of bringing down the entire university line of defense with a single shot. In the space of a few months, all the German states followed the Prussian lead in granting the *Promotionsrecht* to their technical universities. In 1901, Austria-Hungary did likewise.[44] As a concession to the universities, the title could not conferred in written or spoken Latin. The abbreviation "Dr. Ing." was subsequently the butt of a few jokes, but the ridicule could not obscure the fact that the universities had finally and formally lost their special status.[45]

In Switzerland, the PhD question initially took the same course. In August 1900, the School Council presented the Federal Council with a well-argued and broad-based proposal, in effect introducing legislation to allow the Zurich polytechnic to grant PhDs. The underlying rationale was identical to that in Germany and Austria. First, the education at the federal polytechnic was equal in quality to that of the universities. Second, owing to their "cultural achievements," highly educated engineers deserved the same social status as university academics. There could be no social equality without academic equality. "Should we remain second-class citizens, while universities believe the weaker sex to be scientifically worthy of degrees?" polytechnic professor Edward Gerlich prodded SIA delegates in March 1990, quickly correcting the apparent contradiction to the prevailing gender order by adding: "That's obviously very arbitrary." Third, and finally, if it did not have the same rights as its sister foreign institutes, the polytechnic would lose its international status as a training ground. This last argument doubtless drew its strength from the rapid granting of the *Promotionsrecht* to the German and Austro-Hungarian universities after 1899.[46]

The polytechnic faculty unanimously backed the School Council's proposal; the two interest groups SIA and GEP and the students also indicated their support. Moreover, the School Council had numbers to show that demand for the degree existed. Between 1893 and 1899, 90 polytechnic students had earned PhDs at the University of Zurich, though vexingly "the evaluation of scientific work, carried out at the behest and under the supervision of polytechnic faculty, in the main [had to be] left to university faculty."[47]

Yet no *Promotionsrecht* was forthcoming. Why? In Germany, the effort had been stymied by the stubborn opposition of the universities up to the emperor's decree in 1899. Were the Swiss universities now similarly conspiring against the ambitions of the polytechnic? There were such concerns. In addition to differences of opinion, in the early 1890s, "fear of stoking the animosity of the Swiss universities toward the fed. polytechnical school" had prevented the School Council from deciding the PhD question, wrote president Hermann Bleuler in April 1900 to his colleagues on the board.[48] As no steps were undertaken, it was impossible to prove whether these fears were justified. By 1900, they had evaporated. The universities posed no opposition to the wishes of the polytechnic; the University of Zurich even signaled its clear support by awarding five current and one former professor of the polytechnic a doctorate honoris causa.[49] "With this act the faculty of the University of Zurich laid to rest the oft-cited conjecture that it was hostile to giving technical universities the *Promotionsrecht*. The authorities who must conclusively decide the *Promotionsrecht* for the polytechnic may be pleased to find such strong support from the sister institution for resolving the pending business in the right way," read the minutes for the annual meeting of the SIA.[50]


Nr. 312. Den 8. August 1900.

An das Tit. eidgen. Departement des Innern, in Bern.

Hochgeachteter Herr Bundesrat!

Wir beehren uns, Ihnen hiemit eine Eingabe zu übermachen, die der Schulrat an den h. Bundesrat beschlossen hat in Sachen der Einführung der Doktorpromotion an der eidgen. polytechnischen Schule, nach dem Vorgange der technischen Hochschulen Deutschlands.

Bei Übermittlung dieser Eingabe kann der Unterzeichnete nicht verhehlen, daß er dieser Doktorfrage wenig Geschmack abzugewinnen vermag. Er hat es daher auch seinem Kollegen, Schulrat Haffter überlassen, über diese Frage im Schulrate zu referieren und den Bericht zu dem beschlossenen Antrage an den h. Bundesrat zu verfassen, sich vorbehaltend, gelegentlich mündlich Ihnen seine Ansichten in Sachen kundzugeben.

Mit der Versicherung vollkommener Hochachtung.

Beilage.

On 8 August 1900, polytechnic president Bleuler forwarded to the Federal Council the School Council's request to allow the school to award PhDs. In his cover letter, Bleuler expressed his own opposition to the "PhD issue." Copy from the correspondence in the archives of the School Council.

The federal councillor responsible for the matter, however, remained silent. In May 1902, the student divisional associations and the student umbrella association *Verband der Polytechniker* launched petitions in favor of the *Promotionsrecht*. Petitions carrying over 500 signatures – representing roughly half the student body – enabled the School Council to remind the Federal Council of the board's now two-year-old proposal.[51] After the topic was brought up in the federal parliament as well, the Department of Home Affairs finally stirred.[52] It employed its ambassadors to obtain information about corresponding regulations from neighboring countries, and drew up a draft for a Federal Council "memorandum on the awarding of titles by the fed. polytechnical school." Thereupon the government's activities ceased abruptly for another several years. The draft, with comments by the School Council and sent to the Department of Home Affairs, was swallowed up by officialdom.[53]

The most influential opponent of the *Promotionsrecht*, however,was not in Bern but at the polytechnic itself, at the very helm of power. School Council president Hermann Bleuler personally did his best to thwart matters. In a letter to the head of Home Affairs, Federal Councillor Marc Ruchet, accompanying the proposal of 8 August 1900, Bleuler wrote: "In forwarding this petition, the undersigned cannot deny that he has little sympathy

for the doctorate issue. For this reason, he left it to his colleague Haffter to speak on the question within the School Council and to compose the present report on the proposals to the federal councillor, preferring to share his own views on the subject with you in person at your convenience."[54] Over two years later, Bleuler wrote to the secretary of Home Affairs, "Because, as is well known, the doctorate initiative is not to my liking, so far as I am concerned, there are no changes to be made to the draft proposal. Such red marks as I have permitted myself to make are mostly at the instruction of the director."[55]
As president, Bleuler held the key to advancing or delaying matters. It thus helped little that at the School Council meetings Robert Gnehm, chemistry professor and director of the polytechnic, repeatedly argued for pushing the PhD issue forward.[56] According to the minutes, there was never an open dispute within the School Council over the content of the proposal. On one occasion, however, by pitting the question against the matter of disentangling from the University of Zurich, Bleuler made his priorities clear: "The president and Councillor Tièche do not intend to push this issue too hard in Bern, but rather for the time being to concentrate on the proper execution of the ongoing reorganization."[57]
As Bleuler dithered, external support was also eroding. The GEP, which as of 1900 attached no great importance to the question of the doctoral degree and only half-heartedly backed the school's efforts, two years later shelved it "because in Germany and Austria the Dr. Ing. doesn't seem to be good for much."[58] Finally, in 1902, National Councillor Conradin Zschokke, former professor of hydraulics at the polytechnic and later member of the School Council, opposed the *Promotionsrecht* in parliament.[59]
Given the lack of written records, one can only speculate about Bleuler's reasons for not wishing to pursue the *Promotionsrecht* for his school. Bleuler's attitude toward the reorganization efforts, which ranged from skeptical to dismissive, suggests that he shared the opinion of those who considered that a doctorate was neither necessary nor desirable, and that it would likely serve only to compete with existing credentials. "There is no plausible reason for changing the form of our graduation certificate – the diploma – by replacing it with a doctoral degree or by establishing an academic credential alongside the diploma but higher in rank – in effect reinventing the *Doktor-Ingenieur*," an alumnus of the polytechnic told the *Neue Zürcher Zeitung* in February 1900.[60] This conservative impulse to reject in principle any changes to Zurich's time-tested educational practices was widespread, and remained present in the debates that took place the following year.

Acquiring the character of a real university

At the end of 1902, debate on the PhD question subsided both within the polytechnic and in public discussions. But all was not quiet at the school. An "academic teacher" considered the "Polytechnic in the dock" in a July 1903 issue of the *Neue Zürcher Zeitung* and complained: "For the last year, the press has been leading a campaign against the federal polytechnic."[61] The question at the center of the debate maelstrom, which earned several months' worth of newspaper coverage that summer, was that of “academic freedom or compulsory courses at the polytechnic,” as the heading of one of the contributions read.[62] The existing regulations stipulated compulsory courses for the first two years, which included not just formal schedules but also regular review sessions and yearly exams.

In June 1903, the debate found its way to the National Council. Former and current “pupils” of the polytechnic warned “that narrowmindedness would take over the institution and that academic freedom would regrettably be limited.” The Federal Council was requested to reconsider “the question of reorganizing the polytechnic.” The engineering school came in for especially harsh criticism: “once regarded as the jewel of the institution,” it had now “unmistakably declined”; the chance to “make changes at the top had been squandered.”[63] Whereas already the previous year the GEP had appointed a committee to investigate allegations regarding the engineering school,[64] the following month the *Verband der Polytechniker* submitted to the Federal Council a ten-page petition in which the student association criticized the current school regulations and called for academic freedom.[65] In November 1903, the Department of Home Affairs finally contacted the School Council president to get a feel for the school's position.[66]

At the beginning of the year, the School Council faced the question of academic freedom, via yet another channel: an extraordinary number of applications for the *Habilitation* (qualification as a university lecturer), which put the authorities in an awkward position. Looking for ways to restructure the process of obtaining a *Habilitation*, “a comparison was made between the teaching system in the VIIth division (speciality in physics and mathematics), which most of the lecturers belonged to and which promoted academic freedom, and the teaching system of the other divisions, where courses are obligatory.” Henri Golliez, the school councillor tasked with the investigation, suggested “asking the faculty conference whether it might not be appropriate to grant students in all divisions the right to choose their own courses.”[67]

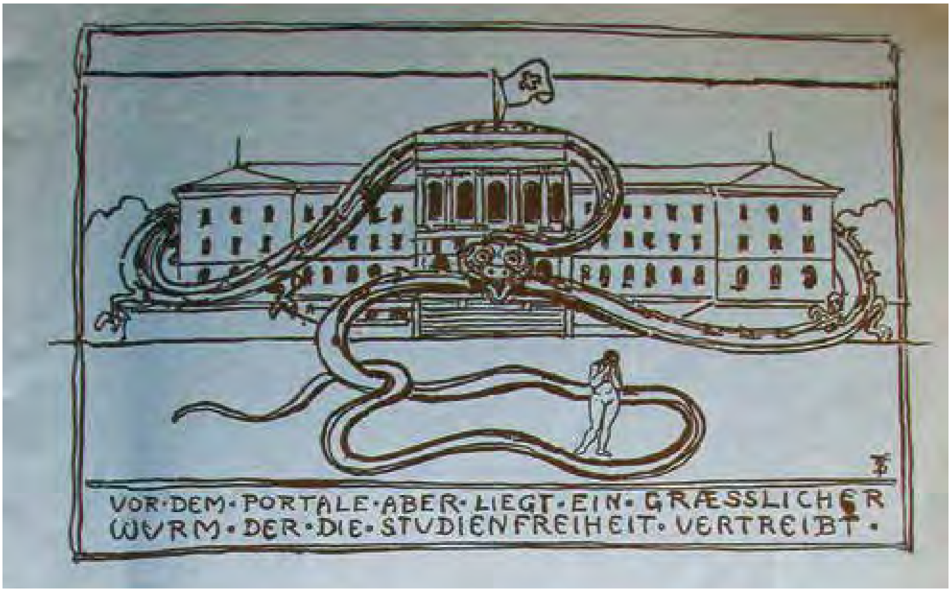
Following the parliamentary debate of June 1903, the School Council formed a committee and set the whole consultation machinery in motion. In late autumn, Robert Gnehm made academic freedom the focus of his speech at the opening of the new academic year. He had stern words for the polarizing treatment of the debate in the press, but restrained from taking a stand himself. Instead, he paved the way for the school to consider the matter internally. “The point of these recollections is purely to show that it is neither as simple nor as easy to decide these questions as might appear at a cursory glance. Doing proper justice to the matter requires detailed study. Advantages and disadvantages must be considered conscientiously, weighed objectively, and the logical conclusions drawn. A proven educational system is not lightly abandoned; there must be good reasons for doing so. When, however, such evidence is clearly obvious, one must be able to cut loose from tradition.”[68]

The faculty conference convened by the School Council was unable to reach agreement on the question. Instead, on the last day of the year, majority and minority opinions were registered.[69] The faculty did agree completely on the "cardinal points, … namely that in the future our polytechnic will fully take on the character of a university, both in the students' enjoyment of the full measure of 'academic freedom' – insofar as this is consistent with serious study – and in the faculty sharing the rights that all other universities take for granted and without which our institution would be branded inferior."[70] While most of the faculty supported the free choice of subjects for the entire course of study, a minority wanted to maintain a compulsory program for the first year, "for only in this way will it be possible to avoid cluttering the advanced classes with unqualified students."[71]

In a report to the Federal Council of March 1904, the School Council approved a reorganization of the polytechnic, although a minority of the members did not share this view.[72] In the controversial issue of academic freedom, the board backed the majority of professors. On the other hand, it rejected the majority request of the faculty for more responsibility. In particular, the School Council wished to maintain its right to award diplomas, fill professorships, and allocate teaching assignments. Likewise, the suggestion of the faculty to change the name of the polytechnic to "Federal Institute of Technolog … to emphasize the nature of our school" found cold reception.[73] The School Council opined that the name of the institute was well accepted at home and abroad and that it had a fine ring to it. The polytechnic had "always been a university and was recognized as such. A name change is unnecessary."[74] In addition, the School Council wished to carry out the reorganization on the basis of the founding charter of 1854. A name change would most likely require a revision to the law; introducing academic freedom would not, although the previous debate on reform in 1880 had determined the opposite. The board concluded: "To avoid misunderstanding, be it so stated that the School Council has no objection to a revision of the founding charter in and of itself; if it consistently advocates the resolution of the above-mentioned question on the basis of the current legislation, the reason is simply owing to the conviction that having first to change the law would cause unwelcome delays."[75]

The unwelcome delays occurred all the same. Shortly after the School Council's report, the Department of Home Affairs received an opinion from the executive committee of the GEP in which – in contrast to the board – the alumni organization supported the minority position of the faculty as well as their request for greater responsibility. The committee subsequently confirmed its opinion in a ballot whose results were announced in March 1905. Over 70 percent of the more than 600 voters shared the committee's position on the question of academic freedom, whereas support for the name change just squeaked by.[76]

Throughout, the federal authorities maintained their silence. Any hope that they might have emulated the German emperor's gesture six years before in Berlin, and used the fiftieth anniversary of the polytechnic as a reason to effect the desired changes, was dashed. Bundesrat Ludwig Forrer, who headed the Department of Home Affairs during 1904 and 1905, simply stated at the ceremony that the Federal Council had been unable



"Reform now!" demanded the polytechnic students on the occasion of the school's fiftieth anniversary: "Raise your voices loud and clear / Sing it so that the governors hear." But the Federal Council did not pay much attention to the call for academic freedom. The text below picture reads: "But in the front of the entrance rests an ugly worm that scares away academic freedom." From the anniversary issue of the *Bierzeitung*, 1905.

to come to a decision. On the issue of academic freedom, he personally advocated a middle ground consistent with the minority view, though he opposed the name change and the granting of doctorates.[77] Following two years of no word from Bern, this was hardly an encouraging sign. Even worse, despite Forrer's somewhat optimistic spin, it would be months until anything happened.[78]

In the meanwhile, the reformists strengthened their influence among the school's leadership. Following several months of health-related leave the previous year, in March 1905 Bleuler finally agreed to vacate the office of president for a seat on the School Council.[79] Gustave Naville turned down the presidency, and instead, the Federal Council chose Robert Gnehm to succeed Bleuler. The change was striking: The chief gatekeeper of the polytechnic's traditions, himself among the first students to enroll in the institution in 1855, was followed by a proven advocate for university reform. Where Bleuler had stood for engineering, the military, and civil service, Gnehm had a personal record as both a chemical industrialist and an academic scientist.[80] His appointment coincided with a reshuffling of the School Council. By 1907, when the Department of Home Affairs finally weighed in on the board's report on reorganization – fully three-and-a-half years after having received it from Zurich – only two of the six members who had originally transmitted it were still active.[81]

The breakthrough of 1908

What roused the Department of Home Affairs from its sleep was a communication from the GEP in early summer of 1907. For years, the GEP maintained, nothing had been done, despite the fact that all parties concerned agreed on the "need of reorganization." The Federal Council was requested "to conclude this important matter as soon as possible." The margin of the letter contains note in Federal Councillor Marc Ruchet's hand that an answer should go out promising a decision in August or, at the latest, in September.[82] In early October 1907, the Council wrote the School Council that it was in essential agreement with the observations and proposals of March 1904. But it also hoped that a revision of the constitution and especially of the federal law could be avoided, and asked the School Council to submit a corresponding bill, thereby enabling the board to extend the scope of its request.[83]

The board immediately took up the work of reorganization, and announced to the federal authorities that its proposed revision to the school regulations would include academic freedom as well as the *Promotionsrecht*.[84] Now the process went into high gear. Preparing the submission, which involved the board, the directorate, and the faculty, took half a year.[85] In September 1908, the Federal Council approved the draft without change. Councillor Forrer's request to delete or modify Art. 40 concerning doctoral degrees was overruled.[86] In a short 12 months, the board and the Federal Council had managed to achieve the long-latent reorganization of the polytechnic by means of a new set of regulations. That they were able to do so is most certainly due to the fact that the Council kept the draft statutes under seal. The GEP, for instance, tried in vain to obtain a pre-decision copy.[87]

The revisions came into force on 1 October 1909. The most important among them involved academic freedom and PhDs. Effective immediately, students could freely choose their courses although they were also presented with a recommended program of study. The annual qualifying exams were abolished, along with disciplinary measures for laziness. The awarding of diplomas, the appointing of faculty, and the allocation of teaching assignments would henceforth be the province of the School Council. The name of the institution remained intact. That the polytechnic now comprised eleven rather than eight divisions represented, except for integration of rural engineering into the engineering division, more an organizational formality than an organic change.[88]

Reactions to the new regulations were reported in the annual report of the polytechnic of 1908: "Extravagant hopes, bitter disappointments, and strong reservations are arising in connection with this reform even before its implementation. Who will prove right in the end – the optimist or the opponent – only time will tell. The spirit that will animate the new organization is far more important to us than the letter of the law, and the ultimate determinant of success. Moreover, those responsible for this spirit, the faculty, have made it possible for us to look to the future with confidence."[89]

Ideological opposites in the debate on reorganization: Hermann Bleuler (left), school president until 1905, and his successor, Robert Gnehm.

The implementation took place over the following months, during which curricula, exam policies, and degree requirements were worked on. The GEP and SIA, which had been passed over in the general revision of the regulations, now redoubled their efforts to have a say in the details, whereas the *Verband der Polytechniker* asked in vain for rectification of the general regulations.[90] The form and scope of the reorganization were agreed to. In keeping with the example of Munich and Austria, the polytechnic eschewed the oft-ridiculed title of "Dr. Ingenier" in favor of "doctor of engineering sciences." For the specialist divisions, the school also secured the right to award "doctor of natural sciences" and "doctor of mathematics" degrees.[91] These customs endured for nearly one hundred years until, following the introduction of a new doctoral degree for interdisciplinary studies, the old distinctions were dropped. Beginning in 2003, the degree "doctor of science (Dr. sc. ETH Zurich)" served for all.[92]

From the "Polytechnic" to the "Federal Institute of Technology"

On 18 October 1909, an air of excitement hovered over the polytechnic. For many "polytechnicians," the day marked not only the start of the school year but also a piece of history. "In addition to the students, many friends of the school had gathered; the faculty was out in force," reported the *Neue Zürcher Zeitung*. "It had been publicly announced that this year's opening celebration would signal a new and important phase for the country's paramount institution – and with it the era of academic freedom."[93]


DIE EIDGENÖSSISCHE
POLYTECHNISCHE
SCHULE IN ZÜRICH
VERLEIHT DURCH DIESE URKUNDE DEM
DIPLOMIERTEN CHEMIKER
HERRN
JEAN-FELIX PICCARD
VON LUTRY, WAADT
DIE WÜRDE EINES
DOKTORS DER NATURWISSENSCHAFTEN
NACHDEM DERSELBE BEI DER ABTEILUNG FÜR CHEMIE IM VORGESCHRIEBENEN PROMOTIONSVERFAHREN DURCH SEINE PROMOTIONSARBEIT:
„ÜBER KONSTITUTION UND FARBE DER CHINONIMINE"
SOWIE DURCH DIE VORGENOMMENE PRÜFUNG SEINE WISSENSCHAFTLICHE BEFÄHIGUNG ERWIESEN HAT
IM NAMEN DES PROFESSORENKOLLEGIUMS DER EIDGENÖSSISCHEN POLYTECHNISCHEN SCHULE
L S

The first PhD awarded by the polytechnic. That its recipient was a chemist was no accident: six of the nine doctorates awarded in 1909/10 went to chemists (two mechanical engineers and a natural scientist were the other awardees). In the following decade as well, roughly half of the institute's PhDs came from the chemistry division.

The polytechnic began the new era with its old name. But already the following year, this decision was called once again into question. In December 1910, the Council of States' agenda contained the item "Allocation of funds for the polytechnic." During the debate, Josef Düring, states' councillor from Lucerne and then member of the School Council, complained that "polytechnic" was "out of date."[94] He was right. For decades, and in many cases even prior to 1870, comparable institutions in the German-speaking world called themselves "technical universities." "Polytechnic" tended less to be associated with advanced engineering education than with secondary engineering schools.[95] The term "Fed. Polytechnical School" became increasingly ambiguous, with a concomitant risk of erroneous classification abroad. Accordingly, the Council of States agreed to ask the government to consider whether the name of the polytechnic "might be amended in such a way as to obviously convey its character as a technical university."[96]
The relevant department – Home Affairs – then turned to the Federal School Council. This time, the views of the various stakeholders appeared to be unanimous. Already in early 1909, when the revision of the general regulations was being criticized as not far-reaching enough, the students' association had proposed changing the name of the school to "Federal Institute of Technology." Reporting on reform at the end of 1903, the faculty conference had recommended the same; in 1911 they confirmed their earlier opinion. At their meeting, the GEP drafted a memorandum recommending the new name.[97]
The official reason given in earlier discussions for opposing a renaming – that it would

entail a change in the law, since the name of the institution was fixed in the founding charter – was debunked by Wilhelm Oechsli, professor at the school and author of the 1905 Festschrift, in a historical elaboration. The official designation “Fed. Polytechnical School,” wrote Oechsli, had in the past not been strictly applied; in fact, “Fed. Polytechnic” was the common usage. The Department of Home Affairs found Oechsli’s argument convincing, and ruled that a decision by the Federal Council would suffice.[98]

The only difficulty vis-à-vis the name change came from the School Council. In the crucial meeting, the president had the casting vote in deciding the name change. However, Gnehm’s suggested “*Eidgenössische Technische Hochschule Zürich*” was defeated four to two in favor of “*Eidgenössische polytechnische Hochschule in Zürich*.”[99] The Federal Council in turn found this name too long and too cumbersome. In June 1911, on the recommendation of the Department of Home Affairs, “*Eidgenössische Technische Hochschule*” carried the day.[100] The French and Italian versions remained as they had been before. The “director” would now be called “rector,” a symbolic gesture that equated the institute with a university.

In so doing, the ETH became aligned with its German and Austrian counterparts, albeit thirty years later. In 1911, Theodor Vetter was the first of his rank to give the opening speech of the school year as “rector of the *Eidgenössische Technische Hochschule:* “We wish to leave fear and narrowmindedness far behind, and in our teaching and orientation to strive for true academic freedom and to prove ourselves worthy of our new name.”[101]

Societal crisis and institutional change

It had taken an entire decade to bring about the reforms to the polytechnic. For many years, they languished under the resistance of the school itself, the inability of the reformists to agree on a coherent program, and the passivity of the Federal Council. At the same time, the opposition managed to play off the shortage of space against the need for change. A key figure in these proceedings was Bleuler, who successfully thwarted attempts at progress. Certainly it was no accident that the internal reorganization came not only once Bleuler had ceased to be president but also after he had left the School Council. As director of the polytechnic, Bleuler’s successor, Gnehm, had already committed himself to reform. In 1909, his professorial colleagues showed him their gratitude by awarding him the institute’s first honorary doctorate.[102]

Nonetheless, it would be too easy to reduce the course of the reform debate to the dealings of antipodes Bleuler and Gnehm. The lack of will embodied by Bleuler, and the polytechnic’s inability to innovate, as evidenced both in the reform issue and in the separation from the University of Zurich, both had roots that went far beyond individuals. The stasis had a structural as well as a psychological component; both were tied to the history of the polytechnic. Founded in 1855 as a political niche product of the young state, the federal polytechnical school became nationally and internationally renowned in very short order. But the ostensibly fruitful expansion also had disadvantages over the

Hermann Bleuler (sitting, third from left) among his former colleagues from the Alpigenia alumni association at the polytechnic's jubilee, 1905.

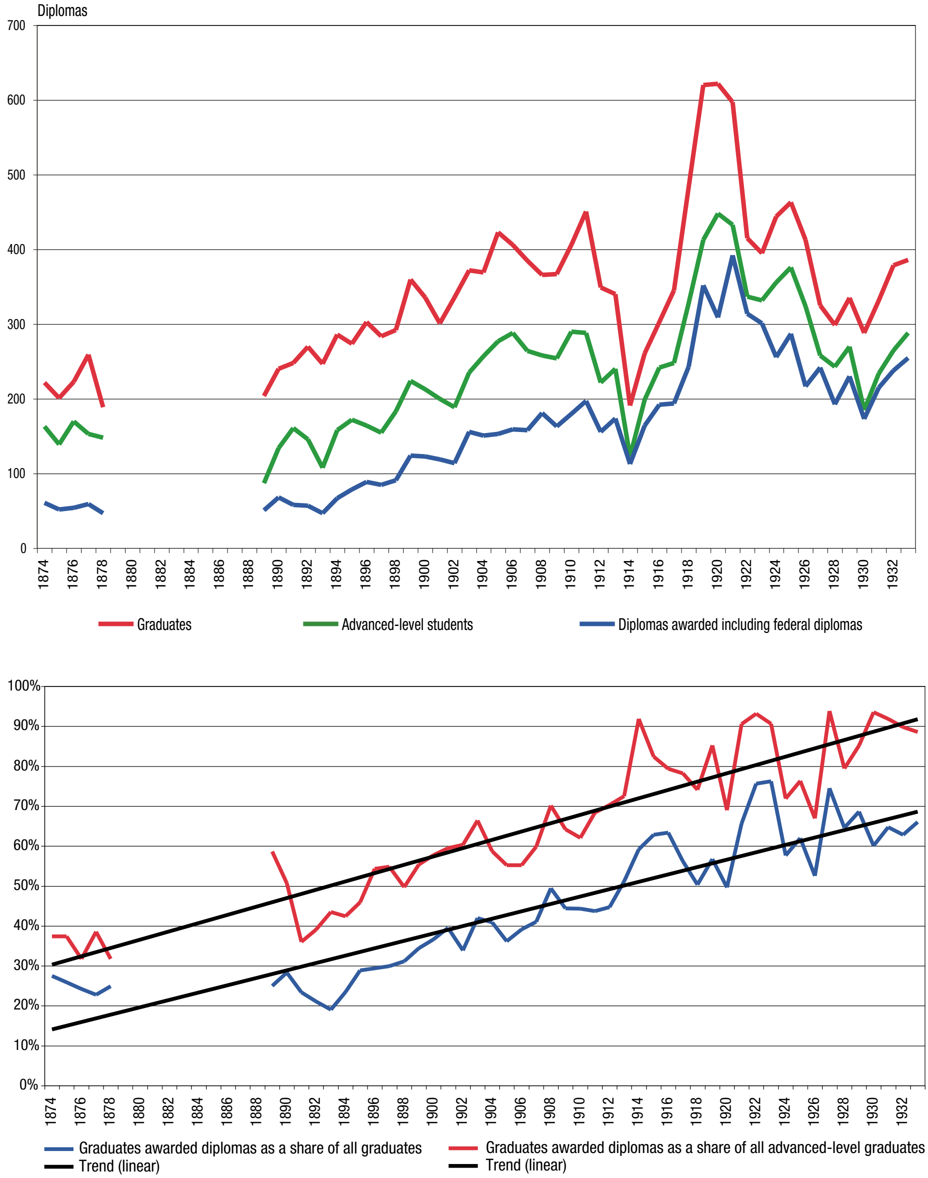
long term. Already, the reform period of the 1870s and 1880s showed that relaunching a successful brand was possible only with the greatest effort. At the start of the twentieth century, the federal niche threatened to become a trap, and the success of the early days to give way to internal paralysis. It would require many years of painstaking negotiations to "weed out" the overlapping communal, cantonal, and federal rights and responsibilities created by the government and the polytechnic during the growth phase. That, five decades after the founding of the Swiss federal state, the federal system of power sharing in which the polytechnic was embedded was still finding its legs was evident in the reluctance of the actors to tamper with the institution's founding charter of 1854. How difficult it was to let go of the model of the *Polytechnikum* was nowhere so clear as in the debate over the school's name. When, at the 1904 annual meeting of the GEP in Basel, Otto Sand, drank to the "*Technische Hochschule*," Bleuler in turn raised his glass to the "Federal Polytechnical School ..., under whose name we have enjoyed such great success."[103] Focusing so narrowly on past glories put at risk the polytechnic's ability to be future-oriented in its actions. The institution that had once been admired internationally as a pioneer and model, had settled for being a latecomer.

Changes in personnel did indeed catalyze reform efforts, including the replacement of Bleuler by Gnehm as School Council president and the transfer of responsibility from Federal Councillor Forrer back to Ruchet in the Department of Home Affairs. But, again, these factors tell only part of the story. The initiatives of the first few years suffered from the orthogonal positions and inadequate support of various groups. In particular, the GEP and SIA realized only later how important the changes at the polytechnic had been for their organizations.

It hardly comes as a surprise that, during all this time, the SIA was undergoing its own realignment. It began with the 1907 meeting in Olten, cited above, which served as a "milestone" in the history of the association.[104] These changes occurred within a context of a crisis in societal values on the one hand, and in reaction to long-term structural changes on the other. In particular, they highlighted the growing importance of formal qualifications. During the nineteenth century, degrees and diplomas played only a subordinate role in the engineering professions. Neither the (mostly) nascent industries nor the new or modernized government bureaucracies paid them much mind. Moreover, widespread granting of degrees was counter to the federalist structure of Switzerland. Recognition of qualifications was usually reserved for the cantons. In addition, degrees were ideologically suspect: they were considered un-Swiss and unrepublican, insignias of a society based on rank and class but not a democratic society in which only performance mattered. In 1900, the argument against introducing PhDs for engineers held that they were a product of circumstances in the German empire, but were inappropriate for Switzerland.[105]

However, as competition in the job market increased in the early 1900s, this attitude began to change. Degrees and certificates acquired greater value. During this period, the proportion of students graduating from the polytechnic with a diploma grew significantly. In addition, engineers with advanced training began to be distinguished from those who had only attended one of the *Technika* – technical colleges established in the last quarter of the nineteenth century on the model of the German, French, and English industrial schools, in order to train "average engineers."[106] There was disagreement over whether graduates of the *Technika* should qualify as engineers or only as technicians. The inaugural issue of the S*chweizerische Techniker-Zeitung* came out in 1904. The following year, secondary school-trained engineers organized into the *Schweizerischer Techniker-Verband* (STV, Society of Swiss Technicians).[107] For its part, the SIA cut itself off from the lower ranks at the Olten meeting, and with the statutory reform of 1909 explicitly became the interest group of engineers with advanced training. In this process of professionalization and differentiation, educational credentials now served as clearly identifiable marks of distinction. "The only thing keeping the technician from the privileges of the engineer is education," declared an engineer and *Technikum* instructor at the Olten meeting.[108] To

Figure 6: Diplomas granted, in absolute numbers and percent, 1874–1933



Up to the early 1900s, polytechnic diplomas were awarded as a supplement to the graduation certificate for "well above average achievement" (ETH Jahresbericht 1897, 6). As applications increased, the school administration raised requirements. Nevertheless, a growing number of students passed their diploma exams. Up to 1914, over 70 percent of advanced-level students managed to graduate with diplomas. The sinking or stagnating numbers between 1903 and 1911 can be traced to new rules regarding the exams. The large dip between 1914 and the start of the 1920s reflects the effect of military service during the First World War. Data: ETH Jahresberichte.

"Zurich – old and new university": In 1914 the University of Zurich moved from the south wing of the Semper building to its new facility. Contemporary postcard.

justify the distinction, education at the polytechnic had to be clearly and visibly different from that available at the *Technika*. "Simply loading up on engineering subjects is to be avoided to enable students time to further their general education," advised a directive from the School Council to the divisions regarding the criteria to be considered in drafting the new general curriculum.[109]

The advanced engineers' interest groups apparently also struggled with recruitment problems. Surprisingly frequently at Olten, statements were made in the name of "younger colleagues" and their meager presence regretted. In their firm commitment to reform at the polytechnic, the SIA and GEP represented the vital interests of the young, not yet professionally established polytechnic graduates, as well as the still-in-training association members to be. The SIA's pointed "get them early" policy made fast headway, not only in the question of reorganization. Even before the First World War, the federal railways and individual cantonal governments began to reserve posts for university engineers. Thirty years later, ETH president Arthur Rohn called the school's diploma a "rank of nobility that opens the doors of the world to the engineer." State protection of titles, he felt, was no longer necessary.[110]

"Noblesse oblige!"

Over the course of the nineteenth century, the intellectual resources maintained, generated, and distributed at and by the polytechnic reached an academic level that for many years no comparable university could match. The second industrial revolution had given

Noblesse oblige. Mechanical engineering students in the drafting hall in the attic of the mechanical engineering laboratory, 1919.

rise to the educated, middle-class, science oriented engineer whose work was being celebrated by the national public for its cultural and modernizing contributions. This success called for an upgrading of the polytechnic's academic status. A lack of compatibility with sister institutions at the international level and inadequate differentiation from engineering secondary schools at home increased pressure to rebalance material and symbolic trappings – or to use an expression of the time – "to fully convey the character of a real university." For years, lukewarm support for reforms and a marked inability to innovate, rooted in the history of the polytechnic as a successful niche product of the young federal state, impeded or hindered fundamental change. While long-drawn-out negotiations did finally bring about alterations in the physical structure, the school's inner reorganization had to await a change in leadership and transformation of the societal landscape.

The results of all these efforts were finally made visible. The separation agreement paved the way for the ETH and the University of Zurich to further develop their own infrastructures. In the 1910s, the university area was turned into a huge construction site. The organic reforms brought academic freedom, the right to grant PhDs, and university titles to the ETH. These changes created a balance between aspiration and feasibility, and increased opportunities for national distinction and international exchange. In addition, they reduced the burden of disciplinary oversight, at the same time giving students more control over their academic lives. The paternalistic authority of the school gave way to the individual responsibility of the student, immunized by rules and regulations and guided by the curriculum. "Noblesse oblige!" rector Theodor Vetter exhorted students at the opening of the 1911/12 academic year, "also applies to science. At this institution, since the beginning and as its name now indicates, you are also members of a university. You have not come to while away your time, but to strive for the most enduring of all knowledge: truth. We do not want you to fear exams, but to welcome them as an opportunity to find out whether your diligence and hard work have really paid off. What the most short-sighted of you still scorn, I mean the handbooks and assignments, you must learn to value."[III]

In the complex debate that took place during the years up to 1911, structures were established that would be maintained for the long decades of the "short" twentieth century. In the further development of the ETH, the clarification of boundaries and the university's reach of responsibility were crucial. The relative gain in academic autonomy largely dependant on science and technology while boosting research brought not only additional successes but also new problems of integration. The increased academic autonomy promoted a new spirit of collaboration between business, politics, and research.

1911–

4. BUSINESS, POLITICS, *and* RESEARCH: *New* ALLIANCES *for a new century*

Daniel Speich

1968

The transformation of the polytechnic into the ETH represented the upgrading of an engineering-oriented, advanced-level school to a modern research university. This makeover was so fundamental that its practical implementation took decades. But gradually, at all tiers of the organization, structures were put into place that established it not only as a seat of learning but also of research. The ETH's research activities also became increasingly recognized internationally, and the growing emphasis on science precipitated a rethinking of the role of the school in business and politics, with an eye to the future. Cooperation and collaboration became the prevailing ethos. As its academic autonomy grew, the school became ever more conscious of its economic importance and civic responsibility.

Initially, however, the polytechnic was so preoccupied with its new identity as the *Eidgenössische Technische Hochschule* that the outside world seemed very remote. The difficult social conditions of the final years of the First World War and the turbulent domestic politics of 1918 were little noticed in the ivory tower. This was despite the fact that many students and lecturers were absent, having been called into military service and deployed to protect the country's borders, construction projects were disrupted, and a shortage of coal made heating the buildings problematic.[1] The school also felt the effects of the inflation of 1917. Germanist Emil Ermatinger and forestry scientist Arnold Engler, both senior faculty, demanded substantial salary increases, as a result of which in March 1918 the Federal School Council raised the pay of all lecturers and assistants.[2] All in all, however, the ETH's problems were insignificant in the face of the prevailing societal uncertainty, which culminated in the nationwide strike of 1918.

For a year or so, Switzerland had been experiencing a serious supply crunch. The threat of famine highlighted the vulnerability of industrialized society. It overlapped with the labor dispute of 1918, which for the liberals in particular underscored the fragility of the existing political and social order. Hans Ulrich Jost considers this convergence of stresses – topped off by a severe flu epidemic – as the worst jolt to modern Switzerland since 1848.[3] The turning point marked the apogee of the Swiss version of the "crisis of modernity" that was apparent before the war.[4] Before it was over, the faith in liberalism born of the nineteenth century was crumbling in all the industrializing nations, in favor of new forms of power politics. Toward the end of the war, two pillars of bourgeois modernism had begun to collapse: the belief in the self-regulating market that underpins a capitalist economy, and the concept of the autonomous individual, which constitutes the political basis of a democratic society.[5]

Criticism of the existing state of affairs came from two quarters, and had a significant effect on domestic politics. Collective and corporate models of society were both incompatible with liberal individualism, and calls for the government to take a hand in planning and guiding the economy grew increasingly louder. As a result, in 1918 liberalism – the impulse at the heart of confederation – lost ground on both sides of the political spectrum. The Liberal Party, which still dominated the government, extended a hand to the left in a surge of sociopolitical reforms that were transacted as a kind of "social galop." But by 1920 the liberals had gravitated to the right, and with the Catholic conservatives and the farmers had begun to forge a kind of "*Bürgerblock*" (conservative alliance).[6] Whereas cooperation with the left advanced slowly (democratic consensus was reached only in 1943, with the election of social democrat Ernst Nobs to the Federal Council), the liberals' shift to the right quickly altered the political reality. Consequently, the political culture of the crisis and war years tended increasingly toward authoritarianism.[7] After 1918, the conservative forces of the far right had more and more influence over federal policy, which translated into a social and economic orientation that was entirely different from that of the middle-class, liberal tradition of the nineteenth century.[8] Antidemocratic ideas and corporatist visions echoed up to the highest political levels. Thus, until 1943, Switzerland was by no means completely opposed to the fascist systems in Italy and Germany.[9] It is hardly an exaggeration to say that this 1920s period reverberated across the political landscape of Switzerland throughout the twentieth century.[10]

What was the effect on the ETH of the shift in power caused by the "first crisis of modernity"? And how did the university adapt itself to the changing climate? Is it also possible to identify organizational decisions and reorientations that had a lasting effect on the scientific world? The answer is yes, given that some of the issues taken for granted during the initial phase of the ETH's history were now at stake.

In the first place, the decline of liberalism meant the diminution of the party whose outlook was part of the fabric of the scientific institution. The legitimacy of the "Poly" could have faltered during the 1920s precisely because it was so closely associated with the rise of liberalism in 1848.[11] The new powers at the left and right fringes of the political spectrum did not identify with the achievements of the federal government in the way that the liberals had done. Indeed, the communists and social democrats may well have perceived the ETH as a tool for enhancing the efficiency of capitalism against class enemies.

A second, far-reaching change had to do with attitudes toward technology, which in the nineteenth century had been almost unanimously positive. Now, conservatives complained about the threat to respectability and moral values, which was reason enough for farmers and small business owners to oppose the new methods emerging from the ETH as directly undermining their livelihoods. Insofar as the "conservative revolution" called into question the entire notion of modernization, the university as a symbol of reason and progress became controversial.[12] This chorus of doubts became louder in the wake of the First World War, on whose battlefields the destructive potential of technology was so brutally unleashed.[13]

Nonetheless, the critical discourse taking shape in the 1920s was not aimed at the ETH itself.[14] The most probable reason for this was the redefining of the triangular relationship between politics, science, and business affairs around the time of the successful internal reform of the university and its consolidation over the course of the 1930s.

Constructing a national center of excellence in science and engineering had been an eminently political endeavor in the epoch of the liberal revolutions of 1848. Yet as it succeeded in becoming more academic, the school largely lost the character of a (partisan) political project. In fact, the professionalization of academia and a growing distance from the day-to-day business of politics went hand in hand. The liberals took careful note of the change. In 1927, for instance, the *Neue Zürcher Zeitung* lamented that the appointment of "egghead" Arthur Rohn as president of the School Council had weakened the relationship between the ETH and liberal politics in clear contrast to the "great years of liberalism" – the Kappeler era. At the end of Robert Gnehm's tenure, it was hoped that the School Council would revive the old tradition of the Kappeler years. But unlike Kappeler – a lawyer and politician who served thirty years as a states' councillor – Rohn was an engineer and scientist who had little affinity for federal politics. The appointment of the former professor of bridge construction, who had also been rector of the school for several years, marked a separation between science and politics. It also signified the professionalization of science, and its internal differentiation accompanying the modernization process of industrial society.[15]

Even before Rohn's election, chemistry professor Hans Eduard Fierz-David warned in a 1925 article in the *Neue Zürcher Zeitung* of "recent activities aimed at adding external management to the institute." He personally was opposed because the leadership requirements of the ETH were so different from "any other administrative enterprise that only those really familiar with it can make the appropriate decisions."[16] In proposing that academics be free to manage themselves, Fierz was advocating the separation of science from politics. At the same time, he situated this "depoliticized" university in a symbolic context that gave it the aura of a political project. In particular, he stressed the vital importance of science to the economic well-being of the political collective. Wealth was not simply a product of the earth, he said, alluding to the words of his colleague Fritz Haber, but also of "human intelligence." He cited Haber's trenchant observation that "from the standpoint of the nation," scientists were "like geese ... that lay golden eggs."[17]

Rohn's election brought a significant gain in academic autonomy. On the other hand, the break between science and politics also required the ETH to renegotiate its external relationships, especially vis-à-vis politics and business enterprises. During the nineteenth century, political liberalism had strongly supported the federal institute because it promised to deliver prosperity in the form of practical applications. Polytechnicians themselves would provide expertise and a highly qualified workforce to the emerging economy. But as the ETH became more academic, this naïve assumption lost its persuasiveness. Professional training took a back seat to research. Within the research establishment, the idea that one worked independently on fundamental science with no concern about practical relevance began to take on weight. In the face of this shift, the utility of science for the national economy had to be redefined. The resulting debate took the form, on the one hand, of a political-economic discourse on innovation – in Joseph Schumpeter's sense of the term – that referred in a very abstract way to the benefits of research and science for the national economy.[18] On the other hand, calls increased for more industry-related, applied research that would help to distinguish the ETH from the nontechnical universities.

The somewhat contradictory phenomena of academic professionalization, the new proximity to industry and business, the move away from day-to-day politics, and the (re)politicization of the school as the national engine of growth underpin the issues addressed below. Why, for example, did the evolving political system continue to support the growing costs of a scientific enterprise that appeared less and less interested in the world around it? What role did the discourse on scientific autonomy play in the state's continuing readiness to pay science's bills even after liberalism had declined in importance? Finally, to what extent did the increasingly academic technical university mobilize money from the private sector?

The dual challenge of ensuring domestic tranquility and attending to outside relationships – in other words, finding an appropriate balance of internal and external cooperation and collaboration – preoccupied the ETH from the interwar period up to and beyond the 1960s. The major developments of those years fall into four broad topics. The pages that follow will examine, first, the discourse on the social role of technology that prevailed in the 1920s. Second, attention will turn to the ETH's relations with the world of business. The third topic concerns the interactions of the ETH with the political system. Fourth and last, the school's international presence will be considered. It will be shown that, thanks to a number of sociopolitical maneuvers, the ETH was able to find its way out of the first crisis of modernity. All in all, its deftness enabled the ETH – as the flagship of the federal government – to navigate the patriotic winds of *Landigeist* (spiritual homeland), *Reduitmentalität* (bunker mentality), and consensus democracy through the perils of war and post-war, eventually turning economic prosperity into academic growth. In so doing, the ETH constantly showed how important it was to the greater well-being of all Swiss society.

TECHNOLOGY BOOM AND BUST

Materialism and the decline of the West

A major symptom of the crisis of 1918 was typified by contemporary references to the "commercialization of politics." On 13 March 1918, for instance, National Councillor Karl Scheurer – a liberal from Bern and later federal councillor – commented on the general strike: "What is happening is very serious, both for our party and for the entire country. This class struggle harbingers the defeat of the Liberal Party, and with it the defeat of political freedom and ideas. Commerce rules."[19] Scheurer was bewailing the irrevocable loss of the Liberal Party's dominance. He saw the extension of political participation to groups outside the traditional liberal circles not as emancipation but rather as politics being trampled by cold-blooded material interests. Scheurer's bugbear was the materialism of the left. But his conclusion, "commerce rules," went much further. In a broad analysis of the problem penned in 1928, the liberal Basel historian Emil Dürr traced the roots of the "commercialization of political motives and parties" also to the growing influence of business associations in the political process.[20]

In the 1920s and 1930s, in the name of "business and fatherland," a corporatist democracy linking the leading Swiss business associations and the farmers' union, and soon also the trade unions, became stronger.[21] This development led gradually to a change in parliamentary politics, though hardly as extreme as various fringe elements wished. In his 1928 analysis, Dürr briefly surveyed the terrain: "There is talk of a representative body based on professional rank, of an economic parliament [*Wirtschaftsparlament*], of a trade-guild parliamentary or councillor system. Maybe fascist Italy will export its ideas here. And what about the Soviets?"[22] Such scenarios were clearly too radical for the stolid Swiss democracy. Nevertheless, change was afoot. The Federal Council's increasing habit of holding "extraparliamentary meetings" could shift the focus of political power away from parliament and the political parties, Dürr complained. "Special interests" of all kinds would become ever more influential.

This turn of events was alarming to Dürr. He saw in it the "eventual annihilation of politics at its human best, and by that I mean cultural, intellectual, and religious values."[23] The old political culture was replaced by a clamor of vested interests; what mattered was no longer how to secure the common good but rather the advantage of this or that group. Utilitarianism and materialism were the signs of a time that Dürr labeled the "materialistic-mechanistic age." The defeat of liberalism was both cause and consequence of this phenomenon. Dürr recalled the heyday of his party, whose program and been devoted entirely to "breaking down historical and psychological barriers," and regretted that following the successful establishment of the federal state, the liberals had not moved forward, but rather had confined themselves to administering their new freedoms. Today, he said, the Liberal Party was "ideologically bankrupt."[24]

Ceremonial event commemorating the 75th anniversary on 5 November 1930. Dignitaries from politics and science, including Federal Councillors Musy, Meyer, Pilet, and Schulthess, as well as Albert Einstein, were seated on the rostrum.

Many shared his views. For example, in 1931 the "Frontist" student movement (*Jugendbewegung der Frontisten*) similarly accused the Radical Free Democratic Party's (FDP) platform of having been coopted "by the state of mechanics" and essentially reduced to a "pedantic stream of empty phrases."[25] The perception of a state of vacuous, technological perfection coincided well with Oswald Spengler's conviction that "exact science must presently fall upon its own keen sword," which he linked to the decline of the West as early as 1918.[26] His vision sparked fears not only among liberal centrists but also the fascist far right wing. The commercialization of politics was equated with loss of culture, and thus with the triumph of material things over mind. At the same time, there was concern that a preoccupation with economic benefits was elbowing out traditional values.

Viewed from this pessimistic vantage, a deep chasm separated "technology" and "spirit," an impression confirmed by Emil Ermatinger, professor of German literature, on the occasion of the seventy-fifth anniversary of the ETH. Ermatinger used the 1930 anniversary issue of the *Neue Zürcher Zeitung* as a forum to proclaim bluntly that study at the ETH was "hopeless at turning out real human beings." Specifically, "university training targeted purely at practical application and stoking the economy will necessarily be to the detriment of the human spirit."[27] As a counterweight to the predominant emphasis on utility, Ermatinger suggested strengthening general education. Yet, strictly speaking, he saw the problem as so fundamental that a simple adjustment to the curriculum would hardly fix it. He had in fact touched on the relationship of soul and technology in an influential essay three years earlier, in which, like Scheurer and Dürr, he looked somewhat regretfully back on the nineteenth century. He shared their unease with the intellectual "vacuousness" of the present, and applied his analysis to an account of literary history: "It is surely no accident," he wrote, "that the spread of the technical ethos in the nineteenth century dovetailed with the decline of poetry, or that the crest of materialist thinking around 1900 coincided with a peak both in psychic brutalization and the impoverishment of literature."[28] His chief witness was the poet Gottfried Keller, whose artistic production reached its high point shortly after the founding of the federal state. Thereafter, Keller's work became "drier, spiritually poorer and more rigid ... even as his artistic technique grew more refined," leading Ermatinger to conclude that although technology began with the mind, "it also destroyed it." Goethe quite rightly ended Faust's life on earth with his grand civil engineering project, an intellectual dead end.[29] In the seemingly apolitical medium of the aesthetic reflection, Ermatinger managed to combine a domestic political debate with a dispute over the value of technology that had been ongoing in Germany since the end of the war. At the ETH, he stirred up much opposition, especially by extending his arguments to include the idea that, with its materialistic mindset, technology was necessarily bound to time and place and thus second-rate to intellectual benefits, which applied everywhere and forever. Now the "technology debate" had arrived in Zurich, too, where it found resonance in older debates about the social status of engineers.[30] An especially thorny question was the role of technology in the social, economic, and political crisis of 1918. Depending on one's point of view, the widely acknowledged "crisis of modernity" was either a direct byproduct of technology, simply exacerbated by misguided mechanization, or on the contrary about to be surmounted thanks to the efficient use of technology.[31] The debate was both political and economic. It wove together assorted values of middle-class individualism, democratic parliamentarianism, belief in the self-regulating power of the market, as well as diametrically opposite opinions of the promise of technological rationalization. A whole arsenal of attitudes and positions were formulated that to this day inform thinking about the relationship between technology and society.[32] This is also true of the ETH's discourse concerning itself, both then and now.

The different factions in the debate over technology are difficult to discern and hardly any easier to classify on a left-right political continuum.[33] Moreover, the picture one gets of Swiss attitudes toward modern science and technology in the 1920s and 1930s is cloudy. All across the political spectrum, the increasing conviction was that science and technology suited any ideological orientation and were therefore inherently apolitical. All the major political groups, from the Catholic conservatives and the leaders of the farmers' unions to the liberals and the social democrats, showed both antitechnology and decidedly pro-science and technology inclinations. The opinions expressed did not necessarily diverge in their assessment of science and technology per se, but rather vis-à-vis the question of how these fields would shape modernity, and what kind of society would best permit the relevant actors to take the steps required. "The future belongs to that strong, energetic, and forward-looking race that can conquer machines and turn science to the service of progress," proclaimed Jean-Marie Musy, a Catholic conservative federal councillor and a major supporter of the reactionary avant-garde in Switzerland. His rhetoric made clear that belief in the problem-solving power of science and technology was a guiding principle that stretched from the materialistic, progress-minded left to the fringes of the right.[34]

In contrast, Emil Ermatinger (who remained pro-German even after 1933) was taken to be representative of a hostility to technology shared by many technically naïve intellectuals of the conservative revolution.[35] This attitude drew more and more opposition from the ranks of engineers. Obviously, in the debate, professional background trumped idealistic values, which also shows how important professional groups were becoming as a source of personal identity. The engineer and entrepreneur Walther Rathenau is a good example: a liberal leftist who advocated technological development guided by moral principles.[36] A further exemplar is Gottfried Feder, who studied engineering in Berlin, Munich, and at the ETH Zurich, and who as an ideologist of the Nazi Party was responsible in the 1920s for theoretically formulating national socialism's favorable stance toward technology.[37] In injecting themselves into the technology debate, the engineers had two concerns: First, they feared that societal antipathy toward technology à la Ermatinger might dampen any appreciation for the work of engineers. Second, they worried that the industrial capitalist system would misread the art of engineering, and that technology would be used only as a means of maximizing profit.[38] This fundamentally anticapitalistic stance united such diverse positions as those of Rathenau and Feder.

A technocratic humanism

An influential reaction to Ermatinger's technophobia came from Aurel Stodola, who from 1892 to 1929 was professor of mechanical engineering and machine design at the ETH. In 1931, following his retirement, Stodola published his sensational *Gedanken zu einer Weltanschauung vom Standpunkte des Ingenieurs* (Reflections on a worldview from the standpoint of an engineer). The text opened by surveying opinions on modern technology by such renowned authors as Rathenau, Spengler, and the American public intellectual Stuart Chase. "According to Rathenau, by automating production, [technology] risks social inequality; Ermatinger sees a threat to the creative forces of the human mind; Chase thinks it has created 'Robots' (iron men); and Spengler proclaims it a manifestation of the predatory nature of Faustian man, and similarly doomed."[39] Stodola gathered alls these pronouncements under the heading "Indictments" (*Anklage*), the better to prepare his thematic "Defense" (*Abwehr*).

In contrast to the engineering disciplines, the pertinence of the art of architecture to the general realm of culture was never questioned. The drafting room of the division of architecture around 1930.

The belligerent rhetoric may to some extent be explained by the fact that, beginning in 1929, the critiques formulated by Ermatinger and others gained momentum from the global economic crisis. Despite a few barbs, Stodola's attitude was basically conciliatory. He did not doubt that the capitalist system's unfettered pursuit of lucre could morally undermine the "glory" of technology, and he was perfectly willing to acknowledge that technology could be "spiritless," in the sense of Ermatinger. Central to his thesis, however, was a plea for the cultural/social value of creative technology when correctly understood and applied. He associated these values with mastery of certain skills specific to engineers. He wished them to be underpinned by a system of ethics that held engineers responsible for the common good. According to Stodola, an engineer was one who "replaces chaotic, unbridled nature with order, with the rule of superior reason." To be an engineer was to believe that knowing the potential of technology entailed an urge to serve the community. "Engineering is an ethical impulse, not a monetary one" was the guiding theme.[40]

Stodola shared the view of many contemporaries that the stock market crash of 1929 was a consequence of the moral bankruptcy of the unregulated capitalist economic system. He approvingly quoted the Catholic conservative national councillor and School

Councillor Heinrich Walther's observation that an economic system based purely on the pursuit of profit was unsustainable. He also concurred with Ernst Laur – ETH professor of agricultural management and head of the farmers' union – that free market competition could not solve the current economic problems.[41] Instead, Stodola proposed optimistically, what was needed was a stronger nation-state to steer the economic process and to level social inequalities. "The union of nationalism and socialism is thus a necessary consequence of modern thinking and must be warmly welcomed," he maintained, most likely with appreciation for the work of his Nazi colleague Feder.[42] The assistance of engineering experts would help to create and entrench an optimal social order. Indeed, wrote Stodola, "If this engineering spirit were to be enshrined in our laws, the world would be astonished at how much of what previously seemed hopelessly utopian is actually achievable." Based on "statistical evaluation of economic flows," policy could proceed from an engineering standpoint and work out technological solutions to social problems.[43] Admittedly, however, it would require that engineers be trained extensively not only in their own fields but also in the humanities. The education of an engineer should be expanded to include history of technology and especially of cultural history, as recommended by Ermatinger.[44] "An engineer works not only with 'metallic' but also with 'human' material. He must be able to understand human nature with all its strengths and weaknesses; he is above all the anointed mediator between capital and labor, which of course is also the tragedy of his profession."[45]

The notion that an engineer's reason entitled him to mediate class struggle was hardly new.[46] In the United States, especially, it formed the nucleus of a "technocratic movement," one of whose early exponents, Thorstein Veblen, had in 1921 promoted a kind of "soviet of engineers" to combat the profit motive of capitalism. Howard Scott, the leader of the movement (which at times also served as a political party), managed together with Columbia University to assemble a board of technocratic experts to analyze whether the US economy was wasting energy resources.[47] The American movement found an echo in Germany, particularly with Heinrich Hardensett, whose writings on "capitalists" and "engineers" reached a peak of popularity in 1932. Stodola regretted that Hardensett was not more systematic in constructing his "worldview." He found particularly arresting Hardensett's concurrence with Veblen and Scott's proposal that the economic order cease its focus on the profit motive, as it only led to overproduction, collapsing wages, unemployment, and social inequality. Instead, economies should be based on "natural need." The "engineer" had the ability to recognize this need and to allocate resources most efficiently.[48]

Gustav Eichelberg, Stodola's longtime assistant and, in 1929, his successor as professor of engineering thermodynamics, combustion engineering, and refrigeration, wholeheartedly adopted German technocracy. In a lecture to the Christian students' conference in Aarau in 1932, Eichelberg pointed out – in contrast to Ermatinger – that engineering was at core a creative enterprise, and he parried the attacks on technology by admitting guilt: engineers had pursued wealth too assiduously and assumed too little responsibility for the community. Now, however, that would change, because the very purpose of technology was "to serve." With respect to the Great Depression, he had this to say: "*What we are experiencing in this crisis is none other than the foundational collapse of the nineteenth-century way of thinking, which failed to fulfill this purpose. Liberal regulation of private profits is breaking down;* it is being replaced by an awareness of community responsibility."[49]

Eichelberg's pronouncement was largely wishful thinking, a utopian guide to behavior inspired by his notion of an ideal society. He inveighed against "senseless" and inefficient industries, among which he counted leisure, middlemen, and advertising, which created "artificial" needs. Instead, he called for a planned economy that he promised would connect everyone involved in the economic process positively to the collective. Were such a process put in place, the greatest benefits would accrue not to the individual but to the community. For this reason, he admired the Soviet Union, where the alienation of workers due to mechanized production had been alleviated through clever organization of production processes. According to Eichelberg, in Russia people worked with "enthusiasm" because "community responsibility was the starting point of operations scheduling."[50] This technocratic perspective also warmed to national socialism, with its antimaterialistic exaltation of the German nation (*Volksganzen*).[51]

The central element of "responsibility" in this antiliberal and anticapitalistic vision became the nucleus of a Swiss form of technocratic thinking that was explicitly humanistic. In 1931, for instance, in a paper titled "*Technik und Wirtschaft in den geistigen Entscheidungen der Gegenwart*" (Technology and economics in to-day's chief problems), Eugen Böhler, an ETH economist, lamented the "flight from responsibility" typical of many engineers and entrepreneurs.[52] Beginning with Stodola and Eichelberg, the official speeches given in the rare moments of self-reflection at the ETH increasingly referred to an ethics of engineering that practitioners could be guided by in serving the public. But to mediate between capital and labor required a personality training in the humanities. An almost prototypical example of such an "ideal engineer" was Stodal's student Ernst Dübi, who in 1937, as president of the *Arbeitgeberverband der Maschinenindustrie* (association of engineering industry employers), concluded a labor agreement with the union leader Konrad Ilg.[53]

"In any event," argued Böhler in 1931, "our current disciplinary situation is in large part due to the fact that [amid all the concern over] the advantages of specialization and differentiation of values, *the importance of general education – the development of personality and character* – was overlooked." Only by strengthening the humanistic ideal of education at the ETH could "the qualities of humankind be adjusted to cope with the characteristics of their creations."[54] In so doing, Böhler formulated an idea consistent with one of the key references of the emerging technocratic humanism: a document published by Karl Jaspers in 1931 on the "contemporary spiritual situation." Jaspers wrote, "With the intro-

The commemorative plaque in honor of Francesco De Sanctis installed in the main building of the ETH in 1948. De Sanctis taught Italian literature at the polytechnic between 1856 and 1860, and later served several times as the Italian minister of education.

duction of technology, we have embarked on a path that needs to be explored further. To go back would render existence close to impossible ... Yet in our attempts to increase the success of our activities by underpinning them with technology, *we must be keenly aware of what cannot be mechanized*. To believe that technology is everything is to annihilate the self."[55] This cautionary note on the "nonmechanizability," which also implied the limits of technology, brought the technocratic impulse down to a Swiss level. The reference to Jaspers largely immunized the Swiss technocrats against radicalization and lent a surprising and enduring consistency to their discourse through thick and thin. In the face of the first crisis of modernity, a way of talking about technology and society emerged that managed to retain its persuasive power up to the 1960s, untouched by the Nazi policy of extermination, the Second World War, the atomic bomb, and technocratic Soviet totalitarianism. Eichelberg's 1965 description of the relationship between humanism and technology could easily have been taken from 1932; in 1959, too, he had spoken of "the responsibility of humans in using technology."[56] ETH professor and later federal councillor Friedrich Traugott Wahlen went even further in advocating a special kind of humanism. Finally, in his reflections on technology and society, Walter Traupel, professor of thermal turbomachinery from 1954 and ETH rector from 1961 to 1965, evoked Stodola and Jaspers.[57]

By the time of the ETH's 100th anniversary, technocratic humanism was already so entrenched that it became grafted on to the school's historic mission. In any case, the *Schweizerische Bauzeitung* led off its special 1955 issue with a quotation from Francesco de Sanctis, who from 1856 to 1860 had occupied the chair of Italian literature: "You are men first, then engineers."[58] The quotation was followed by an evocation of the "university's humanity." Although ETH graduates might initially train according to the practical needs of their profession, that very fact required an expanded notion of education, effectively a "humanism of the deed" to complement the classical "humanism of the word." To this, the editor of the *Bauzeitung*, Adolf Ostertag, added: "The dialog between these two poles – which integrated them and everything they stand for into something more complete – was, I think, the real guiding principle on which the polytechnic was founded, which it sought to realize through all the storms and vicissitudes of time, and which has allowed it – even at one hundred years old – to remain active, vibrant, and open to change."[59] By 1948 a plaque commemorating de Sanctis and bearing the now oft-quoted aphorism was proudly unveiled.[60]

THE VALUE OF RESEARCH

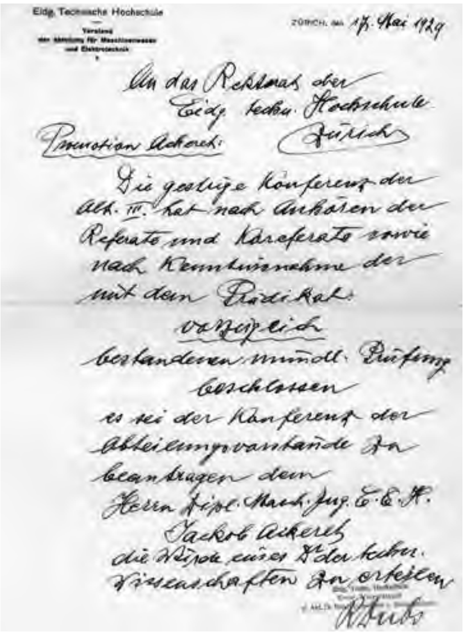
From its very founding, the ETH was oriented toward practical application. In the period between 1911 and 1968, the social and economic value of scientific research underwent considerable structural changes that at times produced stark tensions between science and economic rationality. New fields in the application of science emerged. Engineering became increasingly scientific. The category of unbound, "pure" research began to stand out against the industrial research conducted internally by major industrial companies. And new organizational models for scientific practice unfolded. This section focuses on these long-term changes in the use and usefulness of science and technology. It specifically highlights the modes of financing academic work in view of the needs of the Swiss economy. The establishment of a National Science Foundation by the federal government in 1952 will be analyzed from a more political perspective further below.

Meeting the promises

Through its new regulations adopted shortly before the First World War, the ETH committed itself to an academic program that gave students as well as teachers wide latitude in their choice of subjects, courses, and research. In so doing, the school was effectively betting on the business of the future. Put another way, following the period 1908–11, for the first time, the ETH had to build up key competences in both the natural sciences, engineering, and technology in order to be able to meet academic challenges. Students, too, faced new responsibilities. Fundamental alterations to the traditional course of study overwhelmed the average student. Moreover, the overnight "normalization" of the new academic curriculum put the burden of decision making on students as individuals. In transitioning from a strictly regulated curriculum to the guided program of study characteristic of a real university, the concepyt of a technical university was becoming a more tangible possibility for the polytechnic pupils. Research and teaching were finally as closely intertwined as Humbolt had imagined only in his wildest dreams.[61]

Of course, the commitment to research was still under construction. The right to award PhDs (won in 1908) was no help in finding students both qualified enough to graduate and capable of making contributions to research. Consequently, building the research infrastructure and conditions necessary to produce dissertations became a priority. Individual disciplines took varying amounts of time in setting up a system of formal requirements that met a credible scientific standard. In 1909, the chemistry division awarded six PhDs and redoubled its existing research efforts.[62] That same year, mechanical engineering, which at the time still encompassed electrical engineering, had two PhDs, and 1912 a dozen, whereas less research-oriented disciplines, such as architecture, civil engineering, surveying, and forestry produced very few PhDs. Mathematics, physics, biology, and earth sciences continually generated young researchers, but until 1945 these disciplines taken together never produced more than 20 doctorates a year. In agriculture the PhD-making machinery also ran in fits and starts.[63]

Despite the relatively large number of doctorates in engineering, it would be wrong to see this area as well-plowed field of research going back to before the First World War. The earlier PhDs in Division III were lone warriors; notable research developed only in the 1920s and 1930s and in close cooperation with industry. At the beginning of the century, chemistry and physics at the ETH were also far from being internationally competitive. In 1912, future Nobel Prize winner Richard Willstätter left his ETH professorship with nary a backward look to take up a post at the newly founded Kaiser Wilhelm Institute for Chemistry in Berlin. Concern over status, the quality of the academic environment, and research conditions, and less burdensome teaching obligations drove many faculty away from Zurich. In 1914, Albert Einstein left the ETH for the University of Berlin and the directorship of the Kaiser Wilhelm Institute for Physics. Physicist Peter Debye, mathematician Hermann Weyl, and chemists Hermann Staudinger and Richard Kuhn are further examples of first-rate scientists who before 1930 gave up ETH professorships to work in more attractive places. In 1929, for instance, Kuhn took over as head of the chemistry department at the Kaiser Wilhelm Institut for Medicine in Heidelberg. It wasn't until the 1930s that the ETH was in a position to hold on to outstanding scholars like Leopold Ruzicka. An organic chemist who won the 1939 Nobel Prize in chemistry for his work on many-membered ring compounds, Ruzicka wrote in retrospect what a great relief it was not to have to give the main course in inorganic chemistry after 1931.[64] The respect now accorded to research was also evident in the fact that in 1932 the electrical engineer Fritz Fischer


Eidg. Technische Hochschule
Vorstand der Abteilung für Maschineningenieurwesen und Elektrotechnik

ZÜRICH, den 17. Mai 1929

An das Rektorat der
Eidg. techn. Hochschule
Zürich

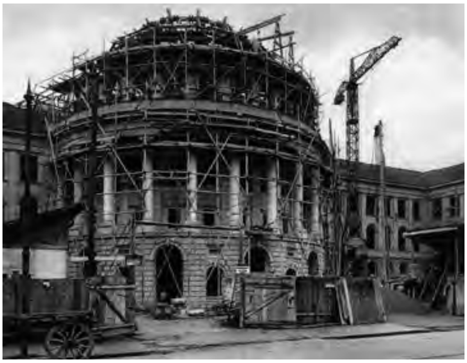
Promotion Ackeret.

Die gestrige Konferenz der Abt. III. hat nach Anhören der Referate und Korreferate sowie nach Kenntnisnahme der mit dem Prädikat:
vorzüglich
bestandenen mündl. Prüfung
beschlossen
es sei der Konferenz der Abteilungsvorstände zu beantragen dem
Herrn Dipl. Masch. Ing. E.T.H.
Jackob Ackeret
die Würde eines Dr. der techn. Wissenschaften zu erteilen

Decision of the division of mechanical engineering, dated 17 May 1929, to award a PhD to Jakob Ackeret.

Eminent scientists of the ETH lost to other institutions between 1910 and 1930. Left to right: Richard Wilstätter (to Berlin, 1912), Albert Einstein (to Berlin, 1914), Hermann Staudinger (to Freiburg, 1926), Peter Debye (to Leipzig, 1927), Richard Kuhn (to Heidelberg, 1929), and Hermann Weyl (to Göttingen, 1930).

could be lured away from the research department of Siemens & Halske in Berlin and, as professor of engineering physics largely free of teaching duties, could busy himself in the laboratory with "advanced trainees and doctoral students."[65]
Fully delivering on the university's promise, however, was going to require better infrastructure. Good research presupposed appropriate space, and acquiring it became a pet project of chemist Robert Gnehm. Appointed president of the School Council in 1905, Gnehm first applied his energy to revamping the legal basis of the ETH before turning his attention to the building needs for future growth – a task to which he devoted the remainder of his term in office until 1926.[66] The separation from the canton of Zurich turned out to be a godsend, as it meant that the federal government could decide the expansion and renovation projects independently. In 1914, with the opening of its own new home, the cantonal university gave up its tenancy in the ETH main building, freeing the entire south wing in one fell swoop.[67] In addition to reorganizing and renovating



Renovation and expansion of the main building according to Gustav Gull's design. Central block of the new east façade with rotunda and cupola, ca. 1919.

the space in the main building, Gnehm also tackled the expansion of the agriculture and forestry institute as well as the erection of a natural sciences institute between Sonnegg- and Clausiusstrasse.

However, these construction schemes – the most visible sign of which was Gustav Gull's enlargement of Semper's original edifice – progressed slowly at first. Problems were already evident during the initial discussions concerning financing. Parliament had to be carefully convinced that the investments under debate were worthwhile. In 1911, Gnehm implored the parliamentary finance delegation to consider the unprecedented and growing competition the ETH was facing. "We have observed with no little concern the rapid rise of the 'Kaiser Wilhelm Institutes,'" Gnehm stated on 9 November 1911 in the Hotel Baur in Zurich. "[These institutes] have managed to attract the best people, world-renowned researchers who also happen to be superb teachers."[68] The subtext, of course, was that Richard Willstätter would have remained at the ETH had it been able to match his offer from the Berlin institute, which was completely devoted to research. The research environment had to be improved. Parliament assented.

The new natural sciences building between Sonnegg- and Clausiusstrasse was to have been ready for occupation in 1913, after which the renovation of the main building and the expansion of the agriculture and forestry institute would be undertaken in succession. But plans were delayed almost from the start. Following the roofing ceremony in winter 1913/14, a long debate ensued over the question of what furnishings and equipment from the old building could be reused, and what needed to be acquired anew. The outbreak of the First World War scuttled any further progress. "For months, the work was at a standstill."[69] Purchasing equipment from abroad was practically impossible. Finally, in January 1917, the building was completed and occupied. Similar delays afflicted the agriculture and forestry building, where work started, while pushing up work on the main building, since the university would not be able to move into its new premises until later. The biggest problems, however, involved the Semper building. Gustav Gull extended the grand old building with a second, imposing façade cum canti-

The prefabricated reinforced concrete structures of the cupola were later covered with tiles. View of the east façade, 1920.

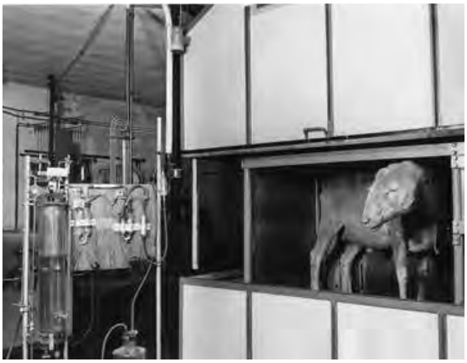
levered entrance along Rämistrasse that he capped with a distinctive dome. But he also insisted that serious flaws in the existing structure be remedied. New floor supports and stronger columns were added to the basement, and the roof pitch of the entire edifice was raised.[70]

Gull's overall intervention was slowed because of the unexpected salvage efforts; he also had to cope with a shortage of craftsmen. By 1917, wartime inflation had destroyed the financing for the projects. In 1921, Gnehm had to ask the Federal Assembly for 10 million francs over and above the initial allocation of 11 million francs. Two years later, he requested 750,000 francs more. Happily, by this time, the end of the decade-long renovation appeared to be near. The entry into effect of the new regulations in 1924 marked the definitive conclusion of the school's internal reform as well. The ETH's divisional structure would endure practically unaltered until 1980; faculty employment procedures were clarified; the pension system for professors was formalized; and engineers could now graduate with a "dipl. ing." degree.[71] In 1923, at the 37th General Meeting of the GEP, Gnehm's optimism was evident: "Thanks to regional authorities' foresight and willingness to make sacrifices, [the ETH], newly outfitted within and without, [has entered] a new phase in its glorious history."[72] As late as August 1920, the public was still grumbling about the "architectural damage" Gull's dome had inflicted on the old Semper building.[73] But this annoyance quickly dissipated in the glow of Gnehm's positive outlook.

The world as a laboratory for agricultural policy

With the upgrading of the polytechnic to a university and the *Promotionsrecht*, the institution's relationship to the everyday working world also changed. This represented a major challenge for the classical civil and mechanical engineering disciplines. But the agriculture division also had difficulty adjusting to the commitment to research and the increased emphasis on science. Since its opening in 1871, it had repeatedly been accused of not being applied enough. Many critics maintained that the farming business could not be learned in a lecture hall but only by daily work in a barn and in the field. Others observed, somewhat less stridently, that the cantonal schools of agriculture, such as those modeled on Philipp Emmanuel von Fellenberg's ideas that proliferated during the nineteenth century, provided all the theory that was needed.[74] While the training at the polytechnic built on the skills acquired at these agricultural schools but clearly also had to offer something above and beyond them, at their divisional meetings of 1908 and 1909 the agronomists hammered out the terms of the new doctorat. If an "educated farmer" was already a contradiction in terms in the eyes of many, great care would have to be taken in defining a "PhD farmer." Whereas the issue with mechanical and process engineering had been to find a way out of the theory-practice dilemma by complementing academics with practical training, agriculture students already had substantial practical experience behind them. Consequently, the value of an academic education would be to provide them a theoretical understanding. From animal husbandry and crop engineering to production management and finally to the societal dimensions of agriculture, the idea was to make the whole enterprise as scientific as possible, on the assumption that only through an elitist detachment from its peasant roots could academic agronomy be put to real use.

The problem was an old one. In proposing to parliament in 1869 that the polytechnic include an agriculture division, the Federal Council argued: "Although at first they will be few, this institution will gradually supply the country with increasing numbers of men whose fundamental training in science, agriculture, and economics will help put the agricultural industry on the right path, and who will train the ranks of the farming population at large and eventually enable them to move up."[75] Rarely was the vision of the government university more poetically formulated than in this sentence, pointing as it did to an admittedly initially weak, though later more strongly evolving potential for intellectual competence that, thanks to a miraculous multiplier effect throughout the rural population, would stimulate a push for modernization. The cautiousness of the phrasing makes clear, however, that the promise was uncertain. Progress would only occur if the matriculants of the agricultural school maintained their connection to the rural world until graduation and then returned to the milieu that had produced them.[76] Only by combining theory and practice would they be in a position locally to satisfy both the "more pressing, general interests and demands" of the farmers and their social concerns "in the proper way" – that is, to implement democracy.[77] From the very outset,



The division of agriculture was constantly striving for scientific validation and was largely removed from the realities of farming. At the institute for domestic animal feeding, the pen became a laboratory. Here, an experimental design for feeding studies in sheep, around 1953.

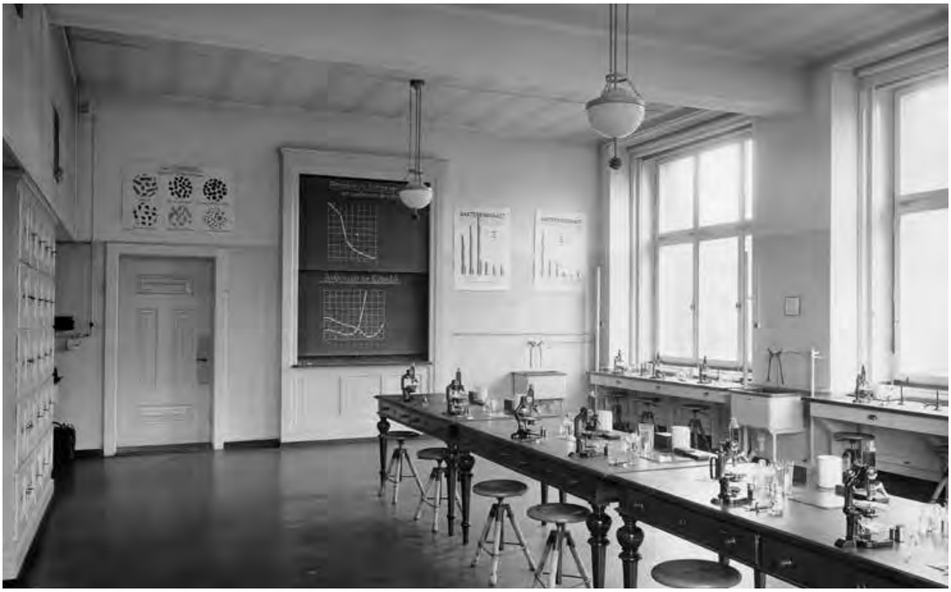
then, the ETH's agriculture division undertook to mediate between rural society and industrial-rationalist modernity, namely, by adding science and economics to agriculture on the educational menu, and offering it up as a service to the real world.[78]

The political aspects of this program were developed at the beginning of the twentieth century by Ernst Laur, a former agronomy student at the ETH who from 1908 until 1939 was professor of farm management. Since 1898, Laur had presided over the government-subsidized *Schweizerischen Bauernsekretariat* (Swiss Farmers' Secretariat) in Brugg, and was also president of the *Bauernverband* (farmers' union), which he made into one of the most effective interest groups in Swiss domestic politics. Laur's goal was to strengthen the position of farmers politically and to secure it economically. As their leader, but also as the Federal Council's ambassador for trade agreements – a post he held from 1904 to 1945 – Laur wielded enormous political influence, although he never occupied a parliamentary seat.[79] Together with his farmers' union he seemed to embody the very "commercialization" of politics that Emil Dürr so vehemently denounced in 1928. Laur himself was well aware that his actions were troubling to the liberal system. But he was unconcerned about the threat of political conflict disintegrating into a quarrel over economic interests. His platform was not materialism, but rationalization; his aim not to *commercialize* politics, but rather (in his own words) to *intellectualize* them.[80]

The crux of Laur's sociopolitical commitment was a large-scale research project in statistics to determine the profitability criteria for Swiss farming. Developed at the ETH, and carried out by the farmers' union, the survey amounted to a kind of "bottom-up statistics,"[81] in which the politically organized farmers provided information about themselves. Beginning in 1924, the farmers' union in Brugg published yearly statistical surveys as well as forecasts concerning agriculture and food, which later came to include statistics on milk. Laur had several objectives with his surveys. First, they constituted scientific research and as such would bring him international attention. Second, they provided him – as president of the farmers' union – with evidence to bolster his political arguments. Finally, the studies pointed the way to optimizing farm management. Lauer wished to turn Swiss farmers into entrepreneurial managers because, in his eyes, only as rational producers for the market did they have a future in the industrial world.[82] In 1942, Laur commented in his autobiography on the intertwining of politics and science: "I am happy to note, however, that in stimulating – I might even say forcing – me constantly to increase my knowledge, my teaching at the *Eidgenössischen Technischen Hochschule* ... has made me far more effective in the Farmers' Secretariat. On the other hand, as professor I had access to the excellent tools and staff resources of the secretariat and have benefited from the experience in drafting and implementing trade agreements that my committee work has give me. *Brugg is to me what the laboratory is to the chemist.* Without the combination of professorship and Farm Secretariat, I wouldn't have been able to properly accomplish either job."[83]

The comparison with chemistry was deliberate.[84] The agriculture division strove to incorporate the new methods of social science as enthusiastically as it had greeted a strong research orientation in the natural sciences. From its beginning, the division included a seat for agricultural chemistry that somehow managed to encompass the entire field of agricultural technology. Laboratory spaces for agricultural chemistry were first provided in the chemistry building in 1886. But the connection to chemistry came seriously only in 1913, when Georg Wiegner – a promising young scientist lured from Göttingen – proceeded to build up Zurich's expertise in soil chemistry to international acclaim. Laur was impressed with the priorities of ETH president Gnehm, who in choosing Wiegner gave greater weight to solid, fundamental science and familiarity with the latest advances than to more specialized knowledge of agriculture and agricultural chemistry. The rationale was that Wiegner could acquire the latter at any time, whereas gaps in basic knowledge would be harder to fill later.[85] The institutionalization of bacteriology subsequent to the appointment of Max Düggeli in 1914 confirmed the increasingly scientific character of the agriculture division. In 1916 the agriculture and forestry building acquired new laboratories, which in the years between the wars, and especially before the Second World War, became the nucleus of a new biology.

The growing importance of scientific research at the beginning of the twentieth century gave credence to the idea that the social world, too, could be used as a laboratory in which cleverly selected experiments could shed light on the workings of societal processes.[86] In this sense, social policy and agricultural policy both became more "scientific." In the interval between the wars, all the industrialized countries designed social engineering experiments at the interface of hygiene, food science, land use, city planning, and rationalization of production, whose goal was not only to better understand the social aspects of these disciplines, but also to be able to adapt social reality to the guiding principles of society. A catastrophic consequence of this connection was the Third Reich's plans to expand eastward, which post-1939 became inherently linked to the goal of exterminating European Jews.[87] But the morally quite differently motivated twentieth-century dike-building projects in the Netherlands, especially the creation of the Ijsselmeer in 1932, are also an outgrowth of this way of thinking.[88]



Above: In addition to the agricultural chemist Georg Wiegner, Max Dueggeli covered agricultural bacteriology from 1914 to 1945 for the natural sciences portion of the agronomy program. The so-called Dueggeli laboratory taught fixed microscopy. View from 1924.

Below: Laboratory space for advanced students in the milk technology institute, around 1955. The infrastructure was expanded in 1945 at the initiative of the Schweizer Milchwirtschaftlicher Verein (association of Swiss milk producers).

In the meanwhile, the *Schweizerische Vereinigung für Innenkolonisation und industrielle Landwirtschaft* (SVIL, Swiss association for domestic land use and industrial agriculture), founded in 1918, paved the way in Switzerland for agricultural policies based on social engineering. The driving force behind the organization was the agronomist Hans Bernhard, who had studied under Laur at the ETH. He subsequently worked for a while at the University of Zurich, lectured at the ETH on agricultural economics beginning in 1928, and in 1939, as a states' councillor for the canton of Zurich, represented the interests of the *Bauern- und Gewerbebund* (BGB, farmers' and artisans' league) in Bern.[89] However, the technocratic vision of these targeted interventions reached its peak in the social sphere only with the outbreak of the Second World War, which owing to issues of food security created a demand for novel organizational services, even in strife-spared Switzerland.[90] The chief engineer for the national food supply was Friedrich Traugott Wahlen, who became professor of agronomy at the ETH in 1943, took over the agriculture department of the Food and Agriculture Organization (FAO) in Rome in 1949, and in 1959 was appointed to the Federal Council. Together with Oskar Howald, Laur's successor at the ETH and in the Swiss Farmers' Secretariat, and with Ernst Feisst, a pro-German agronomist at the ETH and head of the federal food agency, Wahlen seized the opportunity to use science-based contingency policies to bring about structural change. The "cultivation campaign" conducted under the leadership of these engineers was intended both to ensure the current food supply as well as to effect a permanent shift from livestock farming to land cultivation.[91] The coupling of theory and practice brought the generation of agronomists that followed Laur and Bernhard deep knowledge of the sociotechnological dynamics of agrarian society in the age of industrialization. Still more importantly, using the world as a laboratory also suggested principles to guide action – and the courage to act guaranteed them success. The policies they formulated up to 1945 proved socially effective not because of improved yields but above all because of the coordinated actions of the agencies. The extent to which that generation of technocrats bought into this worldview

Friedrich Traugott Wahlen, professor of plant engineering, at a field lecture on potato cultivation, 1945. As the federal government's commissioner for securing the nationwide food supply, Wahlen introduced a technocratic form of agrarian modernization during the Second World War.

was made evident by physiologist Alfred Fleisch, then head of the Swiss war nutrition board. In a look back from 1946, he spoke of the "scientifically guided experiment of our wartime rationing," whose result clearly showed that the level of socially acceptable minimal nourishment could be set quite low.[92]

Beginning with the turning point of the war in 1942/43, this security planning displayed further effectiveness in greater local and global dimensions. On the one hand, as early as October 1942 the ETH staged a major conference on land use, attended by agricultural policy experts and relevant specialists, as well as geographers, architects, and city planners.[93] The event motivated the further development of planning issues in Switzerland and laid the groundwork for the 1959 founding of the ETH Institute for Local, Regional, and National Planning, but also provided a platform for vocal critics of exaggerated planning fantasies like Eugen Böhler.[94] On the other hand, after 1945, Friedrich Traugott Wahlen's wartime expertise gave rise to a sense of global political responsibility that was economically and agriculturally consistent with anticommunist development aid. It is no coincidence that in reporting to the *Gesellschaft Schweizerischer Landwirte* (Swiss Agricultural Society) on the work of the FAO in 1952, Wahlen evoked the "great experiment."[95] The technocrats' laboratory now encompassed the entire world, and the belief in its effectiveness in coming to grips with social issues remained unchallenged for decades. The end of this era was marked by a symposium titled "*Schutz unseres Lebensraums*" (Protecting our habitat) that took place at the ETH in November 1970 and that shaped the ecological debate of the 1970s and 1980s just as the rural planning meetings of 1942 had guided beliefs about the future in the postwar period.[96]

The "scientific transformation of the social" in the factory

It says something about the technocratic vision of the kind outlined above that it claims to be free of ideology. Agropolitical optimization as proposed by Ernst Laur, but also the social statistical surveys carried out by ETH economist Jakob Lorenz, could equally serve fascist, corporatist, conservative, or socialist ends. The apparent neutrality of the scientific approach turned the statistics and surveys into political tools.[97] In the politically heated period between the wars, this state of affairs became particularly explosive. As mentioned, Laur used his data in support of the farmers' union. Lorenz, who in 1933 was appointed professor at the Catholic University of Freiburg, not only sat in the committees for social statistics, business cycles, and wage and price controls but also applied his statistics in the service of the conservative-corporatist *Aufgebotsbewegung*, (an elite rightist movement), as whose leader he campaigned against the "*Verjudung*" (Judaization) of Switzerland.[98] At the other extreme of the political spectrum was the architect Hans Bernoulli, who was titular professor of city planning until his support of free-economy theorist Silvio Gesell caused him to step down in 1938.[99]

The Swiss reaction to the American rationalization movement was equally polarized. In August 1919, back-to-nature reformists proposed that the ETH establish an industrial management institute. The petition envisaged a kind of advisory center for grafting the new methods of *scientific management* from the United States onto the Swiss economy. In addition to finding ways of improving work methods, business organization, pay systems, tools, and so on, a training component was also planned. A new education program would enable the ETH to build a "new professional class of engineers." The new engineer would have his work cut out for him, "mediating between the factory boss and the workers."[100] Through targeted application of scientific resources, the initiators hoped to defuse class conflict, which in post-First World War Switzerland had become especially virulent. They shared the hope – across the political spectrum – that a third agency (science and engineering experts) could help to lessen the opposition between capital and labor. Increasing operational efficiency would raise the productivity of factories (so this argument ran), resulting in higher salaries, which in turn would boost consumption and create new sales opportunities. The engine of this wealth-creating machinery, which would consign all issues of distribution to obsolescence, was the rationality of modern scientific thinking.

Streamlined production processes, optimized methods of human and financial management, punch card- and typewriter-supported administrative processes, but also improvements in industrial psychology and innovations in work physiology and industrial hygiene were the manifestations of a more scientific approach to social problems – both within companies and outside, in society. This "*Verwissenschaftlichung des Sozialen*" (scientific transformation of the social),[101] which in Germany, for instance, was characterized by the *Verein für Socialpolitik* (society for social policy) and in Switzerland gave rise to the *Gemeinnützige Gesellschaft* (Society for the Public Good), posed a direct challenge to the School Council. In 1919, Emil Haemig became the first lecturer appointed to teach "*Übungen zur Einführung in die Statistik und Psychologie der Arbeitsleistung* (Taylor-System) [Exercises in applying statistics and psychology to work performance]."[102] By the same token, establishing an industrial management institute and a training program for production engineers was rejected on the grounds that neither was concerned with basic science but rather with exchanging practical experience. In the 1920s, the ETH systematically resisted becoming the profession-


I. JAHRGANG NUMMER 1 JANUAR 1923

DIE KURVE

WIRTSCHAFTLICHE MONATSCHRIFT FÜR DIE SCHWEIZ MIT KURSKONTROLLE
VERLAG DER NATIONAL-ZEITUNG A.-G., MARKTPLATZ 6, BASEL · REDAKTION: Dr. JAKOB LORENZ

DIE KURVE ERSCHEINT JE AUF DEN 20. DES MONATS. – BEZUGSPREIS: Fr. 8.– FÜR DAS JAHR, Fr. 5.– FÜR DAS HALBJAHR. – BESTELLUNGEN AUF ABONNEMENTS NEHMEN ENTGEGEN SÄMTLICHE POSTBUREAUX UND BUCHHANDLUNGEN SOWIE DER VERLAG DER NATIONAL-ZEITUNG A.-G., BASEL

AUS DEM INHALT: Zur Einführung, S. 1. – 1923, S. 2. – Geld- und Kapitalmarkt, S. 3: Die Bewertung der Valuten im Jahre 1922; Der Clearingverkehr im Jahre 1922; Sparkassenstatistik; Die Bewertung der Aktien im Jahre 1922; Die Wiederherstellung des Bankgeheimnisses in Deutschland. – Warenmarkt, S. 9: Die Preislage im Jahre 1922: Die internationale Preislage im Jahre 1922; Ein neuer Textilrohstoff; Preissturz des Radiums; Die Lage am Kautschukmarkt; Europäische Kunstseide und ihr Konsum in Ostasien. – Arbeitsmarkt, S. 15: Die Arbeitslosigkeit im Jahre 1922; Der Andrang bei den Arbeitsämtern im Jahre 1922. – Produktion und Export S. 16: Stand der Exporte im Jahre 1922; Die landwirtschaftliche Produktion im Jahre 1922. – Handel und Verkehr, S. 18: Neue Wege in der Warenvermittlung; Die Hinterlagen der ausländischen Lebensversicherungsgesellschaften in der Schweiz; Öffentlicher Haushalt, S. 20: Bundessubventionen. – Ausländische Rundschau S. 20. – Kurskontrolle S. 23. – Literatur S. 24.

Zur Einführung.

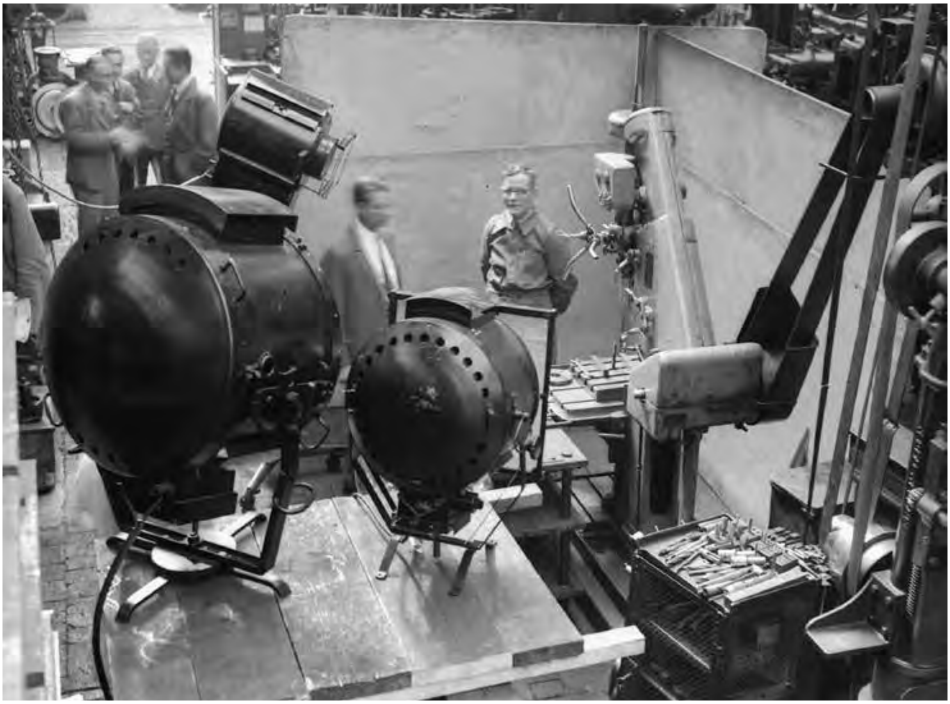
An wirtschaftlichen Zeitschriften ist zwar in der Schweiz kein Mangel. Allein es fehlt eine Monatschrift, die den Leser durch ge- haben wird. Allein für die Bildung dieser Meinung soll wissenschaftliche Erkenntnis massgebend sein, die sich — so weit dies überhaupt möglich

"We need a magazine published at frequent intervals that provides readers with a succinct overview of the state of the economy." In 1923, ETH economics lecturer Jakob Lorenz sought to fill this market niche with *Die Kurve*. The publication was intended as a tool for the technocratic social engineering. The name is a reference to the graphical representation of quantitative information.

alization agency of the emerging welfare state. In 1922, the school quarreled with the *Gemeinnützige Gesellschaft,* which was hoping for more teaching positions in the area of social welfare. In 1925, a petition by Professor Willy von Gonzenbach to expand his bacteriology and hygiene institute to enable training of more factory inspectors came to naught. In 1930, the School Council refused the request of the *Vereinigung Schweizer Angestelltenverbände* (Federation of Swiss Associations of Salaried Employees) to create a professorial position in social policy. When, a year later, the *Gewerkschaftsbund* (Trade Union Federation) demanded a professorship in work physiology to counter the "dangers of overexploitation of human labor" with "objective" methods, they cited the activities of von Gonzenbach and the industrial psychology lectures of Alfred Carrard.[103]

The reluctance of the School Council vis-à-vis the new social sciences may well have been due as much to their political touchiness as to their "unscientific" nature. In any event, the school needed to act. There were, after all, positive examples, such as the close association of the Massachusetts Institute of Technology and the industrialist Alfred P. Sloan Jr., which gave rise to the MIT Sloan School of Management. Accordingly, in 1928, together with economics professor Eugen Böhler and management science lecturer Alfred Walther, School Council president Arthur Rohn organized a one-week "advanced management course for engineers and supervisors." The well-attended event clearly improved the ETH's relations with banking and industry leaders. National bank president Gottlieb Bachmann and industry representatives such as the Brown, Boveri & Cie. director Heinrich Ambühl acted as lecturers. Iwan Bally declared himself impressed. Hans Sulzer of Gebrüder Sulzer in Winterthur, also a speaker, proclaimed that he had finally established the "intimate contact" with the ETH that he believed to be "so important and necessary" for his company.[104]

The immediate consequence of the event was the creation of a private company to develop a management institute. Up to October 1929, a slew of enterprises were encouraged to pay an annual premium of 44,000 francs to run the institute. The ETH would contribute a further 28,000 francs yearly, to be supplemented by an additional 10,000 francs from the *Eidgenössischen Stiftung zur Förderung schweizerischer Volkswirtschaft durch wissenschaftliche Forschung* (Swiss foundation for the promotion of the Swiss economy through scientific research). At the School Council meeting of 7 November 1929, Rohn happily reported that "the viability" of the institute was assured.[105] The tasks of the institute would be, first, to build a technical library; second, to organize an information exchange between industry representatives on the subject of rationalization; third, to conduct industrial research "of interest to the Swiss economy"; and, finally, to organize training courses and produce publications.[106] These actions resolved issues outstanding from 1919. However, although the advisory board of the *Betriebswissenschaftliches Institut* (BWI, scientific management institute) comprised a union representative in the person of future federal councillor Max Weber, it was obviously oriented to the interests of the



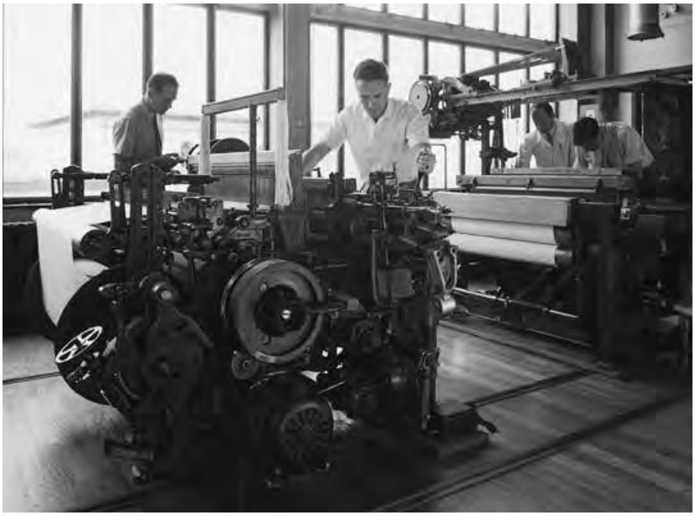
Film recording in a workshop at Escher Wyss & Co., 1935, by staff members of the institute for scientific management. Using machines surrounded by movable walls, artificially staged processes could be optimally illuminated and documented on film. The films were later studied for ways to improve efficiency.

companies. Rohn and Böhler tried to persuade the Federal Council that the proximity to business was absolutely necessary. They warned against advising companies on rationalization issues as a means of paving the way to sociopolitical interventions. "Satisfactory results" could only be obtained "if the research institute had close, lasting contact with industry, worked with industry, and drew its inspiration therefrom. Further, since fruitful collaboration between science and industry requires complete confidence, such an institut can only exist when the state exerts minimal interference and refrains from any form of paternalism."[107]

The desired links to industry were not forged as smoothly as hoped. The original idea was that industry would propose research topics to the institute in the areas of business organization, accounting, building management, factory management, shop technology and manufacturing processes, industrial psychology, psychological testing, and industrial hygiene, as well as standardization. But with the onset of the economic crisis, the companies (which just a year before had been basking in their bright outlook) had their hands full. Moreover, the institute itself was suffering from organizational problems. Leadership of the science division had been assigned to Alfred Walther, whose bailiwick was supposed to be general managerial issues. But instead he followed his own specialty, which was accounting. Heinrich Brandenberger, a lecturer on machine tooling with a focus on optimized production who had given a keynote talk at the 1928 training course on the potential for performance efficiencies, complained bitterly about Walther's unilateral setting of priorities.[108] Eugen Böhler, director of the institute, was helpless to fix it. He fell out with Walther, who left in 1931. Now Rohn had to go looking to industry for a new candidate, but this time one he could simultaneously entrust with a professorship in management science.

The choice fell on René de Vallière, head of the knitting machine company Dubied & Cie. in Neuchâtel. His 1922 publication titled "*L'Organisation moderne des Ateliers mécaniques*" (The organization of the modern machine shop) was an attempt to adapt the principles of scientific management to the Swiss machine industry.[109] But even the practical engineer had a hard time at first. He did have some success in creating the institution's journal, *Industrielle Organisation,* the first issue of which appeared in 1932. But research contracts from industry were thin on the ground, and the planned exchanges between companies failed to materialize. The win/win idea imported from the United States of using the classroom to turn market competitors into collaborators, was met with great suspicion in Switzerland. Looking back, de Vallière wrote in 1955: "It may be a characteristic of the Swiss to be more disposed to give than to receive in this kind of interaction, and discretion vis-à-vis their respective companies limits the scope of information exchanged between their representatives."[110]

De Vallière's laconic remark confirms that most Swiss entrepreneurs viewed the knowledge generated in their companies to be not for general consumption. In Switzerland, training to become a "*Betriebsführer,*" in other words, a manager, could only be done in close contact with a specific enterprise. Arthur Rohn, too, betrayed a similar conviction when talk turned to creating a training course in management science. There is no question, he stated in 1930, of training "half engineers, half businessmen." Rather, the goal must be a "complete" engineer with complementary specialization. Edward Thomann, Brown, Boveri & Cie. director and school councillor, cautioned against "training too many engineering specialists" for fear of flooding the small Swiss job market.[111] These reservations kept business at bay until 1933, when the mechanical engineering division's curriculum was overhauled. New professors for textile machinery (Emil Honegger) and low-voltage engineering (Johann Forrer) had made reorganizing teaching a priority, as a result of which subdivisions IIIA (mechanical and process engineering) and IIIB (electrical engineering) were created. Students in both divisions were given the opportunity to immerse themselves in subjects of their own choosing. Rohn suggested industrial engineering as one of these fields of concentration. "That," he said, "should also satisfy the desire of our industrialists that the training of industrial engineers should be no different from that of mechanical and electrical engineers."[112] Within these concentrations, training in engineering management stressed that students solve a practical rationali-



Students at a Saurer power loom in the textile engineering laboratory in 1955. The Institute for Textile Engineering was established in 1931 in close collaboration with industry.

zation problem in fulfillment of their diploma requirements, preferably in one of the companies under the umbrella of the BWI.

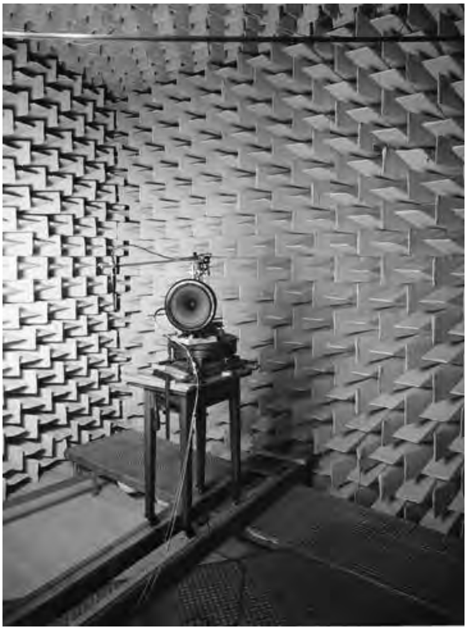
The extremely close relationship between the Swiss machine industry and research and teaching in management sciences became further reinforced over time. The ETH saw it as a way of developing specific competences without having to take a position on their potential for social reform. This potential lay in the application of scientific principles to dealing with social conditions. The price the ETH paid for its approach was having to renounce its own "management school," still being discussed in 1941 and which had been such a successful byproduct of the American technical universities. But in Zurich, people still rejected the idea that "the E.T.H. was the place to train industrial engineers without deep scientific-technical knowledge."[113] The educational field was thus open for the management schools, especially at St. Gallen, which seized the opportunity.

The problem of basic research

One cannot accuse the ETH of having neglected ties to industry during Rohn's tenure from 1926 to 1948. On the contrary, he oversaw the establishment of a number of institutes, among which most, like the BWI, had a foot in both academic science and industrial practice. In 1938, the *Schweizerische Bauzeitung* proudly announced the founding of thirty-one institutes, including those for applied acoustics (1929), aerodynamics, photoelasticity, a chemical high-pressure laboratory, and an industrial psychology institute, which later became the Institute of Applied Psychology.[114] This abundance of new entities within such a short period of time represents a unique period of activity in the ETH's history. Rohn's predecessor, chemist Robert Gnehm, had already tried to strengthen the school's orientation toward scientific research because he observed a growing interest in research activities on the part of the chemical industry.[115] Rohn also took seriously this increased theoretical emphasis, which in 1930 led the machine and metal industries to found research laboratories.[116] He made it his mission to demonstrate the utility of the ETH for the Swiss economy by educating a qualified workforce. The efforts of both School Council presidents helped to improve the perennially problematic business relations. Thanks to Gnehm and Rohn, criteria were established for assessing the direct usefulness of research activities. The co-emerging category of basic research became a problem, however, because it required an entirely different strategy for justification.

Conservative cultural critics took issue with the logical reasoning of modern science and technology because of the alleged soullessness of its utilitarian focus on material benefit. Even more dubious was research in natural sciences and mathematics not oriented toward utilitarian considerations. Ever since Oswald Spengler had lamented Western annihilation by "its own keen sword," science was suspected of consigning more and more areas of activity to theory and thereby obscuring any natural, direct relationship to the modern physical world.[117] In the theoretical physics seminars, in particular, pure mathematics and philosophy seemed to be totally removed from everyday life. For example, Spengler spent pages picking apart aspects of Albert Einstein's theory of relativity. Even more blatant was the ranting of philosopher and science theorist Hugo Dingler, who characterized the increasing mathematization of chemistry and physics, and their convergence in quantum mechanics, as the "collapse of science."[118]

Mechanical engineer Aurel Stodola shared the concern about highly theoretical science, which according to Heisenberg's uncertainty principle made it possible to talk about reality only in terms of probabilities. "The proud and most exact of sciences [i.e., physics] has shattered the great law of causality for physicochemical events, i.e., the uniqueness of an effect from a given cause," he wrote.[119] Nor could Stodola comprehend the work of his colleague Hermann Weyl, who in 1930 gave up his professorship in higher mathematics at the ETH to fill a spot vacated by David Hilbert in Göttingen.[120] Stodola considered the mathematics practiced by Hilbert, Weyl, and Paul Bernays, who had fled to Zurich in 1933, to be as quixotic, and in its aim as radical, as the philosophy of Rudolf Carnap.[121] Stodola found downright scandalous Carnap's epistemological positivism, as presented in his 1928 analysis of the "logical structure of the world." The assumption that there is no reality independent of our consciousness was irreconcilable with the worldview of practically oriented mechanical engineers. Whereas Stodola eventually made peace with physics, thanks to Max Planck, and with philosophy, thanks to Karl Jaspers, many of his contemporaries continued to see no sense in the "futile" search for knowledge in and of itself. Such research was elitist and unnecessary, and at the very

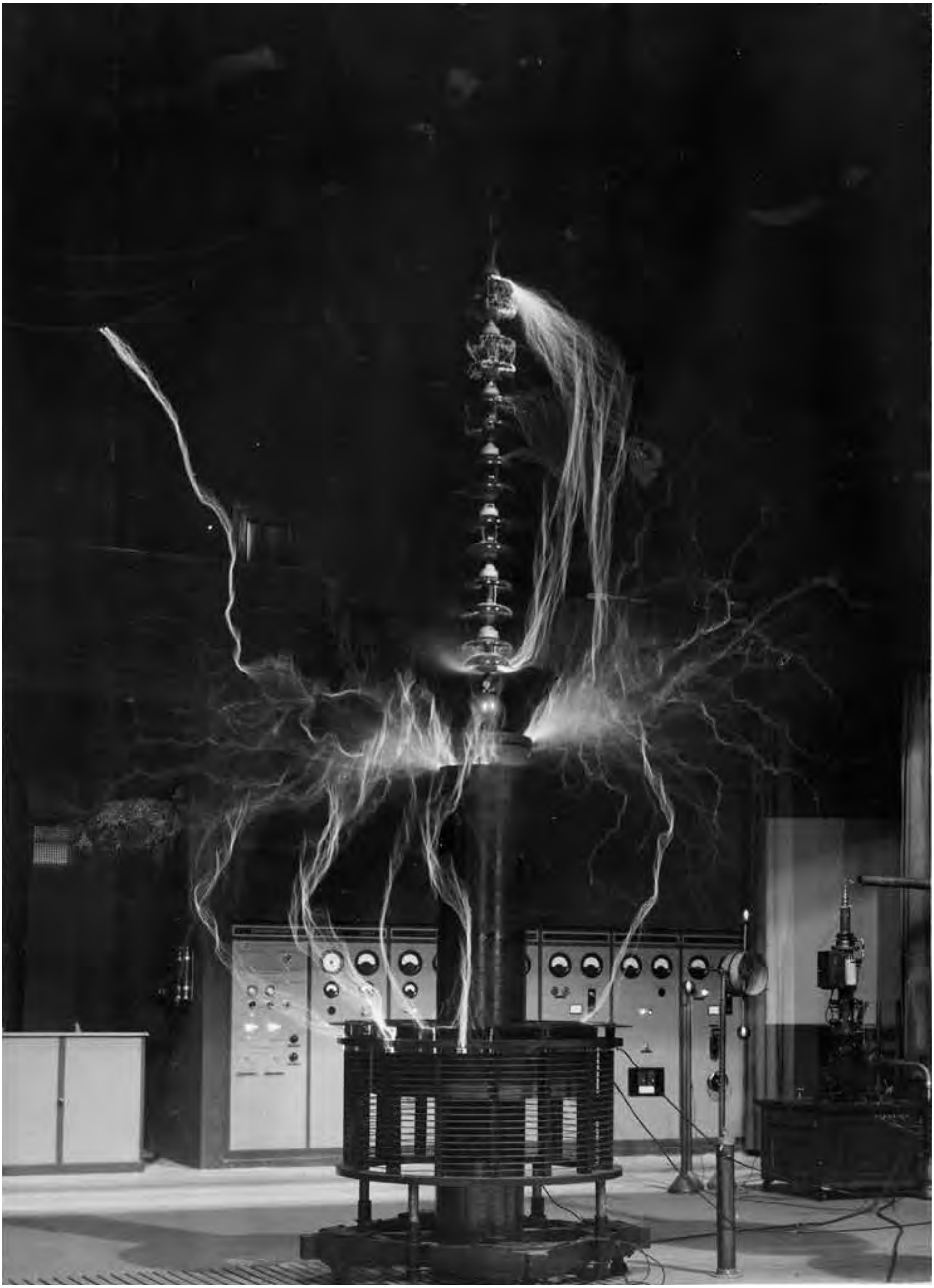


Soundproof room at the Institute for Applied Acoustics, built with private funds in the the mid-1920s by lecturer Franz Max Osswald. In 1931 the ETH took over the research facility, which also served for teaching.

Wind tunnel at the Institute for Aerodynamics. Here, in the 1930s, under the direction of Jakob Ackeret, cutting-edge research was carried out. Photograph from 1955.

least a problem. The Nazis were so bothered by it that they made linking research to practical use the central focus of their political platform.[122]

With the growth of the research enterprise and in opposition to the antiresearch discourse of the sort described here, a category distinction arose between "applied" and "pure" science. Before 1935, the expression "basic research" did not appear in the School Council's minutes, and the category of "pure" research was referred to only rarely. Naturally, there were long-established fields such as "applied electrical engineering," whose name in terms of classification set it apart from nonapplied electrical engineering, a discipline that simply did not exist. Moreover, both chemistry and mathematics differentiated between "pure" and "applied" or "engineering" orientations.[123] But only toward the end of the 1920s did these formulations become relevant at the ETH as abstract categories independent of specific disciplines. As the number of research projects increased, it became increasingly important to make categorical and analytical distinctions between them. Relations with other scientific institutions also adhered to these distinctions. Increasingly, it became accepted that basic research was a matter for the cantonal universities, whose province was cultural heritage, whereas the more business-oriented applied sciences were the responsibility of the federal university.[124]



Experiment on the Tesla coil at the Institute of Electrical Engineering in 1935. Karl Kuhlmann, professor of electrical engineering, strongly focused his work on questions of practical utility.

Especially in the light of the fundamental criticisms of the pursuit of "pure" knowledge, one distinguishing criterion became to what extent a research project promised useful results, for that then could be used as an organizing tool in the division of academic labor. A terminology arose (meaningless in itself) for judging individual research efforts in which, depending on the context, a given project might appear pure or applied. Moreover, this approach made it easy to model pure research as an activity that paved the way for later applied research that in turn could generate economic benefits. With this scheme, even Hilbert's and Bernay's mathematics could be connected to the utility paradigm.

The separation of pure and applied research was beset with practical problems and extremely situation-dependent, as revealed by a glimpse at the daily operations of the School Council. The board first mentioned "pure scientific research" in 1937, in connection with the reorganization of the photoelastic laboratory. Since the early 1930s, the photoelastic effect had become increasingly important in testing materials. Consequently, by 1932 Mirko Ros, director of the Empa, had already established a department for carrying out such tests. But because the ETH already possessed a suitable facility under the direction of experimental physicist Franz Tank, Ros was told that he should collaborate with Tank. Even at this stage, roles were apparently clearly assigned: Ros typified applied research, and Tank pure research. Adding the burden of collaboration to the institute's infrastructure meant bringing in its leader, Paul Scherrer, who subsequently sought a new division of labor with his colleague Tank.[125] A "difference of opinion" arose, in which Tank – a specialist in high-frequency engineering – would now be occupied with applied research, and Scherrer with pure research. When, some time later, the question arose how to reconcile the space needs of the theoretical physicist Wolfgang Pauli with those of Tank and Scherrer, in a turnabout, Scherrer argued from the side of applied research.

The arrangement made between the ETH Institute for Experimental Physics and Empa in 1932 lasted only until 1937. At that point, the School Council gave the Empa director permission to build his own photoelastic laboratory and specified the different functions of the two institutes: "The equipment belonging to the previously joint photoelastic laboratory that is suited to *pure scientific research* – in particular, the interferometer and its accessories – will remain in the ETH's photoelastic laboratory under the management of Prof. Dr. Tank. From now on, this laboratory will use the phototoelastic method only to carry out research, not third-party orders for structural and materials testing."[126] Conversely, for the facility built by Ros, the board reserved all the equipment "needed for practical structural and building materials testing using the photoelastic method and not required for the purely scientific work in the photoelastic research laboratory of the ETH." Ultimately, the School Council achieved a kind of balance by not only prohibiting Tank's laboratory from providing service but also limiting scientific research done at Empa "in general to that which it is immediately critical for execution of a contract and thus is fully paid by the client."[127]

Separating pure from applied science proved equally difficult at the abstract level. ETH rector Paul Niggli was preoccupied with the issue.[128] The mineralogist, whose own specialty was hard to situate within the scientific classification system – for example, as specified by August Comte – observed the growing dominance of the utility paradigm with concern. In opening the 1928/29 and 1929/30 school years, he urgently made the case for an integrated vision of science.[129] Niggli adamantly defended the importance of basic research, and argued that the distinction between it and applied research was one not worth making. The "division of natural sciences into pure and applied (useful)," he said, was "inadvisable, unfortunate, and ultimately pointless ... Nobody is in a position to decree which part of natural science exists for its own sake and which part exists to be useful."[130] His cogent words were intended to preserve the unity of science in an era of increasing specialization. When Niggli reiterated these thoughts almost verbatim in 1947, they took on a political dimension. To his view, the commitment to research "which for the time being does not ask what its new discoveries about the world might be good for" is a matter of survival for an open, democratic society such as Switzerland's. One and a half years after the war, it was now even clearer that "the constant invocation of the so-called immediate practical benefits" in the scientific discourse of all the warring states, especially Nazi Germany, had lowered the quality of science.[131] The wrong goals had been embraced, warned Niggli, thereby aligning himself with the peculiarly humanistic discourse of Swiss science and engineering: "Neither the state nor science and engineering can exist purely for themselves; they serve the purposes of *education,* which requires of each, depending on its structure, the freedom and energy needed for its development."[132]

Matching funds for applied research

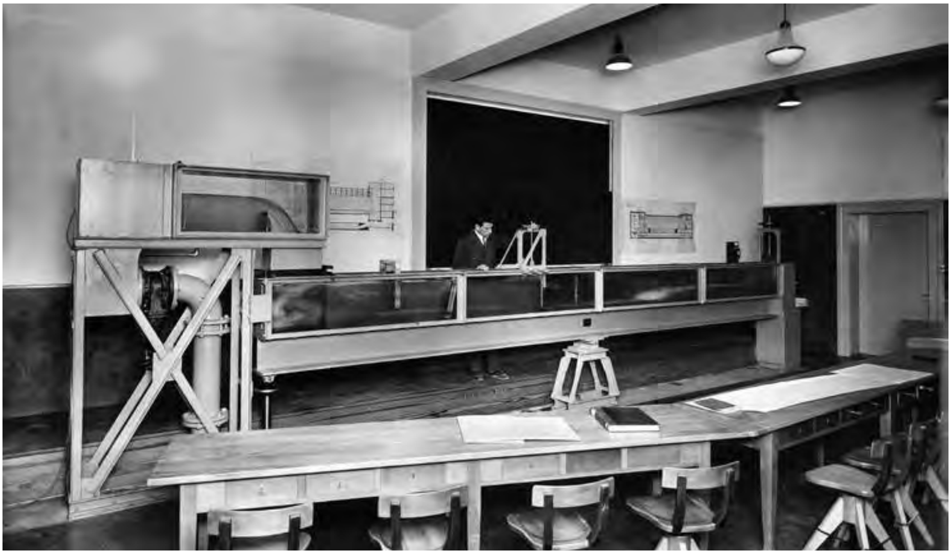
In the complicated interface between academia and industry, private money, government loans, and expenditure items in the regular budgets of the ETH were combined into innovative modes of funding research, making it virtually impossible to retrospectively assign the individual research categories to the various sources of funding. This institutional innovation in the area of financing was the brainchild of Gustav Naville, who as director of the Aluminium Industrie AG (AIAG), board member of Credit Suisse, president of the *Verband Schweizerischer Maschinen- und Metallindustrieller* (Swiss Association of Machinery and Metal Manufacturers) as well as ex-president of the GEP and vice president of the School Council knew the frontier between academia and business very well.[133] Shortly after the end of the First World War, he inspired the shareholders' meeting of the AIAG to gift the ETH 500,000 francs. This *Aluminiumfonds Neuhausen* was intended to fund research in electrochemistry and electrometallurgy.[134] Around the same time, in 1918, the GEP issued a call to form a "*Stiftung zur Förderung schweizerischer Volkswirtschaft durch wissenschaftliche Forschung an der Eidg. Technischen Hochschule*" (Foundation to advance the Swiss economy through scientific research at the Fed. Technical University) which by 1920 had collected around a million francs in capital. On the condition that the range of potential recipients of funds be extended throughout the ETH, the government decided in August 1919 to substantially increase its participation in the research funding body.[135] According to a 1943 review of this *Volkswirtschaftsstiftung* (economic foundation), as the institution was commonly known, well over half of the foundation monies, contributed roughly 50 percent each by the state and private sources, flowed to the ETH, which was precisely as the initiators intended. The rest went to support research in the construction and other industries.[136]

The *Aluminiumfonds* and the *Volkswirtschaftsstiftung* supported individual research projects. In 1920, for example, chemist Hans-Eduard Fierz received 10,000 francs for his studies on how nitrogen behaves under high pressure. In 1921, the *Volkswirtschaftsstiftung* awarded Hermann Staudinger 23,000 francs for work on coffee aroma, and the synthesis of formaldehyde and pyrethrin.[137] The *Jubiläumsfonds* (jubilee fund) established at the seventy-fifth anniversary of the ETH in 1930 and the *Zentenarfonds* (centenary fund) of 1955 were also intended to support applied research. A sometimes confusing variety of other funds and foundations materialized over the course of the twentieth century, so that by 1989 the ETH was managing approximately 100 special pots of money, of which 37 could be traced back to private gifts made before 1933. In 1937, School Council president Rohn estimated the total of all the university's special funds to be around 10 million francs.[138]

A more institutionally oriented form of research financing came from the GEP, which in 1925, together with the *Schweizerischen Ingenieur- und Architektenverein* (SIA, Swiss Society of Engineers and Architects), collected 1.3 million francs to build a technical service center for hydraulic engineering. The financing operation was successful, and the organizational model implemented was shown to have future promise. On 26 April 1930, the *Versuchsanstalt für Wasserbau an der Eidgenössischen Technischen Hochschule* opened its doors. More than half of its service costs were covered by revenues generated by bringing the ETH's hydraulic expertise to the attention of private and public clients.[139] A further organizational innovation was the founding of sponsoring companies (*Trägerschaftsvereinen*). This model was first applied in the case of the BWI.[140]

Some school councillors voiced concern because the provision of private capital often entailed efforts to influence the way the school was run. For instance, in 1934, the Uzwil-based Bühler company – which had supported the BWI sponsoring company, the 1930 *Jubiläumsfonds*, the *Versuchsanstalt für Wasserbau,* and had helped to finance a student house – complained that its opinion had not been sought in the consultation process regarding the reform of the Division III curriculum.[141]

Rohn dispelled the concerns by saying that private funders could no longer be dispensed with: "We will increasingly need to draw on private industry to support research at the E.T.H., as the government can only pick up a small share of the financial burden of new activities."[142] With the founding of the *Gesellschaft zur Förderung des Instituts für technische Physik der ETH* (GTP, society for the advancement of the Institute for Applied



Above: Glass demonstration tank in a lecture hall of the Experimental Station for Hydraulic Engineering, 1930.

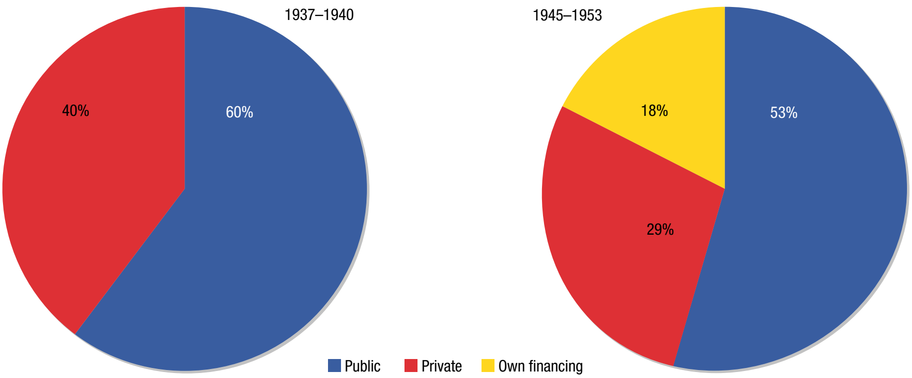
Below: Hall of the service center for hydraulic engineering in the 1950s. The model setup made it possible to study several river engineering problems simultaneously. Even the "Schiffli creek," which in 1939 flowed through the site of the national exposition, was originally modeled here.

The Center for Industrial Research, funded by the Gesellschaft für Technische Physik (GTP, Society for Engineering Physics), was especially active in the area of television engineering. Fritz Fischer and Ernst Baumann oversaw the development of an apparatus for projecting TV images onto a large screen. The photograph shows efforts in May 1959.

Physics at the ETH) in 1937, this strategy again proved successful.[143] For years, Fritz Fischer and Rohn had mobilized support for this company, which it was hoped would help to make Fischer's institute more financially self-sustaining. But not until 1937 were they able to allay the fears of some parts of the Swiss electricity industry that Fischer's research results would not go to the supporting enterprises or, worse, end up in the pockets of Fischer's old employer Siemens & Halske in Berlin.[144] Officially, the company ran a clear-cut Center for Industrial Research (*Abteilung für Industrielle Forschung*) that was not part of the ETH but was linked to its Applied Physics Institute. In reality, however, these institutional borders were blurred, especially since Fischer headed both the institute and the industrial research center. Private financing for applied research and government support of basic research were also hard to tease apart in Fischer and Rohn's construction. In fact, together with the GTP, it was possible to mobilize unprecedented amounts of government monies for industrial research projects. From 1938 until 1940, the government paid 60 percent and private sources 40 percent of the annual operating costs of 430,000 francs.[145] One-time research subsidies were added to this remarkable level of public financing. In 1940, for example, the city of Zurich, the canton of Zurich, and the federal government agreed to make an additional 1 million francs available to the Center for Industrial Research.[146]

In addition to subsidies and granting agencies, direct collaborations between individual ETH scientists and industry were also an important model for enlarging the funding

Figure 7: Funding sources for the GTP/GFF in the time periods 1937–1940 and 1945–1953



Of the 696,750 Swiss francs the GTP awarded to various research projects between 1937 and 1940, over 60 percent came from the public sector. In 1945, the private organization was renamed the *Gesellschaft zur Förderung der Forschung* (GFF) (Society for the Promotion of Research). The society's own share of financing rose, reflecting its success as a service provider. But the share of public funds remained high: 53 percent of the 3,440,200 francs awarded to research projects between 1945 and 1953. Data: EAR, SR2: *Schulratsprotokolle* 1940, meeting of 16/2/1940, p. 8; *Bundesblatt* 2/1954, p. 207.

scope for research. A prime example is Leopold Ruzicka, whose intention from the beginning of his appointment as professor of chemistry in 1929 was to expand the division. By 1940, he was managing a group of fifty scientific collaborators; by 1945, the Zurich lab was the largest of its type in the world.[147] The means for this expansion came not from the school administration but from the Rockefeller Foundation, and especially from Ciba, with which Ruzicka had negotiated a lucrative contract in 1935. With the exception of work on fragrances, he declared himself prepared to share all his research results exclusively with the Basel chemical company, for which he received an additional 3 to 5 percent on top of the agreed annual payments. In 1939, the hormone compound perandren netted Ruzicka 56,546.30 francs. The most profitable of his efforts proved to be a process for the cheap, high-yield extraction of cholesterol from the male sex hormones androsterone and testosterone. During the Second World War, the accrued US patent-licensing revenues from the process came to 3.5 million francs.[148] Ruzicka used the money to finance a remarkable collection of Dutch art, which he gave to the Zurich museum of art in 1948.[149]

Ruzicka essentially operated his ETH laboratory as a private entrepreneur. Nobody was much bothered by the close relationship between scientific and industrial interests, and

His income from direct research collaborations with industry made Leopold Ruzicka one of the best-paid academics of his time.

in fact, it had little effect on the academic quality of his group's research. Ruzicka's Nobel prize was sufficient evidence of that, as was the subsequent honoring of his colleagues Vladimir Prelog and Tadeus Reichstein by the Swedish Academy. One problem with the arrangement was the professional status of the research assistants. Moses Wolf Goldberg and Placidus Andreas Plattner, in particular, were increasingly affected by inadequate job descriptions. Both scientists were supported by external funding and, in Ruzicka's words, "in terms of their skills and abilities, both functioned as laboratory managers or, in the academic hierarchy, essentially as professors" without holding respective titles.[150]

After 1945, Ruzicka abandoned active research. But he continued to develop the research infrastructure. In 1954, for instance, at his initiative, an institute for biochemistry was established and financed by the Basel chemical industry to the tune of several million francs.[151] To rector Karl Schmid's question whether, under such conditions, research results could still be "free," School Council president Hans Pallmann answered that the situation of biochemistry was hardly special. "All academics in university chemistry, not just those at the ETH, have direct connections with industry."[152] This relationship had its roots in the nineteenth century, and remained constant throughout the next. When, for example, at the end of 1960s, the division was looking to establish a chair in macromolecular chemistry, it did so in close collaboration with industry.[153] Basel was even involved in the hiring for the new position. Piero Pino, who was *primo loco* after the favored candidate declined, contacted the chemical companies and negotiated a contract entitling him to compensation at a rate of 70 percent of his salary as professor in return for the right to exploit the results from his Zurich laboratory.[154]

The limits of the "national system of innovation"

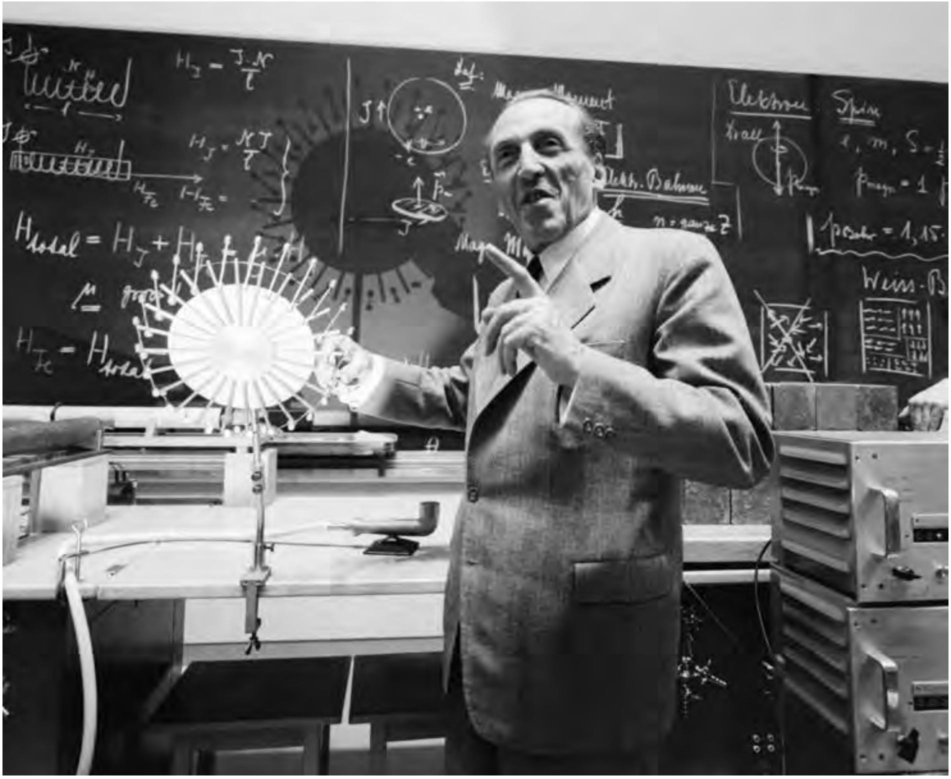
Just as a division of labor (however fictitious) existed between the cantonal universities and the national technical university, in which the cantons were responsible for art and social sciences and the state for economics and engineering, so also the ETH began to bandy about the idea of allocating cost and labor between government institutes and private industry based on a separation between basic and applied research.[155] If there is such a thing as a "national innovation system" in Switzerland, its structure was determined according to the liberal idea of political order in the 1920s and 1930s in which, since the end of the First World War, Swiss companies had been running fairly large research efforts, without recourse to public monies. Naturally, industry-specific differences soon became evident, for instance, the watch industry dipped more deeply into federal coffers to support its research than other industries. It is remarkable that in Switzerland – with the exception of the *Laboratoire Suisse de Recherches Horlogères* (LSRH) in Neuchâtel, which was founded in 1921 and from 1925 onward enjoyed modest government contributions – no government-funded institution for promoting applied research arose comparable to the CNRS (*Centre National de la Recherche Scientifique Appliquée*) in France in 1938, or (in Germany) the partly state-sponsored Kaiser Wilhelm institutes for applied research, or the similarly partly state-financed *Fraunhofergesellschaft*.[156]

Swiss competitiveness was generally characterized by a high research intensity despite a low level of government spending.[157] For 1969, for example, the Swiss Trade and Industry Association (SHIV) found total expenditures for research and development to be 1.7 billion francs, or around 2.1 percent of the Swiss GNP. Public monies made up only 0.3 percent of this sum.[158] The political idea underlying this relationship has been repeatedly affirmed by Swiss business leaders. In 1942, when the federal government wanted to create new jobs by "promoting technological progress" to forestall the dreaded unemployment at the war's end, the "*Vorort*" (board) of the SHIV argued "that the export industry would be better served if the state were to give it only little and take from it only little, than if were it to spend vast amounts of money creating jobs in the export industry and to finance such schemes by imposing a heavy tax burden on the private sector."[159] At the time, the big metal and machinery companies, like Von Roll in Gerlafingen, were spending around 1 million francs yearly on research. Ruzicka estimated total research and development spending on the chemical industry at around 10 million francs yearly.[160] Even in 1961, when the National Science Foundation had already been in existence for several years, the industry associations rejected in principle the notion of imposing fees and taxes on enterprises only to give it back to them later in the form of subsidies. Consequently, a motion made by National Councillor Roger Bonvin to establish a government institute for applied research came to naught. During the parliamentary deliberations, School Council president Hans Pallmann stated that, in Switzerland, "applied or practical research is still basically a matter for private industry." A survey of the *Vorort* revealed that "development in the fields pertinent to industrial applied research should be left primarily to the companies and organizations interested in it. The majority of industry is opposed even to the idea of a closer and fuller collaboration in the area of applied research."[161] In physics, in particular, this "national innovation system" was strongly challenged post-1945 as international scientific practice moved increasingly in the direction of *big science*.[162]

It became increasingly obvious that the private sector had also reached the limits of what it could do in supporting research. An illustrative example is the new field of civilian use of nuclear energy, which in the 1950s gave rise to an unprecedented multicompany collaboration funded generously by the state. Here was an unexpected financial need. In 1966, Georg Sulzer, whose firm had shelled out 20 million francs to help develop an atom reactor in-house, explained his withdrawal from the project: "Throughout the world, the state bears the brunt of these extremely costly developments. It is unrealistic to believe that these sums could be paid by companies in Switzerland, which – measured on an international scale – are still small."[163] In this context, the Geneva states' councillor Eric Choisy, who among other activities chaired the *Schweizerische Vereinigung für Atomenergie* (Swiss Association for Atomic Energy), addressed representatives of the Swiss Watch Chamber of Commerce (*Uhrenkammer*) and advocated "a national foundation for engineering research."[164] The proposal provoked an animated discussion. In the *Neue Zürcher Zeitung* of 28 April 1966, Herbert Wolfer, vice president of the board of directors of Gebrüder Sulzer, welcomed the suggestion wholeheartedly and suggested that a "council for the promotion of applied research" be established within the existing National Science Foundation structure. The *Vorort* set up a "research policy working group" to consider the suggestions. In addition, the group discussed the idea of a governmental investment risk guarantee introduced by Brown, Boveri & Cie. board member Rudolf Sontheim. Yet another idea was to merge the federal committee for the promotion of scientific research with the existing ETH foundations or even to establish a special bank to finance high-risk research.[165]

Following consultation with the science board, the *Vorort* decided to conduct a large-scale investigation to obtain a more accurate picture of the research and development expenditures of Swiss industry. Moreover, a set of "guidelines for creating an organization to promote applied research" was drawn up and given to the association's branches in 1967 for comment. The organization would grant successful applicants interest-free loans or a guarantee covering part of the research risk, provided the research results were made available to the public. Otherwise, the interested party responsible for commercial exploitation would refund the aid.[166]

The reaction of the SHIV sections to the proposal was devastating. The research-intensive chemical industry had been skeptical about the idea from the beginning. The response of the Swiss Chamber of Commerce was typical: Only nine of its trade associations supported the project, six were indifferent, and twenty-three were more or less against it. No one thought that contributions from private industry would be sufficient



Physicist Paul Scherrer, here demonstrating an electron-spin model in the classroom, propelled Swiss nuclear physics into the age of big science.

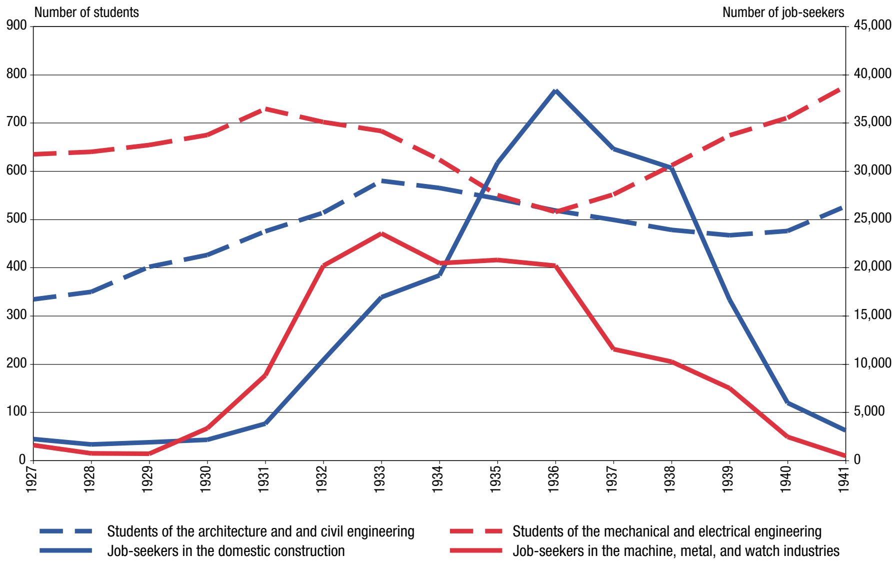
to sustain the planned *Nationalfonds II* (National Science Foundation II). Establishing a foundation "whose first official act would be to beg the federal government for money" was hardly a function of the *Vorort*. Instead, the Chamber of Commerce recommended nonbindingly that the National Science Foundation and the universities encourage more industry-oriented research projects. In general, contact between industry and science should be improved.[167]

Accordingly, the project to create a national foundation for applied research died aborning. Yet all sides agreed that the state should be more involved in supporting industry-related research. In 1972, a so-called research article was added to the federal constitution. In promoting the revision, the Federal Council cited – inter alia – "the current urgent need for greater federal commitment to research that is not purely scientifically motivated."[168] But turning the thought into deed was not always straightforward. For example, when the idea of a governmental investment risk guarantee for fostering innovation was brought up again in the early 1980s, employers and employer associations launched a referendum that resulted in defeat of the proposal in 1985.[169]

STATE INTERVENTION

In defending a bill on cultural policy (*Kulturbotschaft*) at the federal parliament in 1938, Federal Councillor Philipp Etter pledged the national technical university to the intellectual defense (*Geistige Landesverteidigung*) of Switzerland. The propaganda effort also signaled a milestone in the relations between the state and science. Although up to that point the government had kept support of its technical university within the country's normal budgetary confines, now a new funding practice was followed. In a loose adaptation of Keynesian economic policies, the federal government started to pour tax revenues into research as part of a major job-creation program. This nexus enjoyed an upswing in the 1960s.

Figure 8: Job-seekers and students of the ETH, 1927–1941, selected academic disciplines and employment sectors



The labor market crisis of the 1930s shaped the students' choice of subjects. From 1931 onward, as the number of jobseekers in the export-oriented machine, metal, and watch industries shot upward, enrollment in mechanical and electrical engineering correspondingly sank. Similarly, two years later, as unemployment numbers rose in the domestic construction industry, enrollment in architecture and civil engineering took a downward turn. Data: ETH *Jahresberichte* 1927 to 1941; Siegenthaler 1996; Leemann and Speich 2005a.

Getting the economy going again: savings and stimulus

The global economic crisis triggered by the crash of the New York Stock Exchange in 1929 came late to Switzerland. When it did, however, it took the form of two successive, powerful waves. In 1929, the export business was already experiencing a slowdown in its major markets that would last until 1933, when volumes stabilized at a low level and then rose slightly. In contrast, the domestic economy – and especially the construction industry – continued to thrive until 1932. In 1932, however, it too collapsed and did not begin to pick up again until 1937. These developments were reflected plainly in the unemployment numbers. In 1932, the number of jobseekers throughout Switzerland exceeded 50,000 for the first time ever. In 1933, it reached nearly 70,000, and in 1936 shot up to 90,000. The export branches of the watch, metal, and machine industries, unemployment figures peaked at 23,500 in 1933. But relief for the construction industry came only in 1937, after the number of jobseekers reached a high point of 38,000 in 1936.[170]

The crisis touched the ETH in a number of ways. First, the labor market situation obviously had an effect on enrollments in certain disciplines. Coincident with rising unemployment in the metal and machine industries, the number of new matriculants for mechanical engineering and electrical engineering decreased in 1932 and did not start to climb again until 1936. The decline in enrollments in the architecture and structural engineering divisions began to be felt in 1934 and lasted until 1939. There was, however, no drop of student numbers in chemistry, pharmacy, agriculture, or forestry, nor in the natural sciences or mathematics.[171]

The crisis affected more than the economic expectations of the future ETH graduates. The university itself was also at the center of an economic policy debate. Specifically, it was actively at odds with the idea of "free economy [*Freiwirtschaft*]," a movement in which titular professor Hans Bernoulli had been deeply involved during its efflorescence in the 1930s. Economist Eugen Böhler, mathematician Marcel Grossmann, and Oskar Howald, a lecturer in agronomy, all published and spoke against the advocates of free money. In 1938, when the movement had already lost its momentum, the School Council divested Bernoulli of his professorship.[172] Böhler's arguments had clearly prevailed. He moved quickly from the sidelines of the battle against libertarian economic ideas to the central question of how to repair the economy. The crisis had played out against a background debate about policy options expressed, for example, in the campaign against the "Crisis Initiative" of 1935. Leading social democrats like Robert Grimm and Fritz Marbach adopted the approach of the British economist John Maynard Keynes, who recommended countercyclical intervention by the state.[173] Böhler opposed such action, though his opinions did not prevent him from introducing economic monitoring mechanisms at the ETH in 1938. The Swiss Institute for Business Cycle Research (KOF) that arose in this context was in no small measure due to a new Swiss social policy of "avoiding conflicts of interest."[174]

Finally, the ETH was most directly affected by the economic crisis because its funding depended on federal tax revenues. In 1933, the parliamentary finance delegation described the impact on the government: "The situation is very grave," read the report. "Today we are in the midst of the Great Depression, whose connectedness to the international economic system – both good and bad – has been illustrated with startling clarity. Falling revenues and unemployment are more prevalent than ever. Customs and import barriers, quotas, and currency exchange regulations are blocking our export industries abroad; we are facing a catastrophic decline in exports. The plight of agriculture and trade is intensifying, and the hotel industry is suffering the effects of the currency collapse and the coercive meddling of foreign states." That this situation had given rise to a moral responsibility for the community was self-evident. "Businesses are tumbling into distress, like dominoes, and turning to the federal government for help and support. One bailout follows another, federal treasury revenues are declining rapidly from month to month, and expenditures are swelling to menacing heights."[175]

The crisis-induced decline in overall revenues posed a unique challenge to which the government responded with two contradicting strategies. First, it introduced a deflationary monetary policy and strove through austerity measures to balance the budget despite increasing expenditures.[176] Second, as the crisis deepened, stronger means of steering the economy became important, early evident examples being the export risk guarantee and the Banking Act of 1934.[177] In the course of the 1930s, the countercyclical model of economic policy began to gain traction. As it did, people began to look more favorably on state intervention in economic life.[178] Initially, the main concern had been the orderly management of public finances, but later the government also began to make good employment relations an additional policy goal.[179] The two opposing strategies were not staged in phases but concurrently deployed and thus annihilated each other's impact. The budget could not be balanced, yet the extent of the additional expenditures was far too small to be effective. The government intervention was a failure. When the market began to recover in 1937, it was due to new export markets stimulated largely by foreign defense expenditures.[180] The basis for a serious crisis control program was established only in 1939, when voters approved substantial loans to develop the national defense and to combat unemployment.[181]

Both economic policy proposals – austerity measures and Keynesian interventionism – had far-reaching consequences for the ETH. Since 1933, the federal university had faced financial cutbacks, which the School Council resisted initially with derision and later with growing desperation. When the finance delegation suggested that the ETH could save money in procuring chemicals, the School Council groaned and shook their heads because the advice was clearly based on ignorance of scientific practice. In 1933, board member Leo Merz commented sarcastically for the record that it was "one of the unpleasant realities of our democratic administration that an expert often has to pretend that his inept boss was doing things right."[182] Disagreements became commonplace. Arthur Rohn repeatedly insisted that the ETH be treated separately by the federal administration. "With its purely scientific goals, the *Eidgenössische Technische Hochschule* is tantamount to an exotic object in the federal administration," he said in 1933, "to which the proposed general cost-cutting measures should be applied only with extreme caution."[183] But the finance delegation was unmoved. Vaudois states' councillor Norbert Bosset took the lead by zeroing in on Rohn's financial planning and attacking him for his repeated lack of budgetary discipline. With Bosset presiding, the Council of States finance committee in autumn 1935 even tried to have the ETH's budget estimates for 1936 rejected, but did not succeed in pushing the motion through.[184] The subtext of the attack was Bosset's largely fruitless efforts to obtain federal monies for the cantonal engineering school in Lausanne, whose position vis-à-vis the ETH Zurich since 1931 had been highly controversial. For Rohn it was clear that the government should run only one technical university, and Lausanne could serve only as a "vocational annex" to the advanced engineering training in Zurich. Together with Maurice Paschoud, the head of education in canton Vaud, Bosset fought for a more balanced treatment of the two institutions.[185]

In autumn 1935 the government redoubled its savings efforts, and the ETH's criticism moved up a register.[186] First, however, the school took a hard look at its patterns of expenditure and sought economies. Of the 3.5 million francs in the budget, 3 million went to pay salaries and infrastructure costs, at amounts that were fixed by statutory provisions or regulated tariffs for heating, electricity, and so forth. What remained was all that could be cut without degrading standards, and that was usually reserved for allocations to support "teaching and research activities." Naturally, Rohn considered it out of the question to reduce this commitment by the 70,000 or so francs requested by the finance committee. Instead, he envisaged leaving empty the chairs occupied by professors Turmann, Hirsch, Jaccard, and Hescheler, all of whom were about to retire. However, discussions on the matter quickly revealed that only Arthur Hirsch's chair of higher mathematics offered much in the way of savings potential. Leaving empty Max Turmann's French-language spot in economics, finance, and statistics would be politically inopportune. "Such a measure would only play into the hands of those who favor a Swiss-French E.T.H.," observed Merz. But as no suitable French-speaking Swiss economist could be found, the post stayed vacant anyway, which saved 12,000 francs. A proposal to cooperate more with the University of Zurich met with a lukewarm reception: "Renewing a connection with the university would gainsay the entire purpose of the ETH," asserted School Councillor Walther. The ETH had no desire to endanger the profile it had so carefully built through the reforms of 1905–1911.[187]

As it quickly became clear how little potential there was for scrimping within the close local and national political network, the School Council gratefully pounced on Federal Councillor Etter's suggestion to lessen the demands of the finance delegation through better lobbying. Specifically, two or three members of the finance committees of both parliamentary chambers would be given advance versions of the estimates and then be invited for a site visit to the ETH, which took place on 17 and 18 July 1936. In an eight-hour-long meeting, Rohn managed to convince the federal politicians that the ETH had exhausted its savings possibilities.[188] Although Bosset and Rohn were not entirely done skirmishing, for the time being the costs of the technical university were justified on the basis of its economic benefits. Already at the start of the conflict, in February 1935, the School Council had made quite clear that "the research activities of the E.T.H., across a wide variety of areas, contribute to the health of the Swiss economy, thereby ensuring that it will better be able to weather the bad times."[189]

At the annual ETH day event in November 1935, Rector Friz Baeschlin echoed these sentiments in a plea to Bern: "We understand and accept that economies must be made. We are confident, however, that the federal government and the fed. councillors, despite the current dire straits, will not deny the ETH the subsidies it requires to survive. The training of the future academic engineers of Switzerland is at stake. Only the best scientific and applied methods will be able to open additional avenues to our ailing industries and build the foundation for a new prosperity."[190]

Such exhortations gradually strengthened the conviction that the economic crisis was no time to be pulling back on education and science; rather, they ought to be given even more support. The existential threat to the school posed by the austerity measures gave rise to a legitimizing strategy for pouring state money into universities as an investment in the future. Forged against the backdrop of interventionist economic policy, the argument quickly became a versatile, multidisciplinary element of discourse, for instance, in the debate over defense. Thus spoke Arthur Rohn on the occasion of the confederation's largest-ever issuance of defense bonds: "How very odd it would be if this present large outlay of funds to better equip the military were concomitantly to result in less support for the scientific institutes on which the technology depends."[191] But the new discursive element could also be used in a totally different way. Namely, it helped to place the technical university unambiguously in the cultural domain. There is no small danger, Rector Baeschlin stated in 1935, "that the cultural policy work of the state will be neglected in the face of economic hardship ... I urge each person in this assembly to do his part to ensure that the state does not abandon its responsibility to culture."[192] In the latter half of the 1930s, this point would be the nucleus of a national longing to "preserve" and "publicize" culture.

The ETH as an institute for "Geistige Landesverteidigung"

As a result of the arming of neighboring countries, beginning in the mid-1930s, Switzerland's national defense took on increasing importance. The idea of a defense triad that would include military, economic, and – somewhat surprisingly – "intellectual" components, gathered strength. The ETH soon became an indispensable part of this structure. Already in May 1936, together with the University of Zurich, the institute had organized a "university defense week," at whose opening session Federal Councillor Philipp Etter uttered the phrase "*Geistige Landesverteidigung*" for the first time.[193] He intended it to mean "quiet, careful reflection on the spiritual values peculiar [to Switzerland]," in other words, a kind of cultural retreat that could lead to enlightened moral strength and social cohesion. In addition to films and excursions, the defense week offered students numerous lectures, for example, those presented by Paul Curti, professor of military science, and historian Karl Meyer.[194]

The latter, who taught general history at both Zurich universities, was known for distilling the basic history of the Swiss confederation into an epic of successful self-realization.[195] Etter gladly tolerated this politically expedient pseudohistorical confection because it allowed him safeguard a central element of the existing national ideology. His bill on cultural policy presented to parliament in 1938 essentially expressed the historical "meaning" of Switzerland as a political system that had undergone transformation from an act of political will at the time of the founding fathers to reality. The key aspects of this transformation were, first, that Switzerland belonged to the "three greatest intellectual *Lebensräumen**" of the West in that it managed to gather together Italian, French, and German culture within a single *Lebensraum* in a totally unique way that did not erase differences; second, that Switzerland stood out for its democratic tradition; and, third, that the Swiss people were especially committed to the idea of "respect for the dignity and freedom of humankind."[196] A political system, the Federal Council argued, should not be limited to ensuring the economic and military security of its citizens, but must also nurture an intellectual ethos, which promotes national cohesion. In the case of Switzerland, this oneness was "not a matter of race, nor of flesh," but something "born of the mind."[197]

The main point of the bill was to establish a government propaganda agency. This was hardly an original step in itself, but rather was a reaction to Nazi propaganda and rabble rousing, for example, the fascist youth movement that had been operating at the University of Zurich since 1933.[198] In autumn 1938, a rumor was making the rounds that Germany was recruiting "dedicated German students" to attend Swiss universities for several semesters and spread Nazi ideas. German students had already founded an *Arbeitsgemeinschaft Schweiz* (Swiss working group) along these lines, and the School Council clearly recalled the pride with which Austria's Nazi students had boasted of "bringing down Austria with all their might and with great success."[199] One of the most active people at the ETH was not a student but a young lecturer in crystallography, the future Empa director Ernst Brandenberger. From 1936 to 1939, he served as the Zurich gauleiter (regional leader) for the Nazi Party and in this capacity came into conflict with

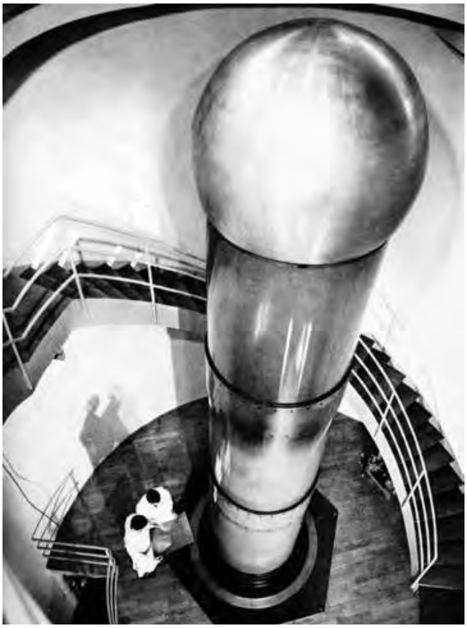
* Loosely, regions, but essentially untranslatable. The term was first defined by the German geographer Friedrich Ratzel in 1897 as a political geographical notion of space, and later used by his countryman Karl Haushofer as propaganda to signify a hyperrefined notion of homeland in the leadup to the Second World War. [Trans.]

the authorities on account of organizing a torchlight procession on 1 August 1938 without a license.[200] Another German sympathizer was Hans Stäger, lecturer for materials science, who worked for Fritz Fischer at the Center for Industrial Research. In 1940, he succeeded in motivating his superiors to sign the *Eingabe der 200*.[201]

Given its totalitarian neighbors, the Federal Council considered it advisable to openly profess an independent – that is, essentially nontotalitarian – national ideology and to accelerate promulgation of the ideas resulting from the "sense and mission of Switzerland."[202] Values such as pluralism, democracy, and freedom were declared central, but in political reality led to glaring contradictions. First, in promoting nationwide unity, the concept of *Geistige Landesverteidigung* gradually melted away the differences that allegedly nurtured the uniqueness of the nation.[203] Second, the propaganda concept, which championed democracy, was launched at a time when undemocratic emergency measures and urgent federal degrees were everyday government occurrences. Third, the "respect" for human dignity and individual freedom that Etter promoted as the essence of Swiss culture did not apply, for example, to the general policy on refugees.[204] Although the ostensible objective of *Geistige Landesverteidigung* was primarily to "guarantee citizens and others free cultivation of the mind," the construct was also used to narrow the diversity of opinions expressed through censorship and control.[205]

With clear targets but thereby multiple conflicting associated objectives, the Federal Council's bill simply lumped the ETH in with the project for *Geistige Landesverteidigung*. Initially, Etter emphasized the "cross-fertilization" effect of the university on the economy and pointed out its importance in the production of young academics.

In 1938 crystallographer Ernst Brandenberger's captaincy of the Swiss army was suspended after he violated official rules in his capacity as the fascist National Front's gauleiter for Zurich. In 1942 the ETH divested him of his professorship. In 1947, he was appointed associate professor and took over the direction of Empa. He was also able to resume his career with the Swiss army. Between 1958 and 1965, he headed *Grenzbrigade* (border brigade) 6.



Above: ETH cartographer Eduard Imhof's relief displays influenced the image that generations of schoolchildren had of Switzerland. At the National Exposition of 1939, the Institute for Cartography exhibited this three-dimensional relief of the Windgällen range.

Left: The exposition also featured the "tensator," a high-voltage machine for accelerating atomic nuclei. The Micafil company built the apparatus for the exposition, after which it was used by the Institute of Physics for research.

Especially at the National Exhibition of 1939 – the famous showcasing of the *Geistige Landesverteidigung* – this close relation of culture and economics was made much of. The ETH was omnipresent at the event.[206] A special allocation of 260,000 francs and more than a year of intensive preparation on the part of the School Council ensured the "proper representation of intellectual and technological defense."[207] The entire school was represented in the university pavilion. Each division featured technological marvels, such as Eduard Imhof's landscape models, Fritz Fischer's TV projection machine, and Franz Tank's prototype high-voltage laboratory, in which (from a safe remove) spectators could gaze in wonder at 2 million-volt bursts of lightning.[208] A special focus of attention was Paul Scherrer's tensator, one of the first particle accelerators in Europe. Not least, experts were also impressed by the architectural exhibition, especially the "*Schifflibach,*" an artificial canal, designed and model-tested in the hydraulics laboratory. Following the event, exhibition director Armin Meili was awarded an honorary doctorate, and chief architect Hans Hofmann was appointed professor in the architecture division.

The ETH had independently realized the unique importance of the National Exposition in the context of the country's *Geistige Landesverteidigung* effort. In defending his cultural bill, Etter had seized on the university's critical contribution to the social life of Switzerland being "its ability to gather together the major exponents of Swiss intellectual life from the different linguistic regions of the country in a shared endeavor, namely, the division of general studies, thereby constituting a common intellectual meeting place for Switzerland's many languages and cultures."[209] In this way, the technical university embodied the key aspects of the national ideology, namely, bridging language and cultural borders by creating a common space for communication. In 1938, when the idea came up of institutionalizing a "national curriculum" (the notion had also been proposed during the First World War), it naturally found resonance within the ETH.[210] In May 1938, a specially created "voluntary association for national education" had approached the School Council with the intention of establishing a national center for *Geistige Landesverteidigung*. The center would provide training and continuing education for course leaders, maintain documentation, act as a clearinghouse, and advise organizations and individuals. Although five ETH professors – Plancherel, Guggenbühl, von Salis, Clerc, and Zoppi – belonged to the association, the petition had little internal support. "The appeal of authoritarian ideologies should not be underestimated," remarked the School Council. Recognizing the need for a Swiss counterpropaganda, the board nonetheless rejected the petition on the grounds that "national education" as a whole was a matter of cultural policy and thus fell within the purview of the cantons. Moreover, "education" in this nationalist-ideological sense was not a task for universities but rather for the upstream school system, where it had a chance of reaching a much broader segment of the population.[211]

Instead of pursuing this far-reaching plan, the five professors, now also with Eugen Böhler onboard, introduced a successful series of "public Friday lectures" whose purpose was to promote civic education in the spirit of the Federal Council's cultural bill.[212] In December 1938, School Council president Rohn reported that three such lectures had already been given to "full and even standing-room-only crowds."[213] Attendance at general studies courses relating specifically to Switzerland was now declared obligatory for ETH Students.[214] Indeed, the general studies division (Division XII), was taking on an increasingly important public role. As early as 1930, Rohn had launched a series of publications dealing with political science and cultural issues of general interest. The appointment process for professors in the division of general studies was modified to include rhetorical skills. Illustrative of this development was the hiring of a successor to Germanist Emil Ermatinger, for which two candidates were in the running. One was fifty-four-year-old Fritz Ernst, whose academic career Ermatinger had repeatedly blocked and who had made his living by adapting numerous literary works for a Swiss Army *Tornisterbibliothek* (knapsack library).[215] His rival candidate was Karl Schmid. "The job of the teacher of German language and literature at the ETH is possibly … more difficult than at the university because he must be able to get students to see the quality of the offerings without the pressure of examinations," Rohn opined.[216] The profile corresponded to that needed for proselytizers of *Geistige Landesverteidigung*, whose task was to bring a nationwide public under their spell.

The choice of Schmid, whose academic credentials were not overly impressive, was nonetheless perfect, for the thirtysomething candidate was a gifted orator. Like Jean Rudolf van Salis, Swiss *Radio Beromünster's* geopolitical correspondent until 1945, Schmid became a nationwide cultural institution both during the war and after.[217] His career shows intellect and defense to be tightly intertwined. An artillery officer in 1928, in 1943 he joined the general staff with the rank of major. He was promoted colonel in 1951, and the next year was made chief of staff of the 3rd army corps. In 1940 Schmid married the actress Elsie Attenhofer, whose involvement with the "Cornichon" cabaret was a good match for his political outlook.[218] Both allied themselves domestically with the *Geistige Landesverteidigung* and externally against Nazism and Italian fascism. Schmid was also a member of the central committee of the *Neue Helvetische Gesellschaft*, and after 1945 joined the patronage committee of the Swiss intelligence service (SAD) in its anticommunist defense work. His interpretation of the work of leading Swiss writers such as C. F. Meyer and Max Frisch brought Schmid fame owing to his preoccupation with the writers' "distance" from Swiss governmental affairs and the eloquence of his presentation. Schmid's analysis of the "the small state and its discontents" was so sensitive that it fully satisfied both the political establishment and the public audience at his evening lectures.[219] He had a particular knack for constructive criticism. Previously, in lectures given between 1939 and 1943 in Luzern, Olten, Frauenfeld, and elsewhere, Schmid had managed to blend appreciation of Swiss nature with very critical observations about the limitations of a small country. After the war, his rhetoric became more explicit. In 1954, he described his ideal of Switzerland as "a strong house, whose doors are open to its neighbors, and with large windows onto the world. To endure, a small state must be both things: strong, and open." Fiercely anticommunist in the era of the Cold War, Schmid emphasized Switzerland's affinities with the Anglo-Saxon world, which, he said, had saved the European values of freedom, human rights, and the rule of law.[220]

Investing in research for jobs

If the ETH could fairly be described as an institute for *Geistige Landesverteidigung*, its importance to strengthening economic independence was even more pronounced. The expert report on crisis measures presented by socialist leader Robert Grimm and radical (FDP) national councillor and ETH graduate Ferdinand Rothpletz in 1934 shifted science from culture more toward economic policy. The authors suggested, among other things, employment programs for out-of-work graduates, as well as structural changes intended to create new industries and government funding to sustain industrial research capacity, which was one of the first areas to be cut in response to the crisis.[221] The connection between economic stimulation and research support gradually solidified. According to a 1937 position paper from the federal ministry for economic affairs, "in Switzerland, the government plays a major role in the area of scientific research." No one doubted "that the state can and should undertake this role."[222] In the absence of an immediate alternative the ETH presented itself as the very tool to implement this government task.

In May 1941, the Federal Council's delegate for labor procurement, Johann Laurenz Cagianut, met with Arthur Rohn to discuss the extent to which state-supported research at the ETH might usefully further the goals of the federal job procurement programs.[223] Rohn accepted the offer of cooperation with alacrity, hoping to consolidate research financing at the school. "Up to now, we have been living hand to mouth at the ETH with respect to scientific research. Almost daily, we are called to urgently provide this or that institute with financial help to allow it to continue its work," he wrote somewhat dramatically to Cagianut after their discussion, by way of reiterating his interest in the new source of money.[224] In the course of further exchanges with the military department-based office, the idea emerged of establishing a national science and engineering research foundation. Whereas the cultural agency *Pro Helvetia* supported the *Geistige Landesverteidigung,* the new national foundation would serve to defend the country's economy.

For about a year, Rohn struggled to promote the project. He began by painstakingly allaying concerns within the ETH sparked by the practical focus of research support in response to economic policy.[225] With the cooperation of professors Scherrer, Böhler, Honegger, and Ruzicka, in November 1941 Rector Saxer produced a report "on the connection between scientific research and the problem of job creation and export promotion" that sketched out the economic potential of the ETH's research facilities.[226] A second round was initiated to bring in the other Swiss universities. But then the project stalled. During a meeting with representatives from the cantonal university in May 1942, two fundamental objections were raised. First, it was explicitly stated that a national science foundation would have to support not only application-oriented sciences, which were mostly concentrated at the ETH, but all disciplines at all Swiss universities. Second, and more seriously, the canton of Basel's ministry of education argued that the planned research funding model was contrary to the federal division of competences in higher education and made a mockery of academic autonomy. Instead of the proposed trustees who were to decide the allocation of monies, Basel suggested the direct apportionment of federal funds to the universities' cantons, which would then finance projects appropriately.[227] Even the intensive lobbying by federal officials with the government of Basel could not soften the dividing lines. In August, the negotiations fell apart.[228]

But Rohn was prepared for failure. At the beginning of September, in consultation with Otto Zipfel (who by now had replaced Cagianut as delegate for labor procurement), Rohn founded a "committee for scientific research" intended to propose the ETH's own projects to the federal delegates for job creation. Shortly thereafter, procedures for the new committee had been drawn up, and its president, Franz Tank, announced the first applications.[229] In April 1943, five applications made the first cut, including one from Paul Scherrer for 100,000 francs "to manufacture artificial radioactive substances for research" and another from Ernst Gäumann for the same amount "to combat plant diseases."[230] Up to summer 1944, a further dozen applications were forwarded to Bern, for a total request of 2.5 million francs.[231] But no support was forthcoming. Following the demise of the national funding project, Zipfel redoubled his efforts based on a Federal Council decision of 29 July 1942 on the regulation of employment in wartime, and on 6 August 1943 confirmed by executive order his offer of research funding to all Swiss universities. Applications were invited from all over Switzerland. To manage the volume, in 1944 a federal-level "committee to support scientific research" was appointed that carried out its first round of application evaluations in October of that year. Fifteen proposals from the ETH were considered, and 13 approved. Of the 21 applications from cantonal universities, the success rate was

Blighted potatoes. Image from the ETH's Photographic Institute commissioned for Professor Ernst Gäumann, 1929. Gäumann headed the *Institute für spezielle Botanik*, which among other things investigated the process of decay in wood and various plant diseases.


Forschung tut not!

In May 1943 the *Technische Rundschau* (Engineering review) drew attention to the research efforts of Swiss industry and, with an eye to the postwar future, called for a stronger commitment by the government.

decidedly lower, a result Zipfel attributed to the lack of preliminary discussions with the research bodies at these schools. Moreover, Rohn told the School Council, the universities were somewhat disadvantaged "on account of their lines of research."[232] By 1946, the federal office – which in ETH jargon soon became the "*Forschungskommission EMD*" (research commission EMD) and later gave rise to the innovation promotion agency (KTI) within the Federal Office for Professional Education and Technology – had handed out 3 million francs, 48 percent of which went to the ETH.[233] Cagianut and Rohn's idea of a national science foundation was thus realized and, in its basic form, contrary to the will of the individual cantons.

The war winter of 1942/43 signaled the gradual defeat of Germany. A kind of anticipation for the post-war period revived an internal Swiss debate that had been broken off in the second half of the 1930s. In 1943 the Social Democratic Party came into the government, old-age insurance and other sociopolitical issues were put back on the table, and economic policy was the topic of the day.[234] In contrast to the interwar years, science and research were now major themes. The new interest was evident, for example, in the success of the coffee table book *Grosse Schweizer Forscher* (Great Swiss researchers), which Eduard Fueter published as a contribution to the *Geistige Landesverteidigung* in 1939.[235] A somewhat less exuberant effort was Walther Staub's comprehensive overview of the Swiss scientific landscape, published in series from 1941 to 1944.[236] In April 1943 the ETH held a major conference on employment, economic policy, and scientific research.[237] The next month, under the boldface headline "Time for research!", the *Technische Rundschau* summarized engineering research in Switzerland, comparing it with Germany, Sweden, Great Britain, the USSR, and the United States. The new interest in scientific research was further evidenced by a special 1945 issue of the magazine *Atlantis* dedicated to the ETH.[238]

Eduard Fueter, secretary of the *Nationale Vereinigung Schweizer Hochschuldozenten* (NVSH) (National association of Swiss university lecturers), celebrated the changed relationship between industry and science as a "milestone" achievement. "This is the first time in Swiss history that scientific research will be made fundamentally and fully available to serve far-reaching social policy measures of the confederation," he said at the inauguration of the *Forschungskommission EMD*.[239] In fact, the balance had shifted. In 1945, parliament was negotiating the support of applied nuclear research and, after some hemming and hawing, voted to approve the notable sum of 18 million francs.[240] In the same year, it granted a supplemental subsidy to the ETH in the amount of 27 million francs, a deal that was not without controversy. Indeed, Adrien Lachenal, national councillor from Geneva, used the funding request as an opportunity to launch a fundamental attack against the ETH, to which Arthur Rohn responded in kind.[241] A debate on the national technical university flared up in the parliamentary chambers, in the press, and in the School Council. Rohn likened it to the debate that decided the founding of the institute in 1854. The crux of the controversy was the allocation formula for the federal monies. Lachenal demanded that the ETH's subsidies be rearranged to include the cantonal universities, a sort of aid to universities, which twenty years later would become a reality. The need for the government to spend more on science and research was, however, widely acknowledged. "The expansion of teaching and research at the E.T.H. is of vital interest to both the state and private economy," wrote the Federal Council in a 1945 dispatch on ETH support.[242] On another occasion, it observed: "There is no doubt about the importance of scientific research for the development of our industry and our exports." And: "Technological progress depends on scientific research."[243]

The science policy "arms race" post-1945

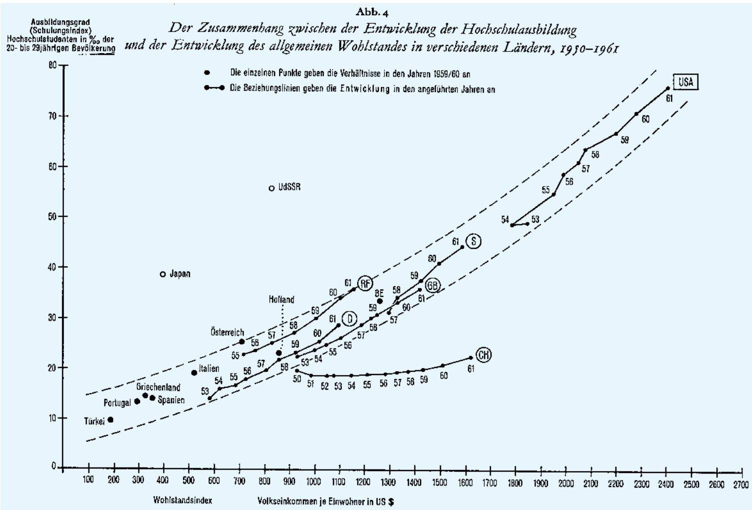
By the 100th-year anniversary of the ETH in 1955, these statements had become dogma. The institutional protection of the federal university was more solid than at any other time in the school's history. In the foreword to the centenary Festschrift, Philipp Etter, who in 1955 had already been running the Department of Home Affairs for so long (twenty years) that he was called "the eternal one," wrote: "If today our country's economy, its industry, commerce, transport, trade, and agriculture, enjoy an unprecedented level of productivity, if they are in the position to support a population that has more than doubled in these hundred years, then it is my conviction that this is thanks to our cantonal universities, and in good, large, and perhaps even decisive measure thanks to our federal technical teaching and research facilities."[244] The federal government had little further comment on the ETH, once a pure teaching facility, having become a prime research institution. Its relationship with the state and with industry appeared rock solid. These actors seemed little aware of its historically evolved structure and institutionalization – surprisingly, even Gottfried Guggenbühl, the ETH historian, who in his celebratory account focused on the school's recent history.[245]

Left: Rector Karl Schmid and Federal Council president Philipp Etter celebrating the 100th-year anniversary of the ETH. This was a rare moment of complete reassurance about the school's trajectory.

Right: *Lehren und Lernen* (Teaching and learning). A mural by Wilhelm Gimmi in the ETH's main building. The gift of the Swiss universities and the *Handelshochschule* (business school) St. Gallen on the occasion of the centenary celebration in 1955 depicts the assiduous activity of the university. The outside world was not of interest.

The new rhetoric was, however, strongly influenced by national rivalry. For example, in 1945 Eduard Fueter praised the willingness of the Federal Council to provide 4 million francs in employment subsidies to support research, acknowledging that, being of a roughly comparable magnitude to the ETH's annual budget, this represented a considerable sum. Compared with the efforts of the United States, Britain, the Soviet Union, France, and Belgium, however, he considered it miniscule. These states were already engaged in a kind of "scientific arms race."[246] The Federal Council also regarded the current expenditures with reference to emerging Cold War. In a 1945 dispatch, the councillors observed that although the war had brought "enormous devastation," it had also spurred the warring states to "important discoveries, the application of novel methods, sophisticated means of fabrication, and the establishment of generous production facilities … thus giving them a head start in the peacetime economy that awaits us … The greatest effort therefore will be required for us to keep pace with other countries in developing technology and in its industrial application."[247] A decade later, in autumn 1957, acceleration of national competition set the stage for the response to the first signals from the Russian satellite Sputnik sent from space. Fritz Hummler, the government's top official for economic development policy, remarked soon after that the Soviets had achieved their technological advance only through immense economic sacrifice and wise use of limited resources. Switzerland, too, would have to rethink its educational and science policy. "Rapid technological development is the most significant structural characteristic of our age," he said on 21 November 1957 in a talk in La Chaux-de-Fonds. To survive in the fierce competition among systems and nations, the country would now "have to devote a sufficient portion of its national income to funding research and education."[248]

Such calls reflected widely held convictions in the 1950s that spending for education and science was a profitable investment in the economy.[249] In all Western countries, especially the United States, science policy makers tried to take advantage of the Sputnik moment to steer more public money to science, research, and education.[250] In the aftermath of the successful reconstruction of Western Europe, the Organization for European Economic Cooperation was also looking for new fields of activity. A series of international conferences on education planning and the science-based economy gave rise to the vision of a coordinated Western European science policy under the auspices of the OEEC and its successor organization, the Organization for Economic Cooperation and Development (OECD).[251] The catalyst was not only political competition from the Eastern bloc but increasingly also the perception of a technology gap with respect to



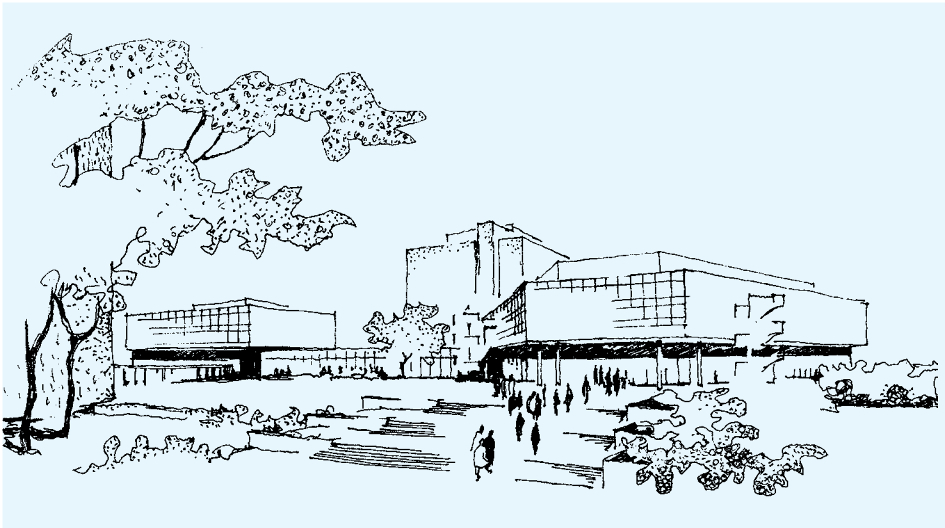
In 1963, the St. Gallen economist Francesco Kneschaurek quantified the efforts of Switzerland in the educational sector. Compared to other industrialized countries, Switzerland (CH) appears strikingly abnormal. The graph provided grist for the debate on the "crisis in education." It measures enrollment in higher education (vertical) against GDP per capita (horizontal) for the years 1950–1961.

the United States.[252] According to an OECD plan produced in 1961, by 1970 Western Europe should redouble its investment in education. The time for the "reform" university had arrived.[253]

The international dynamics were an important point of reference for the Swiss higher-education debate of the 1960s. A later oft-repeated argument emerged according to which the confederation – especially owing to its particular structure – was in danger of slipping behind (or already had), and that this was a situation that only extraordinary (financial) efforts could remedy.[254] One fear was that the cantonal universities would not be able to meet the future demand for graduates and, moreover, that their potential for innovation in science and technology was too small. In fact, a 1963 study by the St. Gallen economist Francesco Kneschaurek indicated a massive gap between Switzerland and other OECD countries. There was talk of a "crisis in education."[255]

In 1962, the Federal Council appointed an expert committee to investigate whether the cantons could continue to fully finance their universities or whether the federal government would have to step in. A year later, the committee concluded that the cantons were massively overburdened.[256] It recommended a higher-education subsidy model that could also serve as the basis for a centralized "higher-education policy at the national level," as committee chair André Labhardt, a professor of Latin from Neuchâtel, put it. "We have the same problems as our neighboring countries, but we also have greater difficulty in dealing with them owing to our country's federalist structure," he noted.[257]

In 1966, the committee's recommendations led to federal payments to the cantonal



Above: An aerial view from 1965 of the construction site for the ETH's Hönggerberg facility. At the center rear is the research building for particle physics. In front, the still unfinished engineering physics building (right) and the Center for Industrial Research (left). The structure at the edge of the forest is the completed chimney tower for the power station. In the foreground are four dormitory barracks.

Below: In the 1960s, Albert H. Steiner, the initial architect of the first construction stage of the Hönggerberg facility, drafted a dazzling vision of higher education. Sketch of a stairway leading to the HPH auditorium.

universities in the millions. The passing of a higher-education act in 1968 established a permanent legal basis for such subsidies, and set up the Swiss University Conference to distribute them.[258]

The work of the Labhardt committee sparked a whole series of other committees, and Switzerland experienced a spurt of science and education policy initiatives that eventually encompassed the ETH. In a special demonstration of the government's new pro-science and education stance, parliament granted the ETH 44 million francs for expansion in 1959, followed by an additional 444 million francs in 1965.[259] However, the funds to the institute had to compete with those to the cantonal universities. School Council president Hans Pallmann noted vis-à-vis the award of expansion monies in 1965 the "particularly high installation and equipment costs of a technical university."[260] In 1967, referring to the rivalry between the ETH and the universities, Urs Hochstrasser, a leading federal official on science policy, spoke of the ETH's right to "privilege" within the government's science funding program on account of its lack of access to cantonal monies.[261] Soon after, the first and up to that point only national school faced additional competition. In 1968, motivated yet again by the Labhardt committee, the government decided to take over the Lausanne polytechnic from the canton of Vaud, and to operate it as a second federal technical university.[262]

Dealing with the military

In marked contrast to the success of individual professors like Jean Rudolf von Salis in representing the "voice of the nation," thus securing the ETH's role in Switzerland's *Geistige Landesverteidigung*, and despite the widely recognized importance of the education and research facility to the country's economic development, relations with the military long remained problematic.[263] This is surprising given the critical importance many other industrialized countries attributed to military research and technology with the outbreak of war in 1939. Indeed, the Second World War ushered in a "scientific transformation of the military-industrial complex."[264] In 1950s Switzerland, however, this trend was still nascent. Recent historiographic attempts to demonstrate new links between science, the military, and industry during the war and immediately thereafter remain unconvincing.[265]

In particular, Peter Hug, whose initial focus was nuclear engineering, framed the beginnings of Swiss science and technology policy in the context of war. "The key decisions of 1942 and 1943 left their mark on the government's support of technology in the coming decades," he wrote of the labor procurement program of those years. "The decisive factor was their subordination to the EMD [federal defense department]. Thus, from the outset, even the civilian components of government policy for support of technology were influenced by military interests and at the same time isolated from economic and university policymaking."[266] Hug argued that the military department somehow dominated science and technology policy. The evidence for this idea is the government's decision in 1946 to promote research on nuclear engineering in the amount of 18 million francs initially over a period of five years and also (secretly) to develop an atomic bomb.[267] The impression of a strong military connection in early nuclear research is strengthened by Hug's comparison of the federal outlays for research and development of 1948 with those of 1963 and 1983, showing that the share of defense-related research decreased from 61 to 46 percent.[268]

Jakob Ackeret placing a projectile in the wind tunnel of the Institut for Aerodynamics. Undated photograph.

Hug's work was critically well received and laid the foundation for the widespread conviction that "the needs of national defense were the initial driver behind state support of research."[269] Indeed, the government's early forays into research support were inseparable from the desire to defend the state against economic and military challenges. If defense research is defined not only as the development of weapons systems but also "the ensemble of scientific and technological research and development ... that contribute ... to the establishment of an autarchic military state," as Helmut Maier suggested with respect to Nazi Germany,[270] then the notion that Swiss science and technology policy was born of the war is not wrong. Fostering economic autarchy was an issue, as contracts between the Wartime Industry and Employment Office (KIAA) and the ETH concerning studies on the potential of local mineral resources show.[271] But the principal dependency of the Swiss economy on import and export was unquestioned.

Such application-oriented research projects, intended to strengthen the economy, were accorded preference among the federal government's subsidizing policy, and as such their impact was far-reaching. Aside from labor procurement and support for exports, the list of priorities also included potential relevance to defense as a criterion for approval. Under these circumstances, it behooved applicants seeking research money from the labor procurement pot at the defense department to couch their proposals in terms of national defense. The ETH, receiving fully 50 percent of EMD employment funding in 1945, constituted, with all its institutes and divisions, a virtual national defense mechanism, in the war-tinged rhetoric of the period.[272] Indeed, the Federal Council argued before parliament in 1954, everything the ETH did was "consistent with job creation and export promotion, as well as the intellectual and economic defense of the country."[273] But what about military defense proper?

From the close discursive connection between research and defense, it does not necessarily follow that the military dominated technology policy. On the subject of chemical arms, Hug observed a "widespread willingness to cooperate with military authorities," but he also noted that no effective "scientific-industrial-military cooperation" was forthcoming. Only Paul Karrer from the University of Zurich and – sporadically – ETH chemist August Guyer managed to cultivate real military links.[274] Moreover, prior to the end of the Second World War, there was little communication between the war office's War Technology Division (KTA) and the ETH, much to the regret of individual professors and members of the School Council. The mésalliance came to light in 1936, when engineering physicist Fritz Fischer was forced to acknowledge that the KTA was not interested in his "Contraves" air defense system and instead was evaluating foreign products.[275]

The problem was not only with air defense. The ETH's efforts to cooperate with the armed forces in building commercial aircraft also came to naught. In their 1934 report on ways of combating the economic crisis, even the experts Robert Grimm and Ferdinand Rothpletz had noted the potential inherent in building a Swiss aircraft industry. They argued that the ETH possessed sufficient know-how, and the army a great enough need for its own equipment, that state support in this area would bring multiple benefits.[276] A study commission was created to coordinate the interests and possibilities of science and of civil and military aviation, but the KTA in particular repeatedly placed obstacles in the way. In 1936, during a debate over mechanisms for ending the economic crisis, National Councillor Theodor Gut fulminated, "It is bizarre for us to be buying our airplanes in Holland when we have such advanced technology here."[277] When the 1936 bond issue raised significant sums for military defense, the question of cooperation between the military and scientific establishments in the area of airplane technology took on added urgency. Arthur Rohn warned the EMD against building its own research capabilities. Rather, why not work together with the ETH, which, in keeping with the recommendations of the study commission, had just strengthened its competence by creating a new professorship in aeronautics? During the appointment procedure, in the course of which Eduard Amstutz, a student of Stodola, was chosen over a candidate from the EMD, the fraught relationship with the military was the subject of open discussion. While in its job search the School Council maintained that "the further development of aviation and especially our own airplane construction ... is absolutely necessary for military reasons," it also alluded to "certain unfortunate circumstances having to do with the EMD's War Technology Division" and said it was looking for candidates with a specific profile: "The new faculty member must especially be of a flexible character to act as a catalyst in the field of Swiss aeronautics, possibly even in the face of resistance, as is the case in military aviation."[278]

Obviously, the head of the KTA, Colonel Robert Fierz, was working hard to keep the army's technological equipage as free from the interests of Swiss industrial

Students with models in the testing room of the Institute for Aerodynamics, ca. 1955. The ETH's expertise in airplane construction had been steadily growing since the 1930s.

and scientific establishment as possible. That in so doing he ignored considerable potential many simply found incredulous. When, in 1940, it became clear how close military leaders in Germany, and also in Great Britain, were cooperating with science, Alexander von Muralt, a physiologist from Bern, proposed to General Henri Guisan the establishment of a science and technology department linked to general staff. Guisan said no. The weapons group already was in "constant contact," for example, with ETH professors Fritz Fischer, August Guyer, and Paul Curti, as well as with Paul Karrer of the University of Zurich.[279] This assessment was in stark contrast to that reached at the ETH itself. "How long must we struggle to enlist our excellent faculty in the work of equipping the national defense?" asked School Councillor Walther forlornly in July 1940. "How our fine lecturers long to put all their knowledge and ability at the service of the country! Once in awhile, *individual* lecturers might be allowed the *opportunity* to voice their opinion. But for the time being, no one seems interested in drawing on them further, leaving them with the sinking feeling that their expert collaboration is not needed. This is consistent with the fact that, for example, in fortification projects critical consultation with engineers and academic experts was generally shrugged off.

The consequences can be seen in the abominations that have been committed in this field."[280]

That the communication difficulties were mainly personal was evident in the change of tone that followed ETH graduate Karl Kobelt's taking over the military department as federal councillor in 1941, and especially with the change in the management of the KTA in 1943. "We note with satisfaction that the K.T.A. is finally seized with a new spirit with respect to scientific cooperation," stated School Councillor Walther in 1943, when the EMD wished to include professors Eduard Amstutz and Jakob Ackeret on its committee on aircraft procurement.[281] At war's end, the military's interest in the ETH increased. In 1946, the national defense committee even requested a seat on the School Council, a move the board found a little too solicitous. Rohn's frosty response was that the activities of the ETH touched "so many vital areas of our state, that not all could be represented by the authorities."[282]

Only in the 1950s did cooperation between science and the military gradually become institutionalized, though on a private basis. In 1954, KTA chief brigadier R. von Wattenwyl invited industry and academic representatives to participate in an "industry report." The contact gave rise, in 1958, to a *Schweizerische Kriegstechnische Gesellschaft* (Swiss war technology society) that counted ETH professors Ernst Brandenberger, Fritz Stüssi, and Franz Tank among its members. The goal of the society was to "intensify efforts to bring together eminent persons in war material procurement from science, industry, and government administration."[283]

SWISSNESS AND SCIENCE

Because science is by nature universal, its relationship to local politics is always complex. In the second half of the nineteenth century, with the rise of the nation-state, science became both national and international. In the years leading up to the First World War, lively congresses and a variety of scientific organizations were active around the world.[284] Three forces maintained and strengthened this internationalism over the course of the twentieth century: first, migration of scientists, which increased dramatically during the 1930s and during the Second World War; second, locally anchored international research centers, such as the European Organization for Nuclear Research (CERN) in Geneva; and third, the practice of science with the research departments of large multinational enterprises.[285] In a world geared to nations, scientific organizations benefited from this international activity. Still, they could not escape national categories. Even philanthropic internationalism, in the context of which, for instance, Alfred Nobel and Ernest Solvay acted as patrons of science at the turn of the century, could not manage to transcend the national order and structure. Rather, they confirmed it. From 1901, the awarding of the Nobel prize to outstanding researchers was also perceived as an

Beginning in the late nineteenth century, the international scientific community enjoyed substantial mobility. The photo shows luggage belonging to the participants of the Third International Phytogeographical Excursion in 1923. ETH professors Karl Schroeter and Eduard Ruebel led the 34-odd plant specialists, from all over the world, to Thusis. Among them was John W. Harshberger from Philadelphia, who took the picture.

evaluative ranking of national scientific power. In this sense, the international organizations created in the postwar period, such as Unesco and the OECD, were at once forums for the exchange, coordination, and reinforcement of national distinctions.[286] For long stretches of the twentieth century, science was a medium of national competition.[287] Of course, projects aimed at furthering national science – the best known being "German physics" in Nazi Germany – conferred no advantage in the international competitive arena.[288] Instead, science policymakers strengthened national categories by giving them an international presence. The national standing of a university generally increased with its international recognition and worldwide renown. These sometimes conflicting, sometimes mutually reinforcing national and international approaches also represented an important frame of reference for the ETH.

The next section takes a look at the international mobility of academics, followed by a few observations on the institutional orientation of the ETH in an international context.

A boat trip on the occasion of the 1935 Zurich conference on physics. Otto Stern, newly emigrated from Hamburg to the United States in conversation with ETH physicist Wolfgang Pauli (right). Behind is the Dutch physicist Cornelius Bakker.

Arthur Rohn's "Jewish problem"

The issue of foreign students at the ETH was a periodically sensitive one domestically, whose cycles were unrelated to the actual enrollment figures.[289] Whenever complaints arose about an imminent "overflow" in the lecture halls and laboratories, the call to limit the number of foreigners was quick to follow. Xenophobic discourse and the semantics of overcrowding had multiple points of overlap.[290] Thus, for example, in February 1908, the parliamentary finance delegation suggested an increase in fees for foreign students as a way both of increasing revenues and "preventing an excessive influx of troublesome foreign elements."[291] The School Council, however, strongly opposed the request, stating, "Among the foreigners there are always elements to be discovered whose influence on teaching and academic success is beneficial. We would not want to miss them." Moreover, it had "always been the tradition" to treat all students equally, because at the conclusion of their studies, foreigners would continue to be ambassadors for Switzerland and especially for the Swiss art of engineering.[292] Only very reluctantly, and in the face of scarce federal funds, were fees for foreigners raised in 1919. Most other universities had done the same. In his opening address for the 1923/24 academic year, Rector Rohn announced that the measures would already be rescinded because they "contradicted the democratic founding principles of our state and the international goals of engineering in the best sense."[293] The real reason was a simple matter of arithmetic. With the doubling of fees to 600 francs, the number of foreign students declined precipitously by more than half, concomitantly reducing overall revenues.[294] But the change in the rules also had something to do with the international scientific climate. In 1926, for example, the ETH established an exchange program with the United States. Between 1927 and 1939, between fifteen and twenty Swiss students attended American universities, and five to ten American students crossed the Atlantic to study in Switzerland.[295]

With the rise of the Nazis in Germany, admissions criteria for foreign students were constantly at issue. As early as April 1933, the Federal Justice and Police Department tightened up the approval processes for foreign student stays at universities. During semester breaks, they had to leave. ETH students from sixteen countries protested these impractical measures, which complicated the examination schedule. Arthur Rohn also objected, going personally to speak with the head of the police department in Bern, and the original scheme was soon restored.[296] In summer 1933, foreign enrollment shot up. Rector Plancherel reported fifty matriculation requests; of those, forty-five were students of Jewish origin. "I might also point out," he added, "that most of the foreign students at the E.T.H. are Jews." The xenophobia that had always been a subtext of the foreign student question now acquired an anti-Semitic dimension. With respect to the enrollment figures, School Councillor Leo Merz opined that one should not "be infected by the current German psychosis," but that it was worth keeping an eye on the evolving problem of the "settlement and professional entrenchment of many Jews" in Switzerland. The characteristic ambivalence of the Swiss attitude toward the refugee issue was already evident in these early decisions.[297] Rohn's own feelings were clearly very mixed. Experience, he said, had to date been good insofar as "the Eastern Jews ... regularly [left] at the end of their studies."[298]

The School Council had always made leaving Zurich after graduation a contingency in times of high enrollment. But the international situation was now increasingly complex. The School Council president watched the swelling flow of migrants with concern, yet stated calmly in September 1933 "that there is no risk of the E.T.H. being overwhelmed with German Jewish refugees, as apparently is the case for the Dutch state universities."[299] Nevertheless, in addition to the actions of the Swiss immigration authorities, the measures taken by the German Reich "against overcrowding in ... universities" restricted the School Council's room for maneuver. At the beginning of 1934, Berlin decided that henceforth college entrants would be selected from among graduates of elite secondary schools not only on the basis of "mental and physical maturity" but also on "good character" and "national reliability." The School Council recognized the regulation as political selection, which Switzerland did not wish to reproduce. But Rohn feared that ignoring the German development might result in a massive influx, "since here we have less rigorous admissions criteria for German secondary school students than they have at home." The provisional introduction of an entrance exam for German candidates resolved the issue for the time being. Nonetheless, it was a hurdle that was certainly not in the interest of the School Council.[300]

A more important factor in the matter of foreign students was the increasing level of xenophobic discourse. In 1934, a provocative article in the fascist newspaper *Die Front* attacked a foreign assistant in the organic chemistry laboratory, renewing the question of raising fees for non-Swiss students. "Is what we have here the kind of 'poster boy' student the E.T.H. takes such pride in breeding?" asked *Die Front*. "Everybody knows that foreign students pay the same fees to the E.T.H. as our local students do, although no other university upholds this practice. The aim of this discount is to increase the number of foreign students at our fed. university. Which means inundating our universities with foreign Jews." Although the School Council officially ignored the article, the ETH did note the anti-Semitic take on academic internationalism.[301] When, in September 1938, Heinrich Rothmund, head of the Swiss immigration authority (*Fremdenpolizei*), quipped that Switzerland was only a waiting room for Jews, Rohn commented: "Switzerland must avoid being overrun by Jews so that we, too, do not end up with a Jewish problem." There was a widespread public argument at the time about keeping out Jews in order not to nurture the anti-Semitism of the Swiss population. The inherent contradiction of this standpoint is typical of Swiss anti-Semitism.[302] But Rohn continued to maintain that, "from the standpoint of the university as well as on humanitarian grounds," it would be best "if at least excellent students were not turned away."[303]

The more international mobility was restricted, the more restrictive Switzerland was in dealing with refugees; and the more clear it became that the ETH would not be overwhelmed with foreign attendees, the more the School Council pressed its case for less restriction. When, following the Nazi Germany's annexation of Austria in spring 1938, the Federal Justice and Police Department instructed the Swiss consulate to deny foreign students entry to Switzerland owing to "overcrowding" at the ETH, the response was electric. "The immigration authorities are not in a position to judge who is qualified to study," barked School Council member Leo Merz in 1938, deploring the "overzealousness on the part of the *Fremdenpolizei*."[304] Shortly after, Merz warned that Switzerland's current policy risked "contributing to the persecution of the Jews and aiding the pursuers."[305] In 1940, the ETH students' association (VSETH) demanded that fees for foreign students be increased, but the request fell flat. It was "almost odious" to request that fees for Jewish foreigners be raised when they were denied access to their assets back home, stated Merz. Rohn repeated emphatically the argument that ETH graduates were ambassadors for the Swiss export industry: "I have been to the Volga and the Pacific; wherever I spied the products of Swiss industry, there were always E.T.H. alumni behind them."[306]

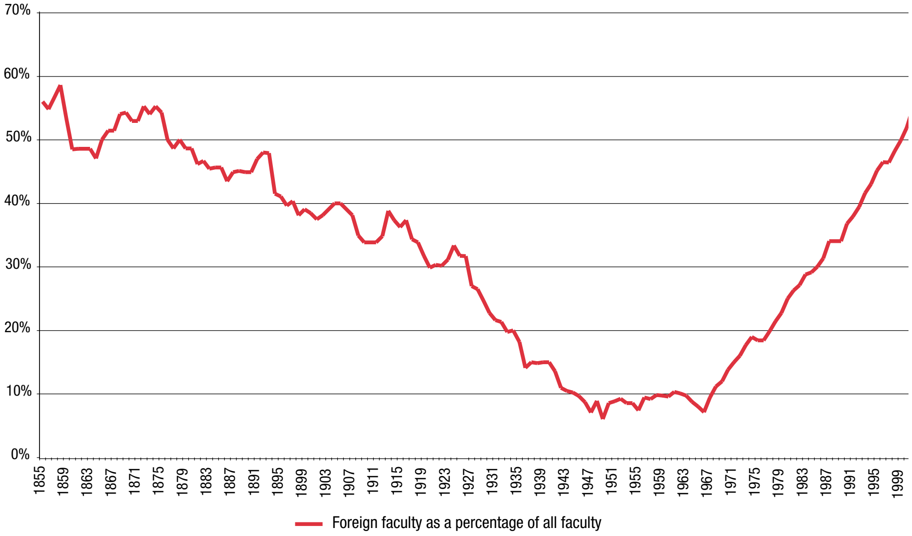
In complete contrast to the calls of the students' association, the School Council during the Second World War even gave individual Jewish foreign students interest-free loans in some cases, thus allowing them to remain in Zurich at critical times.[307] How distressing conditions were is evidenced, for example, by the German Jewish mathematics student Hans Samelson, who in 1940 received the distinguished ETH medal and 800 francs in prize money for his outstanding work on "the topology of group manifolds" but nothing further in terms of financial support from the School Council.[308] "It was clear from the beginning that my only chance was eventual immigration into the USA; in Switzerland my stay was definitely temporary, but as long as I got enough money from home or otherwise to live on – but not from work – they let me stay there." In 1941, Samelson and his wife made a harrowing escape to the United States by way of Spain.[309]

At the end of 1944, the question arose how the Swiss universities should align themselves with the surviving international university landscape following the end of the war. Accordingly, in 1945 the student exchange with the United States that had been stopped in 1939 was resumed. The University of Zurich meanwhile sought a kind of partnership with the University of Leiden.[310] ETH rector Franz Tank thought little of the idea. The ETH's international focus was too diverse to limit itself to promoting a single partner university. Instead, in February 1945 he suggested to the School Council that a large "international academic relief organization" be created that would enable selected foreign students to study at the ETH. At the time, Zurich offered the best conditions for study in Europe, both intellectually and materially. Moreover, Swiss industry was very interested in having many young foreigners around who, upon graduation, "would encourage business cooperation with Switzerland." Tank conceived an ambitious organization and even imagined its physical structure: there should be, he said, "a row of barracks ... for teaching, e.g. in the areaways of the E.T.H., on the Künstlergasse between the E.T.H. and the [University Hospital's] ophthalmology clinic or between the E.T.H. and the university, in such a way that this part of the street would be blocked to traffic, on the terrace of the E.T.H. on the Limmat side, on the grounds of the city's public asylum, provided the city of Zurich agrees, and so forth."[311] For a good portion of the funding, Tank suggested perhaps the "*Schweizer Spende an die Kriegsgeschädigten*" (Swiss Donation for Victims of War), in other words, monies from the national initiative launched by the Federal Council in February 1944 to improve the international image of Switzerland by offering relief to war-torn regions.[312] However, when it became clear that the money from the Swiss Donation could not be tapped, the big plans were recast as a modest program of tuition rebates and special terms of admission for students from Belgium, Holland, and Norway.[313]

Promoting an all-Swiss faculty post-1933

Whereas the School Council deliberately tried to keep a suitable balance of nationalities among the student body, it welcomed and promoted more Swiss faculty. Already in the 1870s, as the first generation of professors faded, the proportion of foreigners fell

Figure 9: Foreign faculty at the ETH, 1855–2002



Between 1948 and 1966, the proportion of foreign faculty at the ETH reached a historic low. The figures are based on the total number of professors, associate professors, and assistant professors. Not counted are titular professors and lecturers. "Foreign" means anyone who was not a Swiss citizen at the time of appointment. Data: Speich 2005b.

off sharply. This trend continued, and sped up markedly again between the two wars. The rapid decline in the number of foreigners was the result of a nationally oriented appointment policy. Up until the 1960s, the School Council president and the Federal Council agreed that, all other things being equal, Swiss candidates should be given preference. Of course, the dearth of foreigners soon after the war also reflected the fact that Germany – traditionally the most fertile recruiting ground – had lost its place as the center of the scientific world. Only toward the end of the 1960s was the ETH in a position to recruit faculty from the new scientific power, the United States, especially among the Swiss eager to return home.[314]

In the 1930s, the discourse regarding the systematic search for Swiss citizens to fill vacant seats took on xenophobic and anti-Semitic tones. In 1932, a group of Swiss students complained that, "in view of the great number of unemployed engineers," Swiss should be hired preferentially for jobs as assistants.[315] The same concerns followed the article titled "Is our Fed. Tech. University overrun by Jews?" of 17 August 1934, cited above, which was especially offensive to the organic chemistry laboratory,[316] where Leopold Ruzicka worked alongside his Jewish colleagues Tadeus Reichstein, of Poland, and Moses Wolf Goldberg, of Estonia. "The federal government chucks its sons out of its own house, to make foreign Jews nice and comfy," *Die Front* concluded luridly. The

In the 1930s, the laboratory for organic chemistry was the target of xenophobic attacks. Pictured is Leopold Ruzicka, in the dark suit, with his staff in 1937. To his left is Moses Wolf Goldberg, and to his right Tadeus Reichstein.

anti-Semitic slurs so unsettled Ruzicka that he submitted Goldberg's postdoctoral thesis (*Habilitationsantrag*) only after he had been assured "that such an application could be refused only on scientific grounds."[317]

According to Richard Willstätter's memoirs, these concerns must have been relatively new, for he described the atmosphere at the ETH prior to the First World War as largely free of anti-Semitic prejudices. "Non-Aryan appointees like the chemists Viktor Meyer, Lunge, Bamberger, Bredig, and the mathematicians Hurwitz and Albert Einstein, and the historian Alfred Stern were welcomed with not a discriminatory word," wrote Willstätter.[318] Even allowing that his recollections might have been a tad rose-tinted, they do show that in the memory of an important Jewish scientist, Switzerland was reasonably tolerant. When Willstätter had to leave Germany in 1938, he chose Switzerland as his country of exile, confirming the favorable verdict on the Swiss. But his case was untypical. Not least owing to the statistical overrepresentation of Jews in science, the Nazi policy of persecution after 1933 caused German universities to lose around 20 percent of their personnel.[319] Of the roughly 3,000 departing academics, 2,000 emigrated, among whom 1,200 went to the United States. "Hitler is my best friend. He shakes the tree, and I collect the apples," Walter S. Cook, director of the New York Institute of Fine Arts allegedly said of this intellectual migration.[320] Switzerland, on the other hand, had quite a difficult time profiting from the potential unleashed by the Nazis. A very restrictive immigraton policy, together with an extremely arduous naturalization process and a ban on employment – which aggravated the economic situation of the refugees – worked to impede the emergence of even a rudimentary "university in exile."[321]

Noteworthy in this regard is the case of Georg Schlesinger, who in 1904 became the first full professor for scientific management in the German-speaking world and played an outstanding role in the discipline. Owing to the Nazi "Law for the Restoration of the Professional Civil Service" (1933), he lost his position at the Technical University of Berlin and fled to Zurich. Having just introduced a production engineering course, the ETH was ready to establish a new competence in Schlesinger's field; yet although all the experienced ETH professors and many business leaders supported him strongly, no job materialized. "Considering the fact that Schlesinger is a German Jewish refugee, and that in industry circles in our country, too, anti-Semitic feeling is palpable," Arthur Rohn preferred to foreswear the services of this "great professional."[322] The person responsible for the successful campaign against Schlesinger was the Winterthur industrialist Robert Sulzer.[323] After Jewish mathematician Paul Bernays lost his position as lecturer in Göttingen, his colleagues in Zurich were able to help him to eke out modest living. "All we could do till now at the Technische Hochschule for the expelled mathematicians is to give a job to Bernays for half a year (for the '*Sommersemester*' 1934) because he happens to be a Swiss citizen," said George Polya, professor of mathematics, in 1934.[324] Subsequently, at irregular intervals, Bernays obtained further teaching gigs, and in 1939 was awarded the venia legendi for mathematics "without … having to write a postdoctoral thesis" owing to his superb qualifications.[325] In Göttingen Bernays had published ground-breaking papers[326] together with David Hilbert. In Zurich he was still a lecturer, though one consulted regularly on knotty problems by the ETH's professors of mathematics. In 1945, he was awarded a professorship *ad personam* with a half-time teaching responsibility. In 1952, the School Council raised the salary of the now 65-year-old professor to the normal salary, after he declined an offer from Utrecht.[327]

In the cases of Schlesinger and Bernays, the School Council was clearly acting anti-Semitically. Had the two scholars not been Jews, the university enterprise would have exploited their renown and expertise. In 1934, the School Council president personally investigated rumors that Jean Rudolf von Salis, professor for history, had Jewish origins. "I talked about this … with the candidate himself, whose features suggest that he could have Jewish blood. He maintained that there had never been any Jews in the von Salis family."[328]

With the outbreak of war in 1939, Switzerland quickly lost its appeal as a country of refuge owing to its geopolitical position. As early as 1938, physics lecturer Gerhard Herzog emigrated to the United States. In 1940, mathematician Georg Polya requested leave to go to Stanford University as a research associate, where he had temporarily resided in 1933.[329] In the same year, physicist Wolfgang Pauli left to take up a guest professorship at Princeton University. "Obviously," Rohn told the School Council, "given the uncertainties of the next period of time, Prof. Pauli was keen to accept the invitation."[330]

Auf Grund von § 3 des Gesetzes zur Wiederherstellung des Berufsbeamtentums vom 7. April 1933 entziehe ich Ihnen hiermit die Lehrbefugnis an der Universität Göttingen.

Berlin den 21.September 1933

Der Preußische Minister für Wissenschaft
Kunst und Volksbildung
In Vertretung

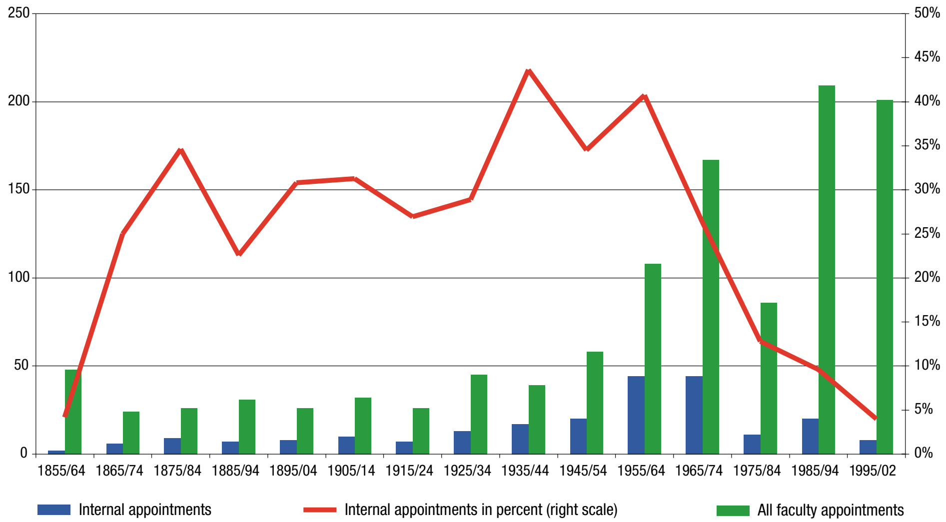
An
den nichtbeamteten ausserordentlichen
Professor Herrn Dr.Paul B e r n a y s
in
G ö t t i n g e n.

Withdrawal of Paul Bernay's right to teach at the University of Göttingen by the authority of the Prussian minister for science, art, and education, 21 September 1933. Following his expulsion from Germany, the Swiss mathematician was appointed a lecturer at the ETH. He became a professor only after the end of the war.

In the winter semester 1941/42, Moses Wolf Goldberg said good-bye to the organic chemistry laboratory at the ETH and switched to a research laboratory at Hoffman La Roche in Nutley, New Jersey.[331] As conditions worsened, the School Council softened its stance toward pursued and persecuted scientists. Thus, in 1939 Stuttgart art historian Hans Hildebrandt was given a teaching contract without discussion, which enabled him and his Jewish wife to stay in Zurich. In 1943, the School Council strongly supported the naturalization of mathematics professor Heinz Hopf after his German assets were confiscated and he was threatened with withdrawal of his German citizenship as a "half-Jew."[332] In contrast, Pauli's naturalization was handled gingerly. When immigration police chief Henrich Rothmund declared Pauli "impossible to be assimilated to Swiss culture" and rejected the naturalization request, Pauli went to America. Before returning to Zurich in 1945, the eminent theorist wrote in his typically provocative manner: "Do Swiss universities now consider scientific qualifications to be the deciding factor, or have they become a kind of subdepartment of the *Fremdenpolizei,* with Mr. Rothmund as de facto rector and School Council president Rohn as his official viceroy?"[333]

After 1945, the power of the *Fremdenpolizei* over the ETH dwindled. In a quick turnaround, the anti-Semitic reflex of the 1930s became an anti-German one. In October 1944, Karl Schmid warned that, now that the phase of "German danger" was drawing to an end, it was high time that the German-speaking part of Switzerland give up its cultural "hedgehog" attitude and once again to look favorably on Germany.[334] But this appeal went unheeded. In 1950, the appointment of the refrigeration engineer Peter

Figure 10: Internal appointments, 1855–2002



Internal appointment (*Hausberufung*) refers to the promotion to full, associate, or assistant professor of a person who previously held the position of lecturer or titular professor at the ETH. Data: Speich 2005a.

Grassmann appeared on the School Council's agenda. The choice was controversial, not because the candidate had been a member of the Nazi *Sturmabteilung* between 1933 and 1945, but rather because a German had already been hired in the person of Kurt Leibbrand, professor of railways and transport.[335] It would be politically ill-advised "to make every new appointment a German," said future federal councillor Willy Spühler on behalf of the School Council. "Everybody knows that a German cannot easily change his mindset."[336] School Councillor Gotthard Egli begged to differ: "If Dr. Grassmann has only his Germanness to speak for him, I would be inclined to reject the appointment, but not simply on account of his past."[337] Arthur Rohn weighed in, "If we are restricted to looking for German experts who were never members of the Nazi Party or any of its branches, then we would have to give up on Germany entirely."[338] Overall, in 1950, the ETH faculty included three Germans, one Dutch, and a Swede. The remaining 105 faculty members were Swiss citizens.[339]

Never was the proportion of foreign faculty at the ETH as low as in the two years following the end of the Second World War. After an embarrassing delay, Professor Pauli, who had previously been driven to existential distress by the *Fremdenpolizei*, was now quickly naturalized. Other foreigners were barely represented among the teachers. Instead, Swiss were given preference, and in view of the fact that the ETH was the only national school of many of the required disciplines, most of them were in-house graduates. Thus, between 1935 and 1964, the proportion of "home-grown" faculty grew from 35 to 45 percent. Moreover, it was a point of pride that the ETH had become a fully functioning machine for producing young researchers, capable of delivering top-quality candidates. In 1943, when Georg Polya announced that he would not be resuming his professorship, the School Council had three plausible replacement candidates: Albert Pfluger, Eduard Stiefel, and Beno Eckmann, all three from the ETH's division of mathematics and physics.[340] The job was given to Pfluger, and a new chair was also created and promptly filled by Stiefel. Commenting happily on the process, Rector Saxer (himself a mathematician), said, "This is probably the first time in the history of the E.T.H. that with one exception (Hopf), all the chairs in mathematics are occupied by Swiss. There is no doubt that Pfluger and Stiefel can hold their own with any bright lecturer from a German university."[341]

The United States as a new center of science

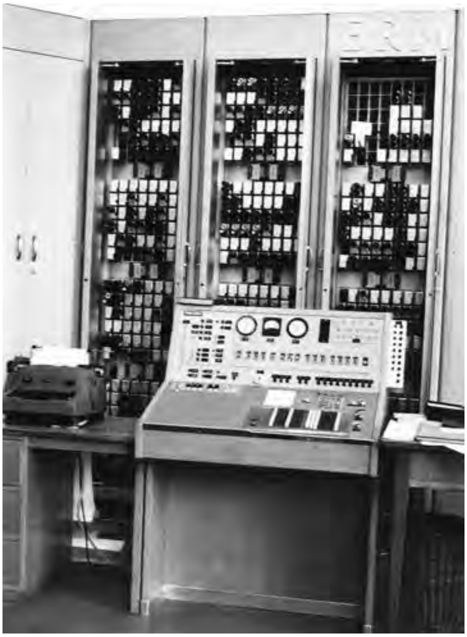
The predominance of Swiss scientists could not obscure the fact that the national university – in accordance with the country's foreign policy of the late 1940s – was trying increasingly to break through the international isolation that surrounded Switzerland because of its cooperation with Nazi Germany.[342] In making this international outreach, ETH officials emphasized the value of the leading position that Zurich now enjoyed in the German-speaking world. "Today, the E.T.H. is the only German-speaking technical university that still provides a good engineering education at the advanced level," Rector Tank said with satisfaction in September 1945.[343] Moreover the institute realized that its stature enabled it to extend the scope of its student exchange programs with Great Britain, Canada, and Sweden. The Western, industrialized world was divided hierarchically in the following way: "Second-rank exchanges would be those with France, Italy, Belgium, Holland, Czechoslovakia, Denmark, and Argentina. Other countries, many of which have been suggested, such as Austria, Poland, Hungary, Yugoslavia, and Germany, are of interest for what they offer culturally."[344] In truth, however, none of these countries, not even Argentina, held the attraction of the United States. The free spot granted to an ETH student at MIT and the connection with the California Institute of Technology (Caltech) now proved to be extremely valuable. Rohn gladly made contact with organizations such as the "Swiss Friends of the United States of America" and the "Swiss-American Society for Cultural Relations," which contributed financially to student exchanges.[345]

During the war, the School Council had maintained institutional connections to a number of lecturers exiled in the United States. In addition to Moses Wolf Goldberg, these included the chemist Max Furter, who envisioned returning to Zurich and bringing along the specific US experience of "living here in the now well-established center for scientific and technological development and taking part in the fantastic progress in these areas, without the constraints of wartime."[346] The shift of scientific influence from

Germany was felt not only in chemistry and biology but also in physics and mathematics. In 1947, regarding the imminent founding of an institute for applied mathematics, former rector Saxer stated: "In connection with the military buildup, certain areas of technology abroad – in particular in the U.S.A. – have experienced an unprecedented boom. Above all, advances have been made in the areas at the interface of mathematics, physics, and applied technology." With the advent of mechanical computing, mathematics grew fairly rapidly into an experimental science, leading Saxer to conclude: "Our division of mathematics and physics wishes to stay linked to these foreign developments, and therefore in future intends to pay more attention to applied mathematics."[347] Very nearly the first step along these lines was taken by Eduard Stiefel, head of the new applied mathematics institute, who spent the winter term 1948/49 on a three-month sabbatical in the United States. Stiefel's assistant Heinz Rutishauser, and electrical engineering student Ambros Speiser, also went to study for a year with H. H. Aiken at Harvard University and with John von Neumann at the Institute for Advanced Study in Princeton.[348]

In the post-war years, experiences like Furter's, who was working at Roche, in Nutley (where the company had owned a site since 1928), or those of Rutishauser and Speiser, who were in the United States to brush up on the state of their art, gave rise to a new type of career profile.[349] Toward the end of the 1950s, it became nearly impossible to succeed professionally in the natural sciences or mathematics without a study visit in America. The appeal of science in the United States was due both to the quality of the institutes, as well as the fact that progression from postdoctoral fellow to full professor was much more flexible than in the cumbersome German "*Ordinariat*" model.[350] In 1962, the young Basel researcher Uli W. Steinlin summarized the ideal biographical profile in a standard curriculum vitae mocking the Swiss German system of science. In fact, Steinlin stated, to be successful one had to be a dynamic world traveler. "Diploma received at 24, PhD from the ETH at 27, at 29 – totally disappointed by local conditions and without hope of a scientific career in Switzerland – off to an American university for a research fellowship, senior research fellow at 31, assistant professor at 34, associate professor at 35, and now (at 37) full professor of physics in a 'division of mathematics, physics, and astronomy,' comprising around 30 full professors and a corresponding number of young lecturers and technicians."[351]

Evolutionary biologist Heinrich Ursprung fit this resume almost perfectly. Born in 1932, he studied at the University of Zurich during the 1950s, graduated there in biology, after which he worked for a year as an assistant. In 1961 he took up a research position at the Johns Hopkins University in Baltimore, and soon rose through the ranks from assistant professor, to associate professor, and finally full professor of biology. In 1969 he was appointed full professor at the ETH Zurich, of which he became president in 1973. One could also cite other physicists, mathematicians, chemists, and biologists who worked at the ETH, for instance, Res Jost (born 1918), who from 1949 to 1955 was a fellow at the Institute for Advanced Study in Princeton, then moved from there to an associate



Above: In July 1949 Edward Stiefel alerted the ETH that it would be possible to inexpensively acquire German engineer Konrad Zuse's computing machine. The School Council was keen. The photograph shows Zuse presenting his apparatus in 1950.

Right: The computing machine ERMETH developed by the ETH's Institute for Applied Mathematics went into operation in 1955. It was fifty to a hundred times more powerful than Zuse's machine.

professorship at the ETH, and in 1959 became the successor to Wolfgang Pauli in the chair of theoretical physics. The mathematician Niklaus Wirth (born in 1934) worked at Berkeley and Stanford between 1963 and 1967, prior to becoming associate professor for computer science at the ETH in 1968. Ralf Hütter (born 1931) was at the University of California at San Diego before becoming assistant professor for microbiology at the ETH in 1967.[352] Following Jost and Rutishauser, who pioneered the track, Ursprung, Wirth, and Hütter became the second wave of postwar researchers to incorporate a stay in the United States in their curriculum vitae as a matter of course. Many others followed them, though not in the engineering disciplines. Here, the necessary qualifications included good contacts with the Swiss industry or the federal institutions. In the social sciences and humanities, the Anglo-American region came to dominate only around the turn of the twenty-first century.

The appeal of the American university system for young Swiss researchers in the natural sciences and in mathematics became a political issue in the second half of the 1960s. Already in its first annual report, the Swiss Science Council (*Wissenschaftsrat*) established in 1965 stressed the urgent problems of Swiss scientists abroad. The deployment of "science attachés" in the Swiss embassies of Washington, Tokyo, and Moscow was proposed. They would examine the science system of these countries and get in touch with local Swiss. Regarding the planned expansion of all Swiss universities, the idea, insofar as possible, was to gather the globally scattered intellectual potential of Switzerland and to encourage nationals sojourning abroad to return home.[353] The problem of the migration of European intellectual resources that came under the rubric of "brain drain" had a strong impact on public opinion. "*Verdummt Europa?*" (Is Europe dumbing down?) queried the title of a much talked about book published in 1968 by the cyberneticist Dimitris N. Chorafas.[354] Consequently, the scientific attaché at the embassy in Washington, Charles Tavel, systematically contacted Swiss living in the United States and notified them of open positions at home. In 1971, his successor, G. A. Grin, calculated the balance of migration to be positive overall, with 184 scientists going to the United States in 1970, and 250 being sent from America to Switzerland that same year. Given these numbers, there was no longer any question of brain drain.[355] The career trajectories cited above of Jost, Rutishauser, Ursprung, Wirth, and Hütter showed that despite the dynamic market for science, which developed in the United States after 1945, the ETH remained an attractive employer.

International research collaboration

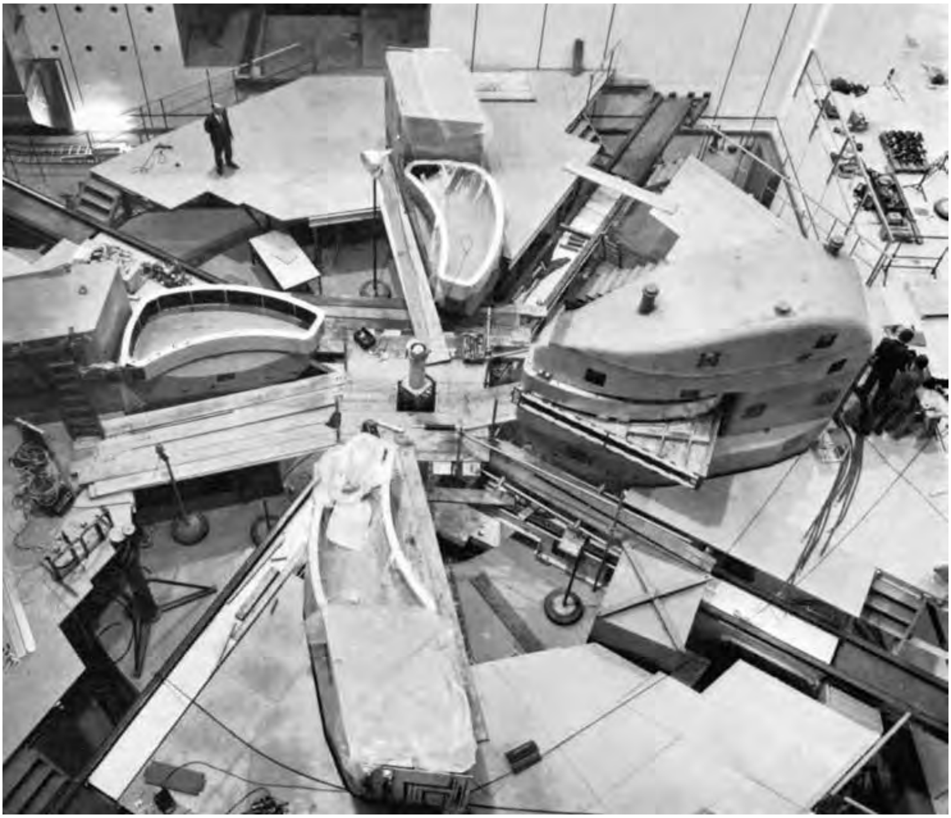
One reason for this was Switzerland's quite successful efforts at participating in research collaborations. In 1949, Eduard Stiefel reported to the School Council in connection with his studies in the United States that MIT would be interested in having a regular exchange of instructors with Zurich. Such an offer from "renowned MIT" was received with respect. Above all, said Stiefel, the United Nations Education, Scientific, and Cultural Organization (Unesco) was pursuing a plan to build a computer institute in a "neutral country." It should have sufficient capacity to process astronomical data collected by observatories in various countries.[356] School Council president Hans Pallmann (who had replaced Arthur Rohn in 1949) quickly realized that this issue carried enormous potential for Zurich. In addition to the Dutch and Italian applications, the dossier he compiled for Zurich would have impressed Unesco officials. But in 1951, when it became clear that it wasn't the international organization but essentially the local community that would have to pay for these costs, Zurich withdrew its candidacy.[357] As the 1950s wore on, the problem of providing large computing capacity shifted from the international to the national level. On the other hand, international collaboration in the area of molecular biology, space research, and high-energy physics remained an area of keen interest.[358] One moving example was the convention of 1 July 1953 in Paris that established CERN. Switzerland joined the convention shortly thereafter, and pledged to pay annual premiums of around 3 million francs. However, the commitment soon entailed further costs that no one had reckoned with.

The collaboration with CERN was a response to the development of physics into big science, that is, into large-scale research organized around ever more complex experimental systems. The architects of these projects, who included ETH physicist Paul Scherrer, shared the conviction that in the future no single Western European country would be in the position to provide the necessary research infastructure. Without collaboration across countries, so the argument went, exploration of certain problems of nuclear physics would soon be possible only at large American laboratories. This trend was especially evident in the case of particle accelerators. Under Scherrer, the ETH had been able to keep pace with the worldwide development of this research instrument by building a Van de Graaff facility in 1936 and subsequently a cyclotron. In these projects, Peter Preiswerk, who in 1954 took over the buildings and facilities department at CERN in Geneva, acquired technical expertise and scientific renown first as a technician, then in 1945 as a lecturer, and after 1950 as a titular professor of nuclear physics.

By the 1950s, the ETH's own equipment was beginning to age. It was no longer powerful enough to study the newest, internationally hot research issues. Collaboration at CERN ensured that Switzerland did not lose its connection to cutting-edge research. But along with the commitment came the responsibility to meet the growing demand for research funds. Operation of the research facility in Geneva entailed additional, unplanned costs for the cantonally structured Swiss research environment. Already in 1965 in its report "on the further expansion of the *Eidgenössischen Technischen Hochschule* (ETH) and its associated institutes," the Federal Council had requested the sum of 92.5 million francs to construct an experimental facility in nuclear physics.[359] The reasoning was seductive: only with a 500 MeV high-intensity proton accelerator could Swiss particle physics progress to the level required for successful participation in CERN projects. "Every top-notch product, like that at international CERN, is underpinned by the capabilities of national research centers," wrote the Federal Council, adding: "In Switzerland, at the present time, we are suffering from this difference between us and CERN."[360] The idea that the plant would actually be a supply facility for CERN, although hardly convincing, still had the desired effect because it emphasized once more the constraints of international competition. To address the perceived weakness, the ETH planned to build an institute for nuclear research in Villigen, in the immediate neighborhood of the government-maintained *Eidgenössische Institut für Reaktorforschung* (EIR, Federal Institute for Reactor Research), whose "relatively central location invites collaboration with Swiss universities."[361] This turned out not to be easy. The universities of Zurich and Basel had already begun preliminary planning for a nuclear physics facility, with the promise of government support – an element that the ETH project lacked – which put the schools directly in competition with each other.

In the spring of 1966, newly appointment School Council president Jakob Burckhardt and experimental physicist Jean-Pierre Blaser decided to take the bull by the horns. Through a survey of all interested academic physicists in Switzerland and the skillful involvement of the science council founded the year before, the ETH succeeded in defending its project. The science council judged the Basel and Zurich accelerator facility as "not desirable," but stated that going ahead with the Villigen project would have "psychological ramifications" that had to be taken carefully into account. Moreover, collaborations would have to be established in a way that enabled the cantonal university researchers to "work there less as guests than as partners."[362] Following the science council's decision, Burckhardt also proposed a management committee for the institute that, analogous to governance at CERN, would consist exclusively of scientists. Of key importance was to "avoid anything that might give the impression that the School Council or the ETH wished to impose their will."[363] Accordingly, Burkhardt tried to involve, among others, future Nobel laureate Georges Charpak as a representative of CERN in the management structure of the Villigen institute, as well as a Swiss collaborator from the German electron synchrotron DESY in Hamburg.

Criticism was also heard from within the ETH, however. In July 1966, Rector Hans Leibundgut stated that there was a "degree of ill feeling" among the faculty owing to the impression that "within nuclear and high-energy physics an application by a single junior scientist was sufficient for approval by the School Council, whereas in other fields well-founded applications submitted by an entire division were unsuccessful."[364] The civil engineers in particular felt disadvantaged in relation to physics. The School Council addressed the resentment in December by making clear that other "urgent tasks of university support … should not take second place to the high-energy project."[365] The fact that the test facility in Villigen finally went into operation in 1974 was largely thanks to the intervention of the research council of the Swiss National Science Foundation. In 1967, its leading figure, Alexander von Muralt, staked his reputation on helping Zurich and Basel to commingle their projects with that of the ETH. Professor Blaser had intro-



View of the inner room of the Swiss Institute for Nuclear Research from 1972. Of the ring accelerator's eight sector magnets, one is fully assembled, and some of the others show at least finished magnet yokes. For a sense of scale, note the person standing in the upper left corner.

duced some conceptual changes to the proposed facility to enable the Zurich and Basel experiments to be carried out. The additional 8.5 million franc price tag for compatability was covered by the National Science Foundation. The project for a Swiss Institute for Nuclear Research (SIN) had to go through all stages of science policy. In the process, all the players realized that owing to the debate over money, SIN probably represented "the last feasible big science project in Switzerland for physics."[366] This assessment was shared by Bernard Grégory, CERN's director, who in 1967 called the Villiger project "remarkable" and the last hope of such projects in Europe.

In fact, the building of SIN coincided with the end phase of unfettered development of nuclear technology.[367] In 1988, after barely twenty years of service, the SIN merged with the Federal Institute for Reactor Research (EIR) into the Paul Scherrer Institute (PSI), whose activities subsequently expanded far beyond the original field of nuclear physics.

1968–

5. *The social* LABORATORY: TESTING *the bounds of higher education and politics post-1968*

Daniel Speich

1975

In 1969, the topic of European universities drew more political attention than ever in its history. In view of the unprecedented boom in activity with regard to higher-education policy, Helmut Schelsky wondered rhetorically whether there was anything left to discuss. Too much had already been said about the subject by professors, students, the lower ranks of academics, and politicians: "There does not appear to be a single structural stone in the university that one has not at least attempted to break open, turn over, and examine for worms, be they real or fictitious. Considering the dilemma between resignation or disgust over the frustrating accumulation of inconsequential or actively misunderstood arguments and counterarguments, and the risk that expressing oneself on university policy will be taken as justification or partisanship, any of the literature published on the subject these days is suspect."[1]

Since the 1950s, this German sociologist was among the attentive observers of a development taking place in every industrialized nation: the keywords research policy, university reform, and education initiative were heralding the growing importance of science, technology, and education policy. A slew of sociological and economic studies appeared, all attributing a new type of economic value to the production and dissemination of knowledge, and pointing to this structural shift as evidence of a "postindustrial" society.[2] Spending on science and education was no longer seen as a province of culture but rather as an investment in future economic growth.[3] In the 1960s, no Western European nation could afford not to be active in this political field. In Great Britain, France, Germany, and elsewhere, so-called reform universities were established. Research funding agencies and national research councils were also created to coordinate the new policies. Everywhere, science and education budgets grew (almost) apace with student enrollments. According to Schelsky, this rapid development changed the relationship between science, politics, and industry in a fundamental way. The Humboldtian university, whose idealized form had served as a guiding principle in Germany and elsewhere, was proving increasingly obsolete. The idea of science as an enterprise conducted in "solitude and freedom" was hard to sustain in the face of the growing service function of research and teaching.[4] Precisely how a university should be organized and what the role of academics in society should be were the subjects of furious debate.

In 1969, the issue of university policy in Switzerland took a complicated turn. In June of that year, a proposal to revise the law governing the ETH failed decisively at the polls.

Banner advertising a Christmas party and a call to a "teach-in," ETH Day 1970: After 1968, leisure time, science, and politics ceased to be distinct.

The popular referendum was necessary because ETH students – to the great surprise of the political public – had sought such a referendum in order to reverse a law previously passed unanimously by parliament. If a politically naïve, socially peripheral, and only loosely organized group such as the ETH students could bring down a proposal, on which the whole political establishment had previously agreed, something was clearly afoot. The profound unease among the political players was evident in the fact that now from left to right, from the lower classes up to the elites, the university was being asked to "experiment." How was it that everyone agreed on the need to take experimentation out of the laboratories and apply it to the university itself? Which social disruptions – as well as continuities and enduring structures – made it possible to embark not only on this step of experimentally determining the future but also, by definition, to leave it wide open? A lecture series held at the ETH during 1968/69 will serve as a starting point for focusing on these issues, and envisioning the contemporary connections between them.

"Educational requirements for the industrial world"?

The idea for the lecture series titled "educational requirements for the industrial world" came from Jakob Burckhardt, president of the Federal School Council, during a meeting in February 1968. Burckhardt wished to invite six representatives from industry, politics, and science to consider the current educational mandate of the university. Following each lecture, the public would be given the opportunity to participate in a discussion, and at the highlight of the event, Burckhardt planned a round table. The project was generally favorably received by the school councillors. Hans Rogger, the Christian Social Party minister of education for Lucerne, was highly enthusiastic and considered the topic extremely important. Claude Seippel, director of BBC and honorary doctor of the division of electrical engineering, also welcomed the idea, though he doubted the usefulness of public discussion. Giovanni Lombardi, a construction engineer and entrepreneur from Italian-speaking Switzerland, was similarly sympathetic. He stressed, however, that it was not the task of the ETH to contribute to the general cultural education of the public. That job really belonged to the gymnasiums, whereas the technical university was primarily responsible for the scientific education of its students. Hans Bosshardt, the longtime secretary of the School Council, countered that, with its division of general studies, the ETH "as the first and for a long time only technical university" had clearly pursued a program of cultural education. A lecture series was a natural outcome of this activity. Its relevance thus confirmed, the event series moved into the planning stage.[5]

Since taking office, Burckhardt had already presented two general education lecture series: one on the history of engineering in the winter semester of 1966/67, and a second the next year on the history of the natural sciences. Now he was opening the series to topics more directly connected to contemporary debates. A veteran diplomat who until 1966 had led the department of international organizations in the federal foreign ministry, Burckhardt was well aware that higher education all over the world was undergoing profoundly radical change. In Switzerland, too, university politics filled newspaper columns. It had become a key media theme.[6] In early 1968, Max Imboden, president of the Swiss Science Council, explained to the *Vereinigung schweizerischer Hochschuldozenten* (association of Swiss university lecturers) that the coming year would be a "fateful" one, during which the university policy would have to be newly worked out between the cantons and the federal authorities. The most important item on the agenda was a bill on financing higher education, which obligated the federal government to provide financial support to the cantonal universities. Also on the agenda were a new *Maturitätsanerkennungsverordnung* revising the entrance requirements to the universities, and the government takeover of the polytechnic in Lausanne, which required a new ETH law. In the cantons of Aargau, Lucerne, and Ticino, the creation of new universities was being discussed. Most important, in Imboden's view, was to engage in a far-reaching, fundamental debate because "nearly every Swiss university is now dealing with the issue of organizational structure."[7] The draft for a new university law was presented in Zurich in February 1968; in Basel and Bern as well, new laws were being prepared.[8]

The many pending reforms affected the position of the ETH in the Swiss higher-education landscape. Within the school, questions arose concerning the administrative organization, and in particular, how to lessen the burden on the School Council president.[9] At the level of teaching, talk centered on upgrading the humanities and social sciences – a bugbear in ETH history. In addition, while both the main building and the Hönggerberg campus were undergoing massive expansion, future capacity could only be roughly estimated. All in all, there was reason enough to seek an understanding on the subject of the "education requirements for the industrial world," in other words, the meaning and purpose of a technical university.

On 7 November 1968, Burckhardt inaugurated the lecture series. It was, he said, a "dynamic era" in which all "traditional ideas and principles were being called into question." The ETH was entering a "period of intense self-reflection" aimed at clarifying how the school would satisfy its educational mission in a "modern and far-sighted" manner.[10] But the School Council president could hardly have imagined the depths of this reflection, or its ramifications. The following years would see plans and proposals for reform galore. However, the chances of any of the ideas coming to fruition gradually decreased, as ideological and political posturing on higher education became more and more entrenched.

The winter semester 1968/69 began painfully for many, as formerly firm convictions seemed everywhere to be eroding. The speakers as well as the public all apparently shared Burckhardt's feeling of doom. For decades, the ETH had engaged in the acquisition, production, and sanctioning of knowledge on behalf of a government, industrial, and academic elite largely without interference. Now these core tasks and their implementation had become extremely difficult. Few appreciated the complexity of the problem. But the need for a contemporary diagnosis was obvious, and attracted a large audience to the lectures.[11]

Kicking off the series were Hans C. Bechtler, founder of a successful industrial firm; Hubert Bloch, director of pharmaceutical research at CIBA; and Ambros Speiser, research head of BBC – three experts who were familiar with the intersection of science and industry. They were followed, in early 1969, by Howard W. Johnson, president of MIT, who presented his thoughts on "New Education for Technology." On 23 January 1969, federal councillor Roger Bonvin addressed "Nos écoles polytechniques à la taille de l'homme" (The human dimension of our polytechnic schools), and on 6 February Gerhard Huber, ETH professor for philosophy and pedagogy, moderated a summary panel discussion involving all the speakers.[12] By Burckhardt's reasoning, the first three experts should represent the current educational training required in manufacturing systems, electrical engineering, and the pharmaceutical industry. Their remarks were


EINLADUNG

Die Eidg. Technische Hochschule veranstaltet im Wintersemester 1968/69 eine öffentliche Vortragsreihe über

Bildungsanforderungen in der industriellen Welt

mit folgenden Referenten:

7. 11. 1968 **Hans C. Bechtler,** dipl. Ing. ETH, M. Sc. MIT, Verwaltungsratspräsident und Delegierter der LUWA AG, Zürich

21. 11. 1968 **Prof. Dr. med. Hubert Bloch,** Direktor der Pharma-Forschung CIBA AG, Basel

5. 12. 1968 **Prof. Dr. sc. techn. Ambrosius P. Speiser,** Forschungsdirektor der BBC, Baden

9. 1. 1969 **Dr. Howard W. Johnson,** LL. D., D. H. L., Präsident des Massachusetts Institute of Technology, MIT, Cambridge, USA

23. 1. 1969 **Bundesrat Roger Bonvin,** dipl. Ing. ETH, Bern

6. 2. 1969 Podiumsgespräch der Referenten (Leitung: **Prof. Dr. Gerhard Huber)**

Die Vorträge finden jeweils am Donnerstagabend um 20.15 Uhr im Auditorium maximum, Hauptgebäude der ETH, Leonhardstrasse 33, 8006 Zürich, statt. – Der Eintritt ist frei. – Sie sind dazu freundlich eingeladen.

Der Präsident des Schweiz. Schulrates

Ad for the lecture series "Educational Requirements for the Industrial World" in the *Zürcher Student*, 5 November 1968.

largely similar. Moreover – as the following brief synopsis of Bechtler's talk shows – they left the audience somewhat underwhelmed.

Bechtler felt clearly that the ETH had ground to a halt. The "industrial world," he said, during the first talk on 7 November 1968, had altered radically since his own study at the technical university over 40 years previously, yet the curriculum seemed to ignore the change in educational requirements. Owing to rapid "mechanization," in future both the government and industry would require ever more graduates equipped with a good general education in addition to their scientific and technical training. But the engineers, most of whom at some point in their career would assume business or political positions of leadership, emerged from their education as "inhibited personalities," shy of exposure, who overlooked the "intricate connections among many issues" at work as well as in their social lives. The talk ended with a call for more intensive "cultivation of guts and feeling" in the training of engineers. Totally consistent with contemporary gender roles, the speaker directed this last comment to the women present, who as the "wife or mother of an engineer or student" should ensure "more often than before, that the engineer-husband returning from his day at work abandoned, for example, the integral sign for the treble clef!"

Bechtler's attitude was not lost on the public – whose female members must surely have included not just students' mothers and engineers' wives but also one or another of the 326 women students at the ETH. "Unfortunately," wrote Hans Niklaus in the *Studentischer Wochenkalender,* "the lecture series does not seem to quite meet expectations." Typical of a "solid, successful middle-class Swiss," Bechtler had developed a few "good ideas," but was "much too vague." His recommendations were repeatedly couched in terms of a basic conviction that the ETH was the "world's best technical university" and that "our state … provides the essential ingredients for building a thriving Swiss industry." For some of the representatives of the *Verband der Studierenden der*

ETH (VSETH) and the *Fortschrittlichen Studentenschaft Zürich* (FSZ, Progressive Student Union), that was hardly radical enough. They asked sharply pointed questions regarding the state and the university, startling both Burckhardt and Bechtler, and finding little support among the audience. "The attack," Niklaus continued, "became ineffective when the speaker, embarrassed by the image of his profession and not wishing to encourage the provokers, let alone being in a position to defend himself, simply clammed up." Disappointed, the student reporter concluded: "The debate … thus hung in the air because Eng. Bechtler's presentation was devoid of the necessary scope … Although hypotheses were proposed, I would be hard put to say what if anything they have to do with educational requirements."[13]

Bechtler intended his proposals to be seen as "unorthodox." But by calling for engineers to be given more general education, he was simply reiterating the well-established value system of technocratic humanism. Bechtler's proposal had already figured in the dispute over the role of academics in engineering education at the turn of the twentieth century, and by the end of the 1960s it had been incorporated into the standard repertoire of the debate on education.[14] Bechtler treated it as typical of his time, aiming a few barbs at the "cool" reputation of engineers, a point made succinctly 10 years earlier by ETH graduate Max Frisch.[15] At the same time, Bechtler seemed to be suggesting that is was precisely this Homo faber* (slightly refined), whose expertise and leadership skills would master the difficulties ahead. Ultimately, at the heart of Bechtler's speech was the idea that social processes could be described using engineering metaphors and directed using an elite, top-down model of problem solving.

This view of the problem was expressed particularly clearly in the talk by Roger Bonvin on 23 January 1969. Based on his personal experience as a civil engineer and politician, the Catholic conservative federal councillor from French-speaking Switzerland tried to distill the educational requirements that would be most generally applicable to the postindustrial world of 1969. According to Bonvin, the ETH had a responsibility to inform students how they might work for the common good, and also to instill in them universal humanistic ideals. The purpose of an engineer was to better society in a constructive way: "therefore, engineers must know both the business and social worlds so that they can be part of them and improve them." Bonvin reminded students that even during their training they should maintain close connections to society and actively engage with it so that the improvement of higher education, which the students were now so intensely committed to (the students had, in the meantime, lodged the referendum on the ETH law with the federal chancellor), could also take place in a constructive fashion. What could be more satisfying, he asked in conclusion, than mustering all one's joy and good will to ameliorate the living conditions of the community, "including that of the ETH?"[16]

* "Man the maker," a concept dating back to Roman times and the title of Frisch's influential 1957 novel. [Trans.]

Bonvin repeatedly addressed the students directly, but his message did not reach them. Adam Wyden, for example, was disheartened by the paternalistic, establishment tone of the speech. "In lofty language, we were served up personalities, activities, and things Federal Councillor R. Bonvin happened to encounter during his career," Wyden wrote in the *Studentische Wochenkalender*. Wyden had come to the lecture well prepared, with good questions, but Bonvin studiously avoided debate. Instead, he expressed himself in the "shopworn rhetoric of a 'middle-class magistrate' writing his memoirs." Even in the concluding discussion, which the moderator (Prof. Huber) was helpless to keep from disintegrating into a "little war of positions," the "real confrontation" of the evening never occurred because the "levels of communication" were too diverse. The federal councillor had simply called for "better 'bumbling about' (planning!)" without developing any genuinely new ideas. But according to Wyden, the students now had a legitimate contribution to make to the discussion on educational requirements in the industrial world, "without calling into question how people should work together and what on. In fact, the students' ideas and actions go much deeper, reaching to the very root of the poor functioning of modern society … The evening was not without purpose, insofar as the gap between the fronts was now clearly visible."[17]

Both Bechtler and Bonvin embodied variations on the model of "leadership personality" that the ETH had so successfully produced for decades.[18] Bechtler came from a merchant family in Zurich, graduated from the ETH in 1927, received a master's from MIT in 1928, and in 1933, together with his brother, founded LUWA AG, an air-conditioner manufacturing company. The internationally active entrepreneur sat on many boards of directors in the engineering industry and was both a patron and collector of art. Bonvin was less cosmopolitan. The son of a surveyor from a mountain village in Valais, Bonvin obtained his *Matura* in 1927 from the Benedictine College of Einsiedeln and graduated from the ETH in 1932. So equipped, he began a successful career as engineer and politician, which led him from the deeply Catholic milieu of his origins to the predominantly Protestant political center of Switzerland.[19] Despite this difference, both men shared the same basic sociopolitical experience. They started their careers during the crisis of the 1930s, and were much influenced by the entrenched domestic political compromise formulas of the time, which bound together optimistic prospects for growth and technological progress with the structural and cultural values embedded in the community.[20] But by the late 1960s, with the appearance of new social actors, this model of success and the belief it inspired in the feasibility of social change was coming under pressure. In the light of unexpected notions of participation and provocative forms of political communication, the time-honored problem-solving model à la Bechtler or Bonvin lost its credibility.[21] The experts invited to the lecture series as opinion leaders discovered that their authority was being called into question. Suddenly, not only what, but who, with whom, and how the debate should be pursued had to be rethought.

In the wrap-up discussion to the series on 6 February, Huber tried to close the Pandora's box by highlighting what he felt to be four main achievements of the lectures. First, consensus seemed to have been reached on the diagnosis of a "crisis in our industrial society," which he described as a crisis of leadership and control of technology. Second, the curriculum at the ETH had to be reformed in such a way as to prepare graduates to find constructive solutions to the problems posed by this crisis. Third, nontechnical subjects needed to be upgraded. And fourth, the relationship of the ETH to the secondary schools, the schools of applied sciences, and industry needed to be redefined.[22] Yet opinions were already split on the definition of "nontechnical." The demand for additional general education in the humanities ran into opposition from the applied social science disciplines such as management science, psychology, and applied social research. As a model of a complete education, Huber suggested (with a trace of irony) the "ideal image of a humanistically educated engineering manager" – reaffirming the guiding vision of technocratic humanism.

The question of educational requirements for the industrial world had indeed been posed concretely, but there was no way to answer it without first resolving much more fundamental questions about the relationship of higher education to society, the prospects of the "industrial world," the meaning of scientific knowledge for industry and government, and societal values. The lectures touched on all these issues, but the concluding discussion failed to reconcile them. Roger Décosterd, an administrative lawyer, remarked laconically, "I fear that if we get bogged down here trying to reform the Poly's curriculum in detail, we will have to repair to the Hallenstadion where it will take us the proverbial six days and probably the nights as well to end this marathon."[23] As it happened, the reform debate ran not for six days but for years and then decades. Nor was it limited to the curriculum. It also involved the administrative structure of the school and its position in society. Leadership skills were demanded not just of graduates of the ETH, but also (most urgently) of the operators of the school themselves. And it was precisely this state of affairs that posed an unprecedented loss of control for the Federal Council and the School Council, the authorities, and the school administration. As spring 1969 wore on, it became increasingly clear that the new ETH law that had so smoothly passed all parliamentary stages would be refuted in the general ballot.

Systemic disruption

Given the extremely tough negotiations resulting in the ETH's founding law of 1854, great care had been taken ever since to implement impending reforms – the upgrading of the polytechnic to a university at the start of the twentieth century, for instance – without having to re-expose the legal basis of the school to national politics. But when the government decided to take over the Lausanne polytechnic in 1967, it ordered the complete revision of the 113-year-old ETH law. Expanding the powers of the School Council to cover two national schools would probably have been possible even without revising the law, but at the risk of the Lausanne institution (EPUL) being seen as an appendage of the Zurich school, which would in turn have offended the sensibilities of French-speaking Switzerland.[24] In a relatively short time, Hans Bosshardt, former School Council secretary, together with EPUL rector Maurice Cosandey hammered out a new, streamlined text. No consultation was considered necessary, and the federal parliament approved the bill unanimously on 4 October 1968. The ETH law, as well as a second law on the funding of higher education, were to come into effect in early 1969, and both the ETH and the EPUL intended to draft new regulations over the course of the winter semester 1968/69.[25]

This reform drive, due largely to the legendary "tempo" of Hans Peter Tschudi, minister of home affairs, was abruptly and unexpectedly halted by the antilaw referendum.[26] The ETH students'seeking the referendum in January 1969 and the subsequent victory at the polls on 1 June 1969 were one with a series of institutional "accidents" that the historian Erich Gruner referred to in 1971 as the "threshold of an era … The increasing momentum of the flow of events … indicates that *deeper shifts* are seriously undermining the *meaning and coherence* of our *institutions*."[27] The most significant sign of the times for Gruner was the new extraparliamentary opposition, which he took to be the expression of a crisis of democracy in response to the overburden of government functions. This new complexity was evident in infrastructural, migration, environmental, and now also higher-education policy. The "predominance of economics over politics" so typical of Switzerland, said Gruner, had led to a massive "development jam" in the public sector. He argued that there were neither enough roads nor enough universities to accommodate the rapid economic growth of the previous decades. The costs of progress could now be seen in the serious impairment of societal institutions, namely, the universities and – at a fundamental level – the federal constitution, whose overhauling had been debated since the mid-1960s.[28]

Gruner's case is a good example of the catch-up frenzy characteristic of science policy as the 1960s wound down. Switzerland's existing universities seemed to be reaching the limits of their capacity. Thus, in the university cantons of Geneva, Vaud, Freiburg, Neuchâtel, Bern, Basel, Zurich, and St. Gallen, as well as in "federal Bern," attempts were made to develop new means of dealing with the growing importance of science both as a boon and threat to prosperity. The initial result, however, was a break in communications. In addition to a Commission for the Promotion of Scientific Research, which after the war migrated from the military to the Department of Economic Affairs, and the National Science Foundation created in 1952, at the federal level there arose the National Science Council (1965), the Permanent Commission of the Federal Assembly for Science and Research (1967), and the Office of Science and Research in the Department of Home Affairs (1969). The Swiss University Conference (1969), a new intercantonal body, assumed its place beside the Conference of the Cantonal Ministers of Education, which dated back to the beginning of the century, and the Rectors' Conference of the

Swiss Universities, which began operating in 1949. In Geneva, a nationwide information center for matters regarding schools and education was set up in 1961, the canton of Aargau was planning to build a coordination center for human development, Lausanne had its sights on a center for school construction, and the federal parliamentary services opened a documentation center for science policy.[29] In view of this embarrassment of organizations, the *Neue Zürcher Zeitung* warned in 1967 against the dangers of "commission inflation," which could lead to paralysis on the part of the federal government.[30] Even the *Handels- und Industrieverein*, which kept a suspicious eye on all government activity, was increasingly skeptical of the "confusion … in Bern on matters of research policy."[31] Anyone interested in science, education, and research might be referred on one occasion to the Department of Economic Affairs, on another to the Department of Home Affairs, or ultimately referred to an intercantonal concordat. Consequently, the *Handels- und Industrieverein* decided to create a separate standing committee for science and research to objectively monitor emerging matters of policy.[32]

All of these newly created bodies were intended to help keep in check the uncertainties that plagued university politicians and planners. These uncertainties began at the ground level and extended upward. One crucial question was how many students to expect. The prosperous post-war years and the growing importance of science and research had led to a rapid increase in enrollment at the universities. At the same time, and surprisingly, the engineering disciplines were stagnating.[33] At the beginning of the 1960s, under then School Council president Hans Pallmann, the ETH envisioned growing to 10,000 students. Although this goal wasn't abandoned, it was no longer clear when it would be reached.[34] The decline in new admissions in civil, mechanical, electrical, and rural engineering, and in chemistry flew in the face of predictions, most of which were calculated on the basis of the baby boom. In 1968, on the occasion of an "informational visit" by the parliamentary finance delegation, the School Council assembled among other facts and figures the following data into a report:

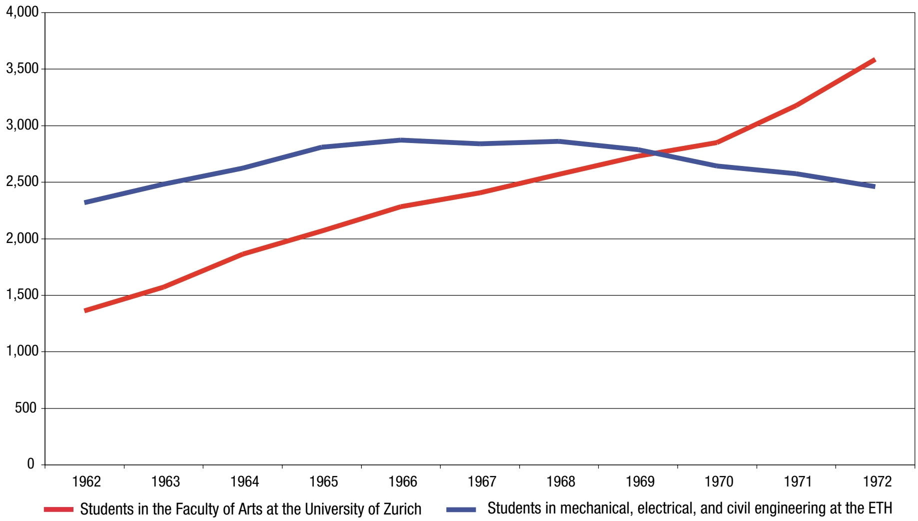
Division	*New admissions 1966*	*New admissions 1967*
Architecture	172	171
Civil Engineering	190	142
Mechanical Engineering	179	153
Electrical Engineering	202	178
Chemistry	107	89
Pharmacy	16	25
Forestry	26	33
Agriculture	88	88
Rural Engineering and Surveying	46	39
Mathematics and Physics	136	157
Natural Sciences	88	105
Gymnastics and Sports	27	17

Source: EAR, SR2: Schulratsprotokolle 1967, meeting of 30/9/1967, p. 633.

Between 1966 and 1978, the main building of the ETH was renovated and reinforced according to plans by Charles-Edouard Geisendorf and Alfred Roth. Extensions to the atrium were intended to accommodate an expected increase in student enrollments.

Below: The ETH Hönggerberg facility in October 1973. How far to expand was not exactly clear.

Figure 11: The crisis in engineering education in the 1960s



Enrollment in the engineering disciplines and the social sciences show differing trends. The "explosion" in the field of education, a topic that contemporaries were much concerned with, occurred in the philosophical faculty of the University of Zurich, but not in the mechanical, electrical, and civil engineering disciplines at the ETH. Data: Siegenthaler 1996; Leemann and Speich 2005a.

Federal Councillor Tschudi was "not pleased" with the publication of the numbers because they "could impede the further expansion of the ETH." Rising costs in a shrinking school were hard to explain. Burckhardt concluded firmly, "We must do everything we can to get past this stagnation."[35] Yet, aside from the question of how to encourage young people to choose engineering studies, it was totally unclear where the demand for academics on the job market might develop, and hence what target numbers to shoot for. The first indications came in 1967, from a survey sponsored by leading business companies. To obtain more accurate forecasts, the government asked the St. Gallen economist Francesco Kneschaurek to supplement his study of the future of Switzerland with an investigation of the future need for academics.[36] Although Eugen Böhler, ETH professor of economics, finance, and statistics until 1964, had warned in 1965 against an exaggerated "belief in long-term planning and long-term predictions" by which a particularly late-modern fear of the future was offset, such opinions remained on the discursive periphery.[37] In general, the dominant view was that better planning and coordinated processes were the key to solving the problem.

Better planning and coordination was also needed for the structural expansion of the university. The two major expansion schemes of the 1960s – the redesign of the main building in the center of Zurich and the construction of the Hönggerberg facility – were showing signs of getting out of control. In February 1968, Heini Gränicher, professor of experimental physics and soon to be based at the new site along with his institute, informed the School Council: "I am beginning to be seriously concerned about the way the planning is being carried out, decisions are being made, and the slow rate of construction."[38] By 1968, the buildings for nuclear physics and engineering on the Hönggerberg, designed by architect Albert H. Steiner, were already complete. The solid-state physics and molecular biology facilities were under way. And the work on the shared lecture halls, the "student restaurant," and the main building with the physics library were about to begin.[39] The complaint of the physicists, transmitted by Gränicher, was that the decision-making authority was vague and too diffuse, communication between the physics professors and the contractors nonexistent, and the decision-making process itself essentially unilateral. The project included no professionals who "knew (or cared to know) the needs of the future users," and as a result, their concerns were largely disregarded. Personnel turnover was a problem, and there was no project manager who understood the issues from all sides.[40]

It wasn't only the physicists who were dissatisfied, but also (and especially) the civil engineers, who felt left out of the expansion process in which there was no relief in sight for their cramped quarters. In summer 1967 Bruno Thürlimann, professor of building statics, had appealed directly to the public through an article in the *Neue Zürcher Zeitung,* "on account of the lack of communication between us and the School Council," as he explained later.[41] This tactic led several concerned federal parliamentarians to inquire of School Council president Burckhardt whether his group was still in a position to bring together the disparate interests of the different divisions. The *Verein Schweizerischer Zement-, Kalk-, und Gipsfabrikanten* drew attention to the importance of the construction industry, and in the National Council, Paul Eisenring demanded a "hearing" on the planning situation at the ETH.[42]

The School Council took the criticisms to heart, and in summer 1968 formed a consultative committee on planning issues to advise the ongoing construction projects and to prepare future ones.[43] The chair of the committee was Hans Hauri, professor for building statics and construction, and – as of 1968 – vice president of the School Council. As Hauri soon discovered, there were basically "no meaningful assessment criteria" for addressing the upcoming planning issues. Up to then, "especially urgent decisions had been dealt with in an 'ad hoc' manner, without adhering to any overall plan, and – worse – with no eye to the future.[44]

To superimpose some order on the planning work, the committee asked one of its members, Jacques Schader, to prepare a background report. As 1969 wore on, Schader, who had just resigned his professorship of architecture, found the situation so confusing that even putting together the key data seemed a major challenge. Rather than recommend substantive planning goals, he suggested instead collecting information to assist possible future planning procedures.[45] In this regard, Hauri had already sent a circular letter to all "interested co-workers and institutes" of the ETH, inviting them to contribute information and documents about their units to the administration. He considered it his duty "to collect as much knowledge about our area as possible to enable decisions to be made objectively, and above all to permit us to assess the likely consequences of such decisions."[46] Schader contacted the minister of home affairs, the science council, and the federal building inspector. He also sought out expertise within the ETH from the School Council associates for personnel and finance, the ETH's building coordinator, and the president of the *Schweizerischen Vereinigung für Dokumentation*, who happened to be an ETH employee. Schader established contacts with the documentation and information center of the VSETH, which was set up in conjunction with the referendum, as well as the head of the ETH library, Jean-Pierre Sydler, who also chaired the science council's expert committee for questions relating to scientific documentation.

The contact with Carl August Zehnder, deputy director of the Institute for Operations Research, proved especially interesting. Zehnder had received his PhD under Hans Paul Künzi and Eduard Stiefel in 1965 on computer calculation of timetables and schedules, and was currently directing the newly founded coordinating group for data processing at the ETH.[47] Schader wished to provide the planning authorities with information that would make the ETH's present position and recent past as clear as its "future development," and perhaps allow comparison with other universities. To enable the documentation center to make "all usage and operational data as well as statistics available at all times," he proposed establishing a database with the help of electronic data processing.[48] As Zehnder had promised, this solution made it possible to deliver "periodic printouts of the latest data from the various card indexes and lists ... At a later stage, with the help of certain programs, these numbers could be used to extrapolate trends that would complement the work of the planning office."[49]

The vision of the future served up by the Institute for Operations Research, which had already carried out a study of the ETH planning at the initiative of Franz Weinberg, shows that at the end of the 1960s, the university had clearly taken on the character of an enterprise. It became the subject of scientific systems analysis.[50] The intelligence and talent of outstanding individuals still played an important role in the institution's collective identity, but the effort to optimize administrative processes, to allocate research activity, and to rationalize teaching gradually moved to the foreground. This shift resulted in a whole new set of demands on the university's management. The old model of self-government, according to which the professors chose a rector from among their ranks, was dismissed as being an "old boys' club 'approach.'"[51] Although from its founding the full-time president, not the rector, was the operational leader of the ETH, here too it was desirable to have professional management aided by the very latest in operational planning tools. Indeed, as Schader's approach showed, the new system naturally entailed a reorganization of interuniversity communication. Individual professors reacted somewhat huffily to this development, as it undermined their painstakingly nurtured informal channels of influence. On the other hand, other university personnel gained more authority as they began to promote their own interests as university "professionals." The *Mittelbau* (academic assistants) took the lead; the technical and administrative personnel followed soon after.[52] The most important proponents of the new "democratization" of the university were the students. Soon after seeking the referendum in January 1969, the VSETH notified the School Council that communication needed to be improved: "We are convinced that the ETH can no longer afford to risk a split between the school administration and the students caused by misunderstandings and a lack of information exchange. The example of the ETH law shows that this danger exists," VSETH president Silvio Vaccani told the school council confidently.[53]

The "student" element

The mid-1960s marked a sharp increase in student engagement with university issues. In December 1965, a leaflet put out by the VSETH talked of a "latent malaise" and opened up a debate on educational objectives in which Professors Gerhard Huber, Gustav Eichelberg, and Adolf Max Vogt all took part.[54] But the discussion went nowhere. At a day of debate in Lenzburg in September 1967 on university and research issues organized by the *Verband der Schweizer Studentenschaften* (VSS), the aura of crisis had already gained wider ground. Representatives of the government and the university cantons, rectors and vice rectors of the universities, representatives of industry, political parties, as well as diverse other education-related groups – such as the *Gesellschaft für Hochschule und Forschung* and the *Vereinigung junger Wissenschafter* – talked about science and research policy. Step by step, the students' demands for participation were voiced. Yet the VSS was still some way away from claiming an agenda-setting role. Max Imboden encountered no opposition in defining the objectives of the event, namely, "to promote creative unrest among the scientists, the authorities, and the public."[55] Although the students had organized the forum, they were not recognized as discussion partners with clearly articulated positions or even "professional" interests. This despite a remarkable opening speech by Bettina Plattner, vice president of the VSS, on the urgency of academic reforms.[56] When businessmen, rectors, and politicians interested in science policy met again in Rüschlikon in the tempestuous May of 1968 at the invitation of the *Schweizerischen Vereinigung Junger Wissenschafter* and the *Gesellschaft für Hochschule und Forschung*, no one noticed the total absence of students.[57] The emerging student organizations were more or less ignored by major opinion leaders in the field and the majority of ETH students were uninterested in university policy. When the VSETH organized a seminar on educational reform in February 1968, six professors and a scant two dozen students showed up.

Unlike the United States, Great Britain, Germany, France, and Italy, in Switzerland universities were relatively calm during the summer semester of 1968. The May riots in

France were closely followed at the Universities of Geneva and Lausanne and sparked several demonstrations. And at the University of Zurich, on the eve of the annual celebration, the FSZ organized a "very well attended" event on university reform to which representatives of the *Sozialistischen Deutschen Studentenbundes* (SDS) were invited.[58] But at the beginning of the semester, the conservative *Schweizer Monatshefte* reported with satisfaction that, once again, the confederation had proved "something akin to a special case." The few demonstrations had taken place "in a consistently disciplined fashion," and even "in the Romandie … the debates managed to remain orderly."[59] What escaped the readers of the *Monatshefte*, as well as the politicians and school councillors, was the fact that even "orderly" events could have explosive power, particularly given that the global events in early spring and summer of 1968 had politicized Swiss students in new ways. Compared to the United States and the Federal Republic of Germany, for instance, where students agitated for extrauniversity issues (the civil rights movements and the military involvement in Vietnam, or the criticism of emergency rule and the boycott of Springer press) and concern about university reform came later,[60] in Switzerland the "malaise" of the universities was always the main topic.

At the end of June 1968, the demand for an independent youth center in Zurich escalated into a violent riot. Student organizations were not involved, however. On the contrary, the VSETH attempted to mediate between the youth movement and the municipal authorities. Gerhard Huber and Karl Bättig, both ETH professors, were among the signatories of the "Zürcher Manifest," by which prominent figures supported the young people.

Even in the ETH divisions, things began to move in May 1968. Around 300 students and 30 professors attended a panel meeting arranged by the *Akademischer Maschinen- und Elektroingenieurverein* (AMIV), at which division heads Peter Grassmann (III A) and André Georges Dutoit (III B) went head to head with students over the curriculum. Student Urs Ramer proposed that the debate be continued at the divisional conference, but the academics rejected the idea of institutionalizing student participation. Instead, Franz Weinberg, professor of operations research and a specialist in organizational optimization, suggested a seminar on internal university issues for the purpose of further exchange of views.[61]

On 31 May, students "crammed into Audi II" after the rumor spread that design professor Jacques Schader was resigning for political reasons. Indeed, Schader confirmed his intention to withdraw, explaining his "dissatisfaction" with the teaching in the architecture division. The *Zürcher Student* reported that division head Hans Hauri subsequently informed the "somewhat surprised students" about ongoing efforts toward curriculum revision, and invited their participation. One week later, at an extraordinary general meeting, the student representatives elected an "action committee."[62] On 12 June the

Delegates' convention of ETH students in a chemistry lecture hall on 13 May 1970. Democratically based decision-making processes were at a high level popularity.

architecture students' group petitioned the School Council to allow it to be the first student group at the ETH to attend the divisional conference,[63] and one week later, it began a two-day discussion with nearly 300 participants. In the *ETH Bulletin* Hauri reported, "Certain actions, such as provocative posters … and the painting of the temporary stairs near the Poly terrace may well have shocked some of us, but should not be made too much of … The chair was able to lead … the debate … Lecturers were also present throughout and intervened occasionally to provide clarification."[64]

The VSETH, the student body's umbrella organization, responded to the activities of its base by professionalizing. Silvio Vaccani was the first VSETH president to interrupt his studies for a year in favor of such efforts. In addition, a full-time vice president for university issues was appointed. From June 1968, Urs Maurer, a budding architect, enlarged the function of the office of vice president by adding documentation and information on university policy, and intensified contacts with the constituent student associations.[65] Maurer later recalled: "During the summer DC [delegates' convention], as a complete outsider, I was – to my horror – elected to the VSETH executive committee … I also happened to be the exemplar of the 'uninterested, nonpolitical average student.'" Maurer gradually learned the ins and outs of university politics, and like many other students, found his radical calling in August 1968 with the defeat of Prague Spring and the subsequent relief action for Czechoslovak refugees.[66]

By the beginning of the winter semester, the air of change was palpable. In the 5 November 1968 issue of *Zürcher Student,* Toni Lienhard reported on a seminar on the "modern university" in Geneva in early October that had attracted 200 science and university policy luminaries from around the world. Lienhard painted a conflicting picture of the event, whose speakers included not only Jakob Burckhardt and Geneva rector Denis van Berchem but also Clark Kerr, former dean of the University of California as well as minds such as Jeanne Hersch, Raymond Aaron, and Alain Touraine. Lienhard was annoyed by the patriarchal tone with which all the speakers, except for Touraine, sought to tame the students' activities and concerns. Hersch, for example, had in characteristic style presented the youth movement as an intuitive response to a new crisis situation: "In fact," she said the students were right, but they were wrong in their analysis of the problem. Lienhard was also disappointed by the two student speakers and VSS president Franz Marty, who courted confrontation with "tough statements,… rude and head-on," but that generally dissipated into the air. Yet Linhard did notice a "change in the atmosphere … Even if the students present were not their own best advocates …, the lecturers and politicians interested in university politics no longer kept to themselves, as was the case in earlier, similar colloquia and seminars. The "student element" had a place, albeit in the background and disdainfully overshadowed by [Jean Hersch's] 'in fact.'"[67]

The campaign against the ETH law, 1969

In the turbulent months that followed, the new power had to be consolidated. This was difficult due not least to the varying agendas of the increasingly confident students. Coherent positions and lists of demands only emerged step by step out of the confrontation with the Swiss political system and the ETH's own system of self-governance. So armed, the students were increasingly perceived as constitutive elements of the system for other "elements" – and this perception turned out to be critical to the change that was starting to take hold throughout the entire system. The most significant demand was that of "participation," in other words, the students managed to integrate into the system by claiming the right to do so. The formal request was also a proof of principle. For the time being, the student initiative in this organizational structure-building process took on the character of a social movement that drew its impulse from a dense schedule of hearings, panel discussions, and plenary meetings. Urs Maurer later wrote: "Silvio Vaccani discovered the federal law of 4 October concerning the organization of federal technical universities. We duplicated it immediately and saw to its dissemination. The catalysts for the law turned out to be the colloquium in Geneva, [and] the lectures series 'Education requirements in the industrial world.' Weekly newsletters and leaflets helped to spread the word. The hearing in the atrium carried the discussion beyond the university walls."[68] On 11 November 1968, student representatives of the ETH and students at the EPUL met in Bern with Federal Councillor Tschudi to discuss the new ETH law. A few days later, in a talk on ETH Day, Vaccani called for massive resistance against the new law. On 19 November, the "hearing" alluded to by Maurer took place in the atrium of the Poly with School Council president Burckhardt and EPUL rector Cosandey. The 21st was given over to discussion, including many sessions devoted to the disputes over the ETH law, followed by a four-hour meeting that night of the VSETH's delegates' convention. The ETH law was pronounced "unacceptable to the student body." In addition to the lack of transparency in the lawmaking process, the new law was criticized as too closely resembling the founding law of 1854. In particular, the students objected to the newly created Article 10, which made no provision for student participation but rather only sought the views of students on university issues "through the mediation of the recognized authorities." That was more than the old law provided for, but far less than the politically organized students wanted.[69] Although a move to seek a referendum against the proposal was rejected by a vote of 40 to 23, "owing to the implications of the decision" the students agreed to submit the motion to a vote by all ETH students. Finally, the VSETH executive committee noted: "We consider the federal law on the Eidgenössischen Technischen Hochschule as a transitional law. Effective immediately, we demand a say in all ordinances and regulations that have not yet been adopted. We demand that university procedures be public, that is, that an observer be present at all the university's decision-making group meetings."[70] This resolution requesting participation and transparency enabled the VSETH board to solidify a basis for further activities related to university policy. But their indecision vis-à-vis the referendum made the official student body lose control of the following dynamics.

In the ballot of 2 and 3 December 1968, a clear majority of ETH students voted in favor of a referendum.[71] A contributor to this result was the FSZ whose barely 100 members, enrolled mainly at the faculty of philosophy at the University of Zurich, were very active in politicizing all students along the lines of the new left.[72] On 5 November, the FSZ announced a "teach-in" about the federal law, and on 13 November it launched a series of lectures on "university and society" that paralleled the ETH School Council's own event. The first day of the series, Ulrich K. Preuss spoke on "emancipating science," and on 20 November Elmar Altvater gave a talk analyzing "the crisis of late capitalism and the student revolt."[73] November was so unruly that the members of the FSZ feared losing their way. "Comrades, owing to the many recent events, the weekly members' meeting has skipped a few times, with the result that we now have a crisis of information," stated a leaflet dated 15 November that listed all upcoming events. "With respect to the student position on the new federal law … – a catastrophically reactionary law notabene, which Tschudi has praised as a model for all of Switzerland" – the hearing in the atrium of the ETH on 19 November would be decisive. "Anyone who has anything to say on the university issue (especially Uni people) should attend this event."[74] Members of the FSZ were also present at the delegates' convention on 21 November, where immediately following the vote on the referendum, they organized a "tumultuous rally."[75]

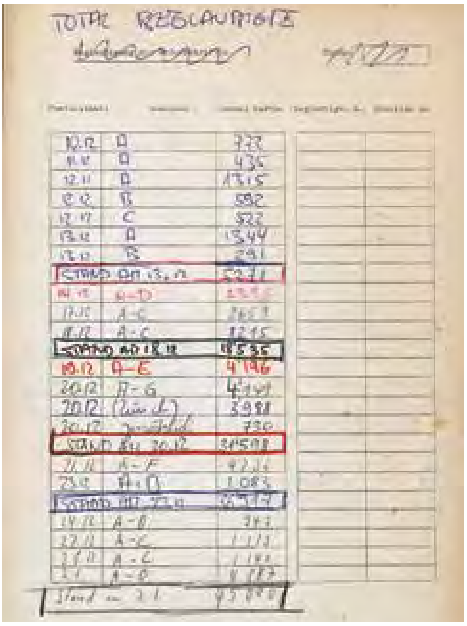
Even before the vote, a group of students convened a "committee for the referendum" and began to prepare for it. The headquarters of the new action group was located in the office of the architektura association,[76] where it collated debate materials and made contact with numerous political groups.[77] Most important, it coordinated the collection of signatures, during which by 8 January 1969 – that is, in five short weeks – nearly 50,000 officially certified signatures of Swiss citizens were gathered.Only 30,000 were needed. Already the idea that a politically poorly networked group could not only threaten a referendum but also effectively pursue it had gone against the unwritten rules of the political system.[78] Moreover, the committee employed many other unfamiliar practices not tried since the introduction of direct democracy in 1874. Within the committee, jobs were up for grabs and not allocated in any systematic way: whoever had time did whatever needed to be done. Urs Maurer reported: "The atmosphere was one of vibrancy and utter spontaneity. There was neither obligation nor coercion – everything was based on voluntary commitment and a climate of joyful, creative enthusiasm."[79] Sections of the VSS and other organizations obtained signatures in every conceivable place and under every possible circumstance all over the country. On 9 December, the *Wochenkalender* wrote euphorically: "At the Zurich HB [main station] 2 student Sandwich-men gathered 300 [signatures] in one hour! On the train from Zurich to Neuchâtel and back, 1 student collected 100 signatures. 2 students gathered 45 signatures during intermission at the movies."[80] Even the formal handover of the signatures to the Federal Chancellery was conducted as a happening: "In contrast to the customary tradition of submitting the referendum wordlessly, in private, we wanted to transmit the 48,256 officially certified signature cards for safekeeping in the form of a grassroots 'procession' to the Federal Chancellery," wrote the committee. The cards, sorted by canton, were transported from the Bern station to the parliament building in a convoy of bicycles.[81]

A contradiction developed between the stodgier VSETH and the dynamic referendum committee that cast a shadow over the further activities of the students: The call for participation and transparency reflected not only a desire to inject a student perspective into the policymaking process but also an attempt to change the rules of the game of participatory politics in a creative way. The form and content of the demands overlapped; theory and practice needed to be unified. What had been tried in the university area – in miniature – fascinated the actors for this very reason: that everything was done with an eye to the broader societal structures – the big picture. "The conflicts resulting from the clash between the VSETH and the referendum committee can serve as a model case for a typical situation today. Cooperation must be established, and democracy reinvented, be it within the study body, or in the city government, School Council, or Federal Council."[82]

This expansive social perspective, which went way beyond the specific question of participation, had its origin in the successful mobilization of the committee. "We have succeeded in launching the referendum against the content, the structure, and the origins of the federal law … We seek to ensure a debate on all related matters of education in the broadest sense," stated the committee in February 1969.[83] Once the Federal Chancellery had confirmed the validity of the referendum on 25 February 1969 and set the date for it, the campaign for votes began. In this the referendum committee structured its organization, lost its spontaneity, and began to more closely resemble the VSETH. Although it maintained the cheerful activism of its early days for some time, it became increasingly professional and even employed the services of the Farner advertising agency.[84]

Unlike their parliamentary delegates, now all the major parties, with the exception of the BGB (Farmers', Trade, and Citzens' Party, which decided to let each member vote as he preferred, that is, not along party lines), came out officially against the federal law. The unanimous consent that had prevailed in the federal parliament soon gave way to a consensus that the proposal took too little account of the current flux in higher education and was therefore unacceptable. On 1 June 1969, the law was rejected by 65.5 percent of voters.[85]

The victory failed to translate into any new surge of motivation or commitment on the part of the students. On the contrary: The consolidation of the loose movement into an identifiable "student element" was associated with organizational efforts that turned the spontaneous actions into routine operations. Consequently, the character of a movement was largely lost. During the voting campaign, the tension between the hierarchically structured organization and the anarchical community – or between "theoretically incompetent ETH administration fetishists" and "true revolutionaries," as FSZ activists



The referendum committee tallied the number of valid signatures constantly. The list reads like the minutes of the successful signature campaign. The count of 45,000 on 3 January was well over the minimum needed. The preprinted form used for this monitoring was the same used to collect the individual signatures.

Titled "Go-in," this leaflet was not urging people to a new form of political action but rather invited them to judge posters rejecting the ETH law. The event took place on Monday, 5 May 1969 at 9 a.m., under the watchful eye of Hans Ess, professor of graphic design.

Right: Students taking part in the voting campaign against the ETH law at the Central in Zurich. To keep costs down, the students screen-printed their posters by hand.


ETH-GESETZ

Thomas Held and Mathias Knauer put it[86] – had resolved in favor of the VSETH executive committee. However, the process radicalized the student body, and for the first time in its history, the student association was positioned as a leftist organization with a sociopolitically oriented platform. In adopting the FSZ's tone in fall 1968, the VSETH's executive committee admittedly very soon re-lost its newly won proximity to its constituency, because with the exception of architecture, the student divisional organizations did not go along with the leftward shift. Meanwhile, for its part the FSZ had been pulling away, already during the voting campaign when it became apparent that the hoped for radicalization would not develop a broad basis nor would student demands expand to include socially transformative goals. Actions such as go-ins, institutional sit-ins, and strikes, which the FSZ was still advocating on 12 February 1969 in the form of a talk by the German student politician Wolfgang Lefèvre, were not popular at the ETH.[87] "At the university ... the left disappeared more than 6 months ago," wrote Held and Knauer in June 1969.[88] Yet the failure of the campaign's success to translate into political triumph wasn't a phenomenon unique to the left. Even on the day of the vote, the VSETH board announced that they were satisfied with the negative result and considered it a "binding contract with the legislature" for comprehensive educational reform. But the record-breaking low of 30.65 percent citizens' participation in the referendum was seen as a defeat because the goal "of persuading the people of the urgency of the education problems" had been achieved only "to a limited extent."[89]

In the heated runup to the referendum in December 1968, the Swiss political elite was initially perplexed by the student initiative. For example, the future minister of education for Zurich, Alfred Gilgen, praised the fact that the students were addressing their concerns via the referendum, because he saw it as a sign of "confidence" in the existing order. Even National Councillor Peter Dürrenmatt, a conservative from Basel, stated approvingly that the goal of the student movement was not revolution, but rather – through the referendum – "a path of evolution more common to this country." Moreover, the campaign was forcing the students to "condense their nebulous ideas about education reform and make them more concrete."[90] Others, however, feared that the students' newfound power could undermine the political system, given their inexperience and the assumedly primitive level at which the campaign was fought. Some feared that the reputation of higher education was at stake, and the importance of the issue was not being properly communicated to the public. In late 1968, in an effort to maintain control, Geneva national councillor and Free Democratic Party president Henri Schmitt attempted to revive the debate in the federal parliament. He moved that the Federal Council immediately address a revision of pending law. What was needed, he said, was a "coordinated, nationwide discussion" on the question of higher education that should also involve the lecturers, assistants, and students of the technical universities.[91] On 17 December, in a vote of 78 to 51, the National Council rejected Schmitt's motion, arguing that the mix of "anger at the sudden student opposition and concerns vis-à-vis the revi-

"*Es nei as Bei*" (We say no!) – A voting song recorded pro bono by cabaret artists Alfred Rasser, Ruedi Walter, Margrit Rainer, Walter Horath, and Schaagi Streuli.

sion of a pending law combined with sympathy for the young people's fighting spirit" made for an unholy alliance.[92]

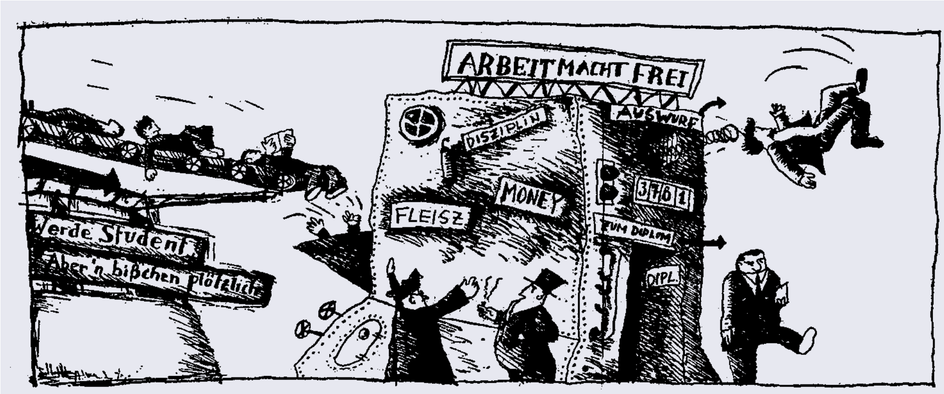
In the course of the referendum, an "open door" strategy was gradually instituted that enabled the political system to successfully integrate and domesticate the new players. The disputed bill was conceived as a lean framework law. Individual rules and regulations would have been handled separately in order "to keep the school's organization as flexible as possible and capable of adapting quickly to new situations."[93] Thus the proposed law did satisfy the conceptual demands of the time. Two years later, the OECD could announce: "Today, apart from meeting demand, the fundamental problem of higher-education policy is to bring about structural reform, to introduce innovations with a view to adapting teaching to its new functions by creating an environment of continuous change integrated within a long-term planning process."[94] Federal Councillor Tschudi even believed that the law could be a model for its upcoming cantonal higher-education counterparts.

Owing to its conciseness, the law had little else to recommend it. Proponents emphasized that it would ensure an orderly merging of the EPUL. Apart from that, it left practically all possibilities, including the participation of students, open, provoking Federal Councillor Bonvin to comment in his speech to the ETH in late January 1969: "Convinced that the law of 1854 needed to be revised from top to bottom, the Federal Council set the necessary steps in motion. But in the interim, it offered the possibility of closely allying the EPUL to the ETH and you, you progressives, you oppose this action? That we find surprising."[95] Yet most of the parties quickly recognized the political opportunity inherent in the referendum. Although a no vote would leave their federal parliamentarians out on a limb, it would show that they took the concerns of the youth seriously. Moreover, they were ready to reward political commitment to democracy – especially if it didn't require making any major political concessions. Ultimately, the disagreement between the opponents and supporters of the ETH law came down to the matter of process. On the eve of the vote, all agreed that – with or without a new law – a fundamental discussion on the issue of higher education had to take place, and the students had to be part of it.[96] In this way, the "student element" could neatly be welcomed into the political system as one of many specialized interest groups. At the same time, their anarchistic potential had been edged off the national political stage and relegated to the more limited higher-education system. The VSETH soon abandoned all talk of reinventing democracy in the "city, school, and Federal Council."[97]

The revolt of the knowledge workers

The faculty of the ETH was one of the few groups to argue for a "yes" vote to the ETH law to the bitter end.[98] Among the minority of professors who shared the students' concerns was economist Bruno Fritsch, who classified the debate within as a secular process of increasing democratization of social subsystems. The clamor for a say in university affairs was one with the rise of workers' councils in big companies.[99] Fritsch advocated a "critical consciousness" that collective decision-making processes in liberal societies needed to be continually revised with the aid of advanced science. The social sciences had much to contribute in such an effort, as they could deliver decision-relevant predictions as well as the "social engineering" needed to implement change. Of course, the project required a basis in empirical data that had yet to be developed. Fritsch's colleague Jacques Schader knew a thing or two about that. What was needed above all was a temporary phase of collective experimentation with "intensive, meaningful communication between the productive base of science, the representatives of the activist youth (especially and obviously students), and representatives of all the political and economic interest groups". The objective would be together to devise a system of "democratic social engineering" that would make it possible to transform conflict into "adaptive cooperation" on an ongoing basis.[100]

Fritsch attributed the students' requests for participation to societal upheaval that was part and parcel of a (constantly evolving) knowledge-based society. He was hardly alone in this interpretation. In 1969, the neoliberal American management theorist, Peter F. Drucker, argued in his best-selling book, *The Age of Discontinuity,* that future "knowledge workers" would not be able to fully realize their power in hierarchical structures. As knowledge factories, universities would have to contend with this fact. Moreover, Drucker considered the demands of the "rebelling [Berkeley] students" for more socially-



The university as concentration camp (echoing "*Arbeit macht frei*" over the gate at Auschwitz). At times the ETH's student critics sank to inappropriate levels of tastelessness. Illustration in the *Zürcher Student*, 8 February 1969.

"For a university in the service of workers – against a university in the service of capital." Demonstration in front of the ETH main building in summer 1971.

relevant curriculum content to be justified.[101] Opinions at the other end of the political spectrum were not much different. Obviously mixed feelings led to the conclusion "that the crucial momentum for reforming the university comes from progressive, research-focused capitalism, and in the current situation, the radical students and some of the capitalist leaders agree on certain goals."[102]

The partial agreement in the matter naturally was ignored in the combative rhetoric. In a leaflet dated 1969, a variety of student groups (the FSZ, *Jeunesse Progressiste Lausanne, Progressive Studentenschaft Basel,* and *Forum Politicum Bern*) diagnosed a "crisis of the bourgeois university" rooted in the "ever greater number of knowledge carriers whose insight into the societal consequences of their activity does not guarantee them access to the ever narrowing circles of power." For the new left, the higher-education initiative and the expansion of the universities went hand in hand with the democratization of the educational institutions and of society. That this had not happened was depicted as a deliberate strategy of the "bourgeoisie." The organization and curriculum of the contemporary higher-education system and especially the ETH was – from the vantage of class conflict – designed to meet the growing economic need for highly qualified workers without "arming the future socially disempowered academics with the knowledge they needed ... to understand our societal system. This strategy led to the mechanism that enabled the bourgeoisie to increase enrollment: the assembly-line university (the ETH is the best example)."[103]

The initial response to the referendum on the ETH law was to launch into social engineering experiments, for which interest had been building in the interim.[104] There was a surprisingly broad consensus on the need to reform the university system. The wave of democratization at the ETH met with considerable sympathy and culminated in the establishment of a reform commission in 1970 and divisional councils in 1971. The National Council advisory committee tasked with drafting a transitional regime necessitated by the rejection of the ETH law even included student participation in appeals procedures.[105] Education for "nerds" was opposed, and a more flexible curriculum demanded as well as interdisciplinary and multidisciplinary courses. The idea was that students should be in a position to locate problems in their broader social context. Seminars instead of lectures, team-oriented teaching and research instead of the traditional hierarchical university – these were some of the demands that also found support among lecturers and by no means only those in the leftwing camp.[106]

Under the leadership of Federal Councillor Tschudi, the transitional arrangement came into force on 1 October 1970 in the form of a temporary federal decree. At the same time, Tschudi set in motion a comprehensive consultation process for a new ETH law. An expert commission led by Henri Zwahlen[107] had worked out a detailed questionnaire that was now sent to a collection of people that matched the pattern of interest groups as envisioned by Fritsch. All the cantonal governments and political parties, science and policy institutions, industry associations, university rectors, academic interest

When ETH president Hans Hauri refused to extend the teaching contract of a guest lecturer named Zinn, the students felt he had acted arbitrarily. There was no longer any consensus on procedures or rules of conduct. Cartoon in the *Studentische Wochenkalender*, 22 June 1971.

groups, alumni organizations, gymnasium teachers, the *Schweizerische Naturforschende Gesellschaft,* professional engineers' associations, career counselors, and even the "*Vereinigung Schweizerischer Hochschuldozenten in Deutschland*" were invited to formulate their vision of the ETH by October 1971.[108] Within the ETH Zurich, the reform committee comprised representatives from all professional ranks who worked hard and cooperatively to produce an "ETH-Modell 1971," which formed the basis for their views on the bill.[109] It would be decades until a new law came into force, due in no small measure to the radical change in mood that occurred over the course of 1971.

Already in May 1969, School Council president Burckhardt had outlined his position on student participation in stark terms: "Let us consider the *management structure,* which brings us to the heart of the broad debate over the democratization of higher education, autonomy, and participation. Up to now, the ETH has distinguished between *general opinion* [where students had a constructive role to play] and *administrative decision making*. I have every reason to believe that, in the future, opinion and decision making will continue to be kept separate."[110] That notwithstanding, student influence increasingly began to be felt at the decision-making level, and as it did, positions hardened. The pièce de résistance was the appointment of faculty members, traditionally the most important instrument of university policy.

In summer 1971, the University of Zurich canceled a lecture by the psychiatrist Berthold Rothschild on the psychology of fascism, triggering student opposition in the form of an "anti-university." The high point was an "antifascism week" in June at the end of which the cantonal education minister closed the university.[111] At the University of Bern, the philosopher Hans Heinz Holz and the sociologist Jean Ziegler were prohibited from conducting courses critical of society. Things also came to a head at the ETH.

Over the course of several semesters, architecture students had been actively debating the form and content of their training, and trying to reach some consensus on "higher education and political reality" – the title of a seminar in November 1970.[112] Now discussions between students, assistants, and instructors in architecture over a new division model began to unravel. The students insisted on being able to select a division head from among their own ranks.[113] The failure of several guest lecturers to have their appointments renewed fanned the flames, as the teachers involved, the administration, and the students all disagreed on the borders between politics and science instruction.[114] "Differences of opinion existed over the question whether the training of architects should be a specialist discipline, which also presupposes awareness of the social, economic, and political context, or whether it should be a "political action" aimed at changing the social and political status quo," wrote architecture professor Bernhard Hoesli diplomatically in 1980.[115] In June 1971, confrontation between President Hans Hauri, who was responsible for allocating teaching assignments, and the architecture students' organization *architektura,* which claimed this competence for itself, culminated in a walk-in of the presidential office. Hauri was blocked from leaving for several hours, and felt physically threatened.[116]
Architektura had the support of the VSETH, and in particular of the groups' president, Pierre Freimüller. The experimental phase had morphed into a "freezing phase," he wrote in the *Studentischer Wochenkalender*.[117] In October 1971, he was even more pointed. In a welcoming letter to the newly matriculated students, Freimüller described the ETH as the "*Nationale Technische Kindergarten,*" where students were "drilled in science."[118] For Rector Pierre E. Marmier, that was the limit. He started a disciplinary procedure against the VSETH president, in response to which Freimüller quit the university.[119]

The end of the experimental phase

Participation, democratization, co-determination: these words describe the transition from the Fordist model of an "assembly-line university" to the post-Fordist system of adaptivity and cooperation. The trigger was not so much a student emancipation movement, although the label "1968" conjures up precisely that. Rather, it was the inclusion of the "student element" in an ongoing process of increasing flexibility within Western industrial societies that gradually wrested control from the political elites. The turbulence of the universities was merely the most obvious expression of this loss of control. According to Fritsch, the greatest difficulty lay in finding a balance between "having to solve every initiative by debate," on the one hand, and on the other, "violent hardening of positions that results when no debate takes place."[120] At the ETH Zurich, and elsewhere, the balancing act was unsuccessful. Up to 1971, the debate on university policy had reached polar extremes: the administration, students, *Mittelbau,* regular employees, and students were at loggerheads in lengthy debates over structural reform, and the

In November 1971, the school administration threatened VSETH president Pierre Freimüller with disciplinary action. The incident caused a major stir.

Cartoon about the Freimüller "case" in the *Studentische Wochenkalender*, 6 December 1971. ETH president Hans Hauri and School Council president Jakob Burckhardt hold the arms of the slingshot bearing VSETH president Pierre Freimüller, as Rektor Marmier stretches the elastic.

potential for violence was rapidly increasing. With the onset of the economic crisis of 1973, the reform process came to a virtual standstill. The government's austerity measures narrowed the scope for debate and institutional experiments essentially to zero. The ETH instituted a general "no hiring" policy. In the words of ETH president Heinrich Ursprung, who had followed Jakob Burckhardt, university growth had been placed in a "straitjacket."[121]

Despite all this, by the 1970s, the new planning machinery, ambitiously conceived in the 1960s, was only a few lofty illusions of feasibility the poorer, and for that reason all the more powerful in its implementation. Institutional experiments could now be taken up and translated into permanent applications.

The fact that the rejection of the ETH law in June 1969 was not immediately followed by a new law was, as Urs Maurer stated, "the best thing that could have happened at the time." For the delegates of the VSETH, who had thrown themselves into the effort against the ETH law, an immediately drafted new law "would have gone totally awry."[122] The ETH's late 1969 decision to institute a transition period – in line with student demands and the referendum debacle – was an astute one, and perhaps the only real option for the university. For in the early 1970s, no one was in a position to formulate an ETH law acceptable to all, as soon became evident by the results of the consultation launched by Federal Councillor Tschudi. Student influence had little to do with this particular development. However, the success of their political activities was a direct cause of their ability – beginning in 1970 – to participate in the long process of reform and the pressure on the university to continually review and modify its self-image.

The buzzword at the time – "experimental phase" – gave the institutional reform process a decidedly glamorous aura, although from an academic point of view, there was hardly anything at the ETH more humdrum than experimentation. In the course of the twentieth century, innumerable experimental systems had been introduced in the various laboratories. It might thus be assumed that for the university to speak of an "experimental phase" was nothing out of the ordinary. Yet it was, and for two reasons: first, the academic staff held the organizational stability of the university in extremely high regard; second, the ETH generally embraced a very popular science type of understanding of what an experiment was.

In contrast to the apparently straightforward concept of experiment, the verb "experiment" doesn't only refer to the theory-based checking of variables and systematic observation. "To experiment" also connotes tinkering, "poking around in the fog," producing new knowledge, as noted by Ludwig Fleck, François Jacob, and Hans-Jörg Rheinberger. The ETH s scientists at least must have realized that "experimental systems" serve "to answer questions that we are not yet in a position to properly ask."[123] To proceed this way toward the institutional future required substantial courage. Those participating in the experiment had to be able to endure the uncertainty of the outcome. "Recognizing that complex problems are not rapidly solved, the university conference recommended an experimental phase," commented *Année Politique* for 1969. "It advocated, on the one hand, permitting free access to information for everyone participating in the academic debate, and on the other hand, suspending statutory provisions and replacing them with temporary, more flexible regulations." The "experimental phase" enabled the ETH for the first time to dare to present and to model its own future as uncertain, without having to fear damage to the school.[124]

The idea was to design procedures that over time would at least make it possible to clearly formulate questions. In report on education and research of 1972, the Federal Council stated: "In surveying the current situation of structural reform in our country, a common element seems to be missing, namely, prior to committing to a solution, taking the time to prepare and to test, thus proceeding in stages ... This inclination was reinforced at the university conference in the addresses by the political authorities and the recommendations of the universities to conduct experiments and collect findings that could be used in the effective design of a new university law (so-called experimental phase)."[125] The application of the idea of experimentation to the institutional situation of the university in the 1970s may well have led to the revision of the popular concept of an experiment. Even the methodological anarchism of Paul Feyerabend – appointed professor of philosophy of science at the ETH in 1979 – had its day.

Experiments that have no clear outcome, that cannot be precisely designed, experiments that go beyond mere demonstration – in other words, experiments intended to determine how we know what we know about the future – these experiments were all the rage of the 1970s.[126] The fundamental openness of the ETH's "experimental phase" post-1970 was a test of the future of the institution, that is, its very organizational structure. It meant learning to live with transitional arrangements that by definition would ultimately need to be revised. For example, a student commentary on a 1970 curriculum reform stated: "We believe ... that the new curriculum can be introduced, as is, although we do not consider it final but rather an experiment that can be further altered, if need be."[127]

The experimental metaphor spread rapidly and was used equally for all sorts of argumentation by students, academics, the president, and the members of the School Council. The students, in particular, further developed this symbolic parlance by introducing the polemical term "*Zementierphase*" (freezing phase) with reference to the ETH architects' and engineers' most popular building material – concrete – whenever they wanted to complain about a lack of participation. They pointed out that the experimental conditions were being ignored because without their own contributions nothing new could result – and where nothing new resulted, no experiment had taken place. The upshot of false variables was that the "smooth transition from proven to more proven" was no transition at all, and that here, too, no experiment had occurred.[128]

Even Heinrich Ursprung employed the metaphor with rhetorical skill in a School Council meeting when he spoke of improving conditions as an experiment in exploratory learning. "I think it is fundamentally wrong to change the 'design' of an experiment before its findings have been fully evaluated."[129] In the same context, another school councillor remarked categorically: "If ever we give the green light for an experiment again, limited to a certain period of time, then we must insist that an evolution be carried out and that we be advised of it."[130]

1975 –

6. *All about* FLEXIBILITY: MANAGING SCIENCE *and* TECHNOLOGY *in the post-industrial* WORLD

David Gugerli

Crises have to be narrated time and again, even once they are long over. That is how they are dealt with in collective memory, slowly developing their own generalizations and metaphors, as well as their own temporal patterns of beginning and end. Thus, crises come to occupy memory space and acquire meaning. This is also true of the 1968 crisis, which in Zurich came to encompass the ETH law, a referendum, the "Globus" riot, architects, sociologists, divisional councils, "ringleaders," "string pullers," and "diehard naysayers" – elements that over time became so tightly interwoven as to defy easy analysis. The crisis ended with the resignation of President Hans Heinrich Hauri in 1973 and the untimely death of then Rector Pierre Marmier that same year. It was, according to one source, a fortuitous coincidence that afforded incoming President Heinrich Ursprung and Rector Heinrich Zollinger a fresh start.[1]

The problems laid bare by "1968" were fundamental and by and large bequeathed to the "postindustrial" or "postmodern" age.[2] The following chapter takes the position that increasingly, the postmodern university used management of science to translate crucial political and academic problems into administrative solutions. What forms of cooperation (or boundaries) should apply between the academic world, on the one hand, and politics and industry on the other? Why did universities exist? Whom did they serve? What did they accomplish? What were they entitled to ask for, and from whom? How could they improve their rules and procedures? What were their objectives, and by what means did they pursue them?

Such questions are more easily asked than answered. Every answer implies a different allocation, distribution, and use of resources. In the last third of the twentieth century, the university invested enormous effort into reaching consensus on these questions through institutional differentiation and reintegrating university policy.

Indeed, the crisis of 1968 was precisely the result of traditional university models faltering just as a new, forward-looking academic identity was being forged. As in other areas of society, new structures were needed to solve new kinds of problems.[3] Some of the difficulties were domestic products of the universities. For example, surging enrollments led to rapidly rising demands for the procurement of university knowledge. Both content and teaching methods were forced to change in response to this development.[4] The issue of teaching was especially acute at a time when academic success was beginning to depend less on instruction and more on research. In addition to the changes within

Swiss universities, 1968 gave rise to uncertainties that were not easily explained as byproducts of growth but that had to do with academic notions of progress and tradition. This conjunction of progress and tradition constituted a major challenge for the universities in the 1970s. Even the fields best equipped to explain the crisis were at a loss. Neither political philosophy, nor social system theory, nor economics was able even to describe the situation in a helpful way, let alone to provide some means of understanding it.[5]

At first, progressives and conservative academics exploited the issues of tradition and progress to generate new theories. For instance, in the early 1970s, Jürgen Habermas was considering the legitimacy problem of late capitalism, while Hermann Lübbe was preoccupied with the unintended consequences of scientific and technological progress, and consequently the ethical implications posed by rapid economic growth in the West. Both scholars had to adapt their customary approaches to make analytical headway. "The application of Marx's crisis theory to the changed realities of 'late capitalism' is problematic," wrote Habermas, "giving rise to some interesting attempts to recast the old theories and also to develop new crisis theories in their place."[6] Not only traditional ideas about crises but also the concepts previously used to describe the relationships between progress and tradition had to be rethought. For, as Lübbe wrote, the problem was no longer "restricted progress, but progress under way." Forces needed to be mobilized not to safeguard progress itself "but to ensure and to preserve the very conditions it threatens."[7]

Despite the scholars' ideological differences, their assessments of the situation were surprisingly similar. The crisis was consistently linked to legitimacy issues, which in turn were held up as a problem of social control.[8] The institutional strategies, that is, organizational reform, industrial planning, and academic and engineering networking that had helped to eradicate the uncertainties of the early 1970s were soon connected to the name of the new ETH president, elected in 1973. But those who saw Heinrich Ursprung as synonymous with the end of "1968" also saw in him a person who brought about change by instilling law and order, and prevailing against long-haired hippies who sat on the floor, debated endlessly, or – God forbid – committed all these transgressions simultaneously. This perception of an academic political hero made Ursprung appear more powerful than he was. And to the extent that "1968" stood for independence, movement, democracy, rebellion, and youth, then by definition the vanquisher of 1968 represented suppression, ossification, dictatorship, control, and backwardness.[9]

The solutions devised during Ursprung's tenure at the ETH up to 1986 were neither wholly democratic nor totalitarian. For example, the call for independence was met by reforms, the pressure from below by increased flexibility from the top, the request for democracy by granting a limited voice, and the impulsive youthfulness of the reformers by the new "American" dynamism of the president. The result, over the coming years and decades, was an exciting but rarely explicitly expressed linking of interests between




The administrative changes that occurred in 1973 were perceived by many contemporaries as the end of "1968." The new officers attempted to advance the university's development through redistribution. Many student demands were lost among the paperwork of the new legislative machinery or were taken up by groups that were only marginally influential in the scheme of things. Rector Pierre Marmier and President Hans Heinrich Hauri (above) were replaced by Rector Heinrich Zollinger and President Heinrich Ursprung (below).

the students and the ETH Executive Board. The students' antitotalitarianism suited the Board's desire to restrict the power of the professors and thus could be tolerated; the nonconventionalism of the 1968ers was compatible with the abolition of old disciplines and the introduction of new subjects. The university's new computer-based administrative efficiency helped it to shake off its musty image, and complaints about inadequate transparency were collected in a published annual report that simultaneously served to advertise the Board's new image.[10]

These developments were neither sudden nor unexpected. Academic hierarchies, administrative machinery, and scientific training structures cannot be remade anew from one day to another. In this, universities, industry, and political systems are similar. Industry underwent a painful separation from Fordism, with its rigid, inflexible standards of mass production. Likewise, in government bureaucracy, cookie-cutter notions of how to administer gave way to the flexible response of new public management. In the last third of the twentieth century, the university, too, gradually threw off a regime of teaching and research committed to the standardized, programmed instruction of students.

This transformation was intended to stabilize over time into permanent mechanisms of change management. What made it possible was a series of long-term trends in development. A generalized focus on projects permitted far more flexible structures. The ETH's subsequent internationalization of recruiting and collaboration opened forward-looking options. In the postindustrial era, no matter the field, universities favored a recombinatory mode of operation facilitated by the massive computerization of university services. Moreover, these restructuring processes, carried out in connection with preliminary and detailed analyses by management consultants, helped the university to discover its own adaptability. Finally, the academic canon of the technical university was found to have changed radically – disciplinary borders were porous and needed to be shifted or removed.

READY FOR ANYTHING

In the 1970s, the ETH introduced an institutional change that percolated into all aspects of university life. It led to a thorough reorganizing of the rules of university practice and consequently to more flexible models of priority setting and decision making. This new flexibility constituted a step toward the "uncommitted potentiality of change,"[11] but like any such effort, it presented a double paradox. As Thomas Lemke put it, "On the one hand, flexibilizing procedures must always presuppose stability without producing it themselves ... On the other hand, more flexibility also produces its opposite. The perpetual questioning of everyday practices, ways of acting, and patterns of identity leads not only to social and individual fears and insecurities, but also to new obsessions and the revival of old fundamentalisms."[12]

The following section strives to document the history of the relaxation of the ETH's structures, procedures, and regulations. To the extent that the goal post-1968 was to translate the problem of university politics into a managerial and technical question to be decided by professionals, this process often consisted of experiments, models, and many, frequently very small, steps toward reform. One of the most effective tools for introducing flexible structures was no doubt the "project." Since the 1970s, the project concept has enjoyed a meteoric rise, and has concomitantly transformed research, teaching, and administration.

In the mid-1980s, Heinrich Ursprung referred to "reform in a straitjacket ... It is not simply small size that makes a jacket a straitjacket. If it were a little more elastic, its wearer could breathe more freely. But stiff bands are sewn in, in the form of legal norms, that restrict our freedom of action."[13] The image of a straitjacket provokes reflection about which models and means are actually useful in making institutional rules in research, teaching, and administration more flexible. How was the ETH to extract from its social and engineering networks the security and stability it had lost in the uncertainties of 1968 and the experiments of the 1970s?

Flexibility as a prescription

In the late 1960s and early 1970s, changes to existing structures and institutional rules became an issue not just for higher education but also the milieu in which it existed. Far-reaching transformations began to be evident in industry, economics, politics, the federal government, and education. Flexibility served as an incantation, an all-purpose paradigm, and a platform for action. No small number of coordinating authorities in industry, public administration, politics, and business interest groups invoked flexibility as a model for resource allocation. Forecasts and programs gave way to "broad concepts" suited to trying out "variations" enacted within "scenarios." Simple cause and correlation were out; coming to grips with interdependent variables was in.

Since the 1960s, industry had been experimenting with flexibility in allocating resources. For example, new temporal structures were developed to regulate production processes, administrative methods, material flows, and careers. Flexible working hours and "just in time" or lean production enabled nimbler handling of differences between supply and demand. Continuing education and retraining programs enabled more complex career trajectories for workers, employees, and managers than was previously possible.[14]

In late 1973, Eberhard Schmidt, professor of industrial engineering and manufacturing engineering at the ETH from 1950 to 1953 and thereafter a rising star at Sulzer, Nestlé, and BBC, explained to the Basel statistical economic society that the rapid changes in the economy could only be met by greater suppleness: "We face new situations, new shortages, and new shifts in the economy and the markets, and all these changes will take place very fast. Dealing with them will require companies to have a strong and flexible structure, a rapid response capability, and an innovative working environment."[15]

In economic terms, Switzerland was experiencing a fundamental reorientation toward a more flexible trade and monetary policy. In July 1972, the country joined the European Free Trade Association. Half a year later, in January 1973, the Swiss National Bank was the first European central bank to abandon dollar parity and to float the franc, in other words, to replace a pegged exchange rate with an elastic currency.[16]

Many political processes also became more flexible during this era and managed in a more complex and necessarily less rigid manner. One example is the 1969 constitutional amendment on spatial planning, which made necessary a very elaborate coordination of municipal, cantonal, and federal requirements regarding the use of space. Some of these political exercises in flexibility worked only on paper, and proved impossible to implement. Such a constitutionally ineffective, though interesting, effort was an expert commission tasked with completely revising the federal constitution, which between 1974 and 1977 devoted itself to discussing an open, adaptable constitution. The "Furgler Commission" not only envisioned a reorganization of the division of powers but also proposed the constituency's right to present projects of law and submit them to a referendum; furthermore, the commission wanted to expand the constitutional court, and to provide for social rights in the form of a legislative mandate.[17] A particularly important feature of Switzerland's new flexibility was the number of social movements that championed, for example, environmental and energy issues. The demands and concerns of these movements were very different, and were not presented in the style of political party platforms but rather ad hoc, depending on the type of project. Because of their loose and focused character, these "grassroots lobbying groups" were able to target their efforts in terms of space and time, thus making them highly adept at organizing staff into groups placed in very different situations with very different goals but articulating similar lines of argument.[18]

But the greatest influence on the ETH may well have been the profound changes taking place within the federal government. From the late 1960s to the 1980s and beyond, all the major administrative departments were ordered to shake things up – though for different reasons in each case.[19] The army took the lead and introduced *Truppenordnung 61*, a comprehensive plan for restructuring the national defense, substituting lean, mechanized forces for the old fortress paradigm. Instead of barricades, bunkers, and fortifications, the army would now rely on the mobile battle capability of their upgraded, motorized divisions.[20]

With this new troop policy, which had taken years to realize, old ideas about security were made more flexible, and many apparently reform-resistant areas of the army were fundamentally overhauled. The purchase of light helicopters, transistorized radios, portable antitank missiles, and armoured howitzers illustrated the willingness of the army leadership to relax resource allocation for engagement (even nuclear-based) that in the Cold War seemed so imminent, but for reasons of political neutrality had to be directed toward very abstract enemies with very different goals.[21] Even the air force's financial scandal-plagued acquisitions program showed its versatility: the Mirage should henceforth be used for reconnaissance, battle, interception, and as a tactical bomber for pre-emptive nuclear strikes. “These different functions are possible only with an intrinsically multipurpose aircraft.”[22]

In considering the various arms requisitions made in accordance with *Truppenordnung 61,* flexible deployment of weapons systems was not the only issue. The debate over transforming the military’s tactical organization revived the basic question of the politics of the defense landscape, from the professionalization of the army to civil defense, from paramilitary influence in sports policy to public service. Thanks to the Münchenstein citizenry’s referendum on a civilian service, after 1972 it was possible to seriously discuss the flexible deployment of personnel for national defense.[23] At the same time, to stay competitive with the private sector, the army wished to improve the recruiting of militia officers through more flexible career planning and new systems of qualification as well as equal opportunity and support for junior staff.[24]

The same can be said of PTT (post, telegram, and telegraph) operations. Technologies that would have enabled the state-owned enterprise to operate more flexibly led to institutional crises with profound consequences. In 1968, the PTT together with industrial partners formed a working group to examine the possibilities of digital transmission and switching of telephone calls as well as so-called service integration within a single network. The project achieved considerable success and also showed the versatility of digital technologies. But the “integrated telecommunication system” stagnated after 1976, proving by its failure the need for institutional reform and deregulation of the PTT.[25]

In 1968 the PTT also launched a major project to automate sorting and accounting of postal payments. In the 1970s and 1980s, the PTT managed to increase the number of account holders, thus acquiring funds for investments.[26] The “cumbersome” organization of the project did not augur well, however. “Smaller and simpler solutions” were lost on management, stated an internal report, which also bemoaned “lack of flexibility” in project management.[27] The federal government’s tariff policy of 1976 was aimed at exploring a more purposeful and flexible management of the PTT, and especially to develop an adaptable method of determining rates.[28] In terms of personnel, after 1972 a “flexible remuneration policy” was sought that would “take the demands of the workplace, benefits, and seniority into account,” ensure the “right people for the right jobs,” and “focus on recruiting adapted to operational needs, including the possibility of part-time work for both management and the rank-and-file.”[29]

Under pressure from the cantonal railways, the Swiss federal railways (SBB) also opted for a more technically and operationally flexible organization during this period. At the end of the 1960s, the federal railways began to experiment with many new technologies. Organizational issues were discussed in terms of their potential for rationalization. This included computerized route simulations as well as experiments with timetables, automatic coupling, electronic signal and safety systems, and tilting-train technologies to increase speed. The call for a master plan for transport that would enable a situation-specific, "flexible" tariff policy, pointed in a similar direction. Following a dramatic increase in its deficit following the cyclical slump in freight transport in 1974, the SBB finally restructured. It subjected some areas to evaluation by management consultants such as Hayek Engineering AG, brought marketing staff onboard, and intensified efforts toward a synchronized timetable, which ultimately allowed passenger rail travel to compete with cars.[30]

In short, flexibility was a point of convergence for development processes in innumerable political, social, administrative, and economic contexts in the 1970s. Even the university showed itself more malleable in its relationships. The 1968 draft of the new ETH law mentioned specific measures in this regard. "In view of the rapid developments in science education, which a university must always take into account, it seems right that specific provisions, even those that are insignificant in themselves, be enshrined in regulations so that the overall organization of the school can remain as flexible as possible and can quickly adapt to new situations. The basic provisions of the current ETH law, which is showing its age, are tried and true."[31] But the marriage of codification and flexibility found few admirers, and the 1969 draft was rejected by referendum. This is all the more surprising in that the ETH's own history could be told as a series of institutional steps toward ever greater flexibility through the reforms of 1881, 1908, and 1968/69.

Increased flexibility often accompanies radical modular process design. Meal time in the new canteen at the ETH Zurich, 1976.

A more tailored education policy was also much talked about, at least when it came to “flexible courses” for the “flexible graduates” of universities. The demand for more maneuverability in education was hardly new. “The goal of general education must be to continually adapt to new situations and to bring flexible ways of thinking to all the major areas of science,” proclaimed a prominent German OECD publication from 1966 on economic growth and the cost of education, disparaging, among other things, the “tradition-bound rigidity” of university curricula. “Against the background of the broadest possible knowledge, albeit reachable within a plausible timeframe, general education should above all enable thinking, that is, rethinking and considering unusual and new ideas (teamwork).”[32]

Information theorist Karl Steinbuch, whose books on cybernetic anthropology in the 1960s and 1970s underwent many editions, commented in the same vein. In an article on education reform that appeared in the *Schweizerische Hochschulzeitung,* he expounded on his idea that “implementation of the education system” had to reflect “the needs of the present and the foreseeable future. Educational planning needs to be flexible, taking into account the fact that traditional occupations will disappear in the future and new occupations will be created.”[33]

In 1971, the Swiss Federation of Commerce and Industry (*Vorort*), the managing body of the umbrella organization *Dachverband der Wirtschaftsverbände,* stated during the consultation regarding a revision to the ETH law that the school’s training system had to “remain flexible” and open “to new combinations of subjects and fields of study.” It justified the need for openness on the increasingly interdisciplinary nature of problems. “Finally, one cannot ignore that the links between academia, government, and industry are changing profoundly. The relationship between scientific knowledge and technological innovation is a dynamic one.”[34]

In 1972, the Federal Council’s dispatch on the education and research amendment to the constitution expressed the same ideas. “The rapid change and increased mobility in the academic professions suggest that in future we should focus more on broad professional fields of activity instead of static job descriptions. Therefore, courses should be organized more flexibly and in a modular way, and new forms of disseminating knowledge should be explored.”[35] In its 1973 research report, the Swiss Science Council announced that “new technological and social developments” had given rise to new requirements “for flexibility, mobility, [and] lifelong learning.”[36]

The expectations for the curriculum and the students were completely consistent with the functional specifications of a production machine as imagined by ETH professor Eduard Gerecke in the *Technische Rundschau* a good ten years earlier. At the time, Gerecke had anticipated partial automation “suitable for medium unit quantities and mid-sized enterprises.” It would be particularly advantageous to have “robots used for this purpose to be flexible, in other words, adaptable, and that a variety of products be manufactured.” An ultimate convergence of these developments would be a “universal machine … quickly adaptable to many needs and profitable for small series."[37] The interlinking of educational policy program with concepts from the early automation literature was in line with broadly accepted ideas of the time. In the 1970s, notions of flexibility that originated with production processes were applied to organizational structures, just as the more flexible curriculum was now grafted onto students.

Flexibility provided many politicians and lobbyists with a formula for handling interdependencies between business, politics, and education. "Mutable structures" was the catch phrase when it came to the future. "Let nothing be set in stone," was the motto. The only fixed point was the certainty that resources would be allocated flexibly. "Optimal use of public funds to support academic research is predicated on their flexibility," stated Karl Schmid, then president of the Swiss Science Council, in 1971, in an analysis of science policy issues.[38]

Planning and anticipating the future had lost none of their interest. But as the ambitious planners had long ago lost control of the parameters necessary for planning, flexibility became the rhetorical joker in a forward-looking mode of speaking. The planners hoped through this discourse to secure for themselves the utmost freedom and potential for change, because the accelerating circumstances suggested that tomorrow everything would be different.[39]

That breaking down petrified structures could lead to optimal allocation of resources was taken for granted in the 1970s. But it was easier said than done. Even the university had to undergo an expensive, lengthy process of reform. As the following sections will show, reform showed up increasingly frequently on the ETH's agenda, with the project being its default implementation strategy in research, study, and administration at the ETH.

The permanence of reform

By the 1970s, the ETH was in acute need of reform more or less everywhere: anything was fodder for discussion. And for each problem, the prescription was the same: flexibility. The question was how much, and how to introduce it. An additional issue was how to guarantee institutional stability, once the rules were loosened. One particular point of controversy was participation. Some considered it a legitimizing force, others a threat to stability. But even the conservative GEP conceded that "a number of reforms are necessary and useful … and … on most points of dispute reaching a good solution is more a question of degree than of principle."[40]

The range of issues requiring reform and debate was astonishingly inclusive, even for those who had little sympathy with the evangelical stance and procedural escapades of the students. For example, the GEP could safely assume that the negotiations on institutional reform would encompass an unusually broad agenda. The *GEP Bulletin* proudly published a list of agenda items by the Schultz Commission. "Institutional autonomy, participation and co-determination rights regarding university classes, teaching and research freedom, relations between the university and industry, university manage-

The characterology of the Reform Commission's conference table. From left: Advocate, Optimist, Know-it-all, Chatterbox, Shy Accommodationist, Naysayer, Mr. Couldn't Care Less, Big Animal, Interrogator. *ETH Bulletin*, 1974.

ment, educational objectives, admission requirements, study aids, continuing education, evaluation."[41] Even though this list was actually intended as a program for a concluding discussion, it might also have been succinctly titled "Essential aspects of a university."

No less fundamental was the reform debate over the ETH itself. "An enormous amount of discussion took place in the reporting year," stated President Ursprung in his first annual report, laying the basis for his eventual *ceterum censeo*. "Now and again it happens that individual university members cannot come to the point. That is a shame. The same thing happened in 1973 and in some quarters raised doubts about the usefulness of speaking up." But Ursprung also recognized that many of these reform discussions served less to advance reform than to show how communication itself was a fundamental internal problem at the university.[42]

After years of endless debate, the desire for talk gave way to discussion fatigue. Reform had become routine. "What works for the Church – namely, the Church always needs reforming – also applies to the ETH," said a member of the ETH Council* blandly in a "debate" with the president of the Reform Commission, Heinrich Baggenstos, at the end of 1977.[43]

Baggenstos, then associate professor of electrical engineering, knew only too well that he was entering a minefield – his commission had just written a position paper, held a press conference, and sent the document to the Federal Council and to all of parliament. In the eyes of the ETH Council, the Reform Commission was being insubordinate in

* In 1969, the Federal School Council (*Eidgenössischer Schulrat*) was replaced by the ETH Council (*ETH-Rat*) as the strategic management and supervisory body of the entire ETH complex (ETH Domain). [Trans.]

acting outside the official channels. But it was the only way to get any notice, either on television or from the authorities.[44]

The commission was originally established in 1970 precisely to ensure that its suggestions would be taken into consideration. It emerged from a legendary "joint commission." This earlier commission in turn was born of necessity – a child of the institutional crisis that developed out of the success of the student referendum against the ETH law in 1969. The outcome of the vote had called so many assumptions about university policy into question that even veteran representatives of the university system were unsettled. It was crucial that representatives of the divergent interests be brought together. At the invitation of Rector Pierre Marmier, four professors, assistants, and students had sat on the joint commission, beginning in February 1970, to discuss fundamental issues of academic organizaton, communication, and participation. That took time, and consequently the joint commission proposed establishing a permanent reform commission intended to be a mix of university reform agenda, brain trust, legitimate representation, and general university parliament.[45]

The commission regarded the need to work out an acceptable ETH law in the early 1970s as a positive challenge. The board members wanted the new law to have a broad basis, and thus through the "*ETH-Modell 1971*" to create almost a new ETH, or at least a new way of talking about it. "The model attempts to use new terms that do not appear in the existing order. Of course, it may not be possible to avoid familiar terms, even when they relate to a different context."[46]

Throughout the ETH, efforts were under way to formulate new institutional guidelines, to determine who should have a say in academic appointments, to publish standards, and to devise new methods of learning. In 1975, when the extension of the transitional arrangements for another five years made clear that the ETH law would be a long time in coming and as reformers simultaneously realized that five years was a short time in which to experiment, frustration began to set in. "Concern about the progress of reforms at the ETHZ, in particular the Reform Commission's unsatisfactory rules regarding the involvement of academics at the level of the Executive Board, led the Reform Commission to fundamentally rethink its position and the purpose of its activities," stated the annual report of 1977.[47]

The Reform Commission began to lose its way. The crisis it had been created to address had long since evaporated. The reformers' advice to the Executive Board fell on deaf ears because, in addressing fundamental questions, it far exceeded its mandate. On the other hand, no proposals could be implemented without the Board's support. Baggenstos summarized the problem succinctly: "Many [on the Reform Commission] are feeling abandoned. People are beginning to ask what the point of the work is. The more concrete the proposed reforms, the more they encroach on existing regulations. This has been our experience with our suggestions regarding course content and educational goals. The more abstract the reform proposals, the greater the difficulty in communication. That in turn makes it hard to translate the proposals into terms that the other members of the ETH and the administration can understand."[48]

However, just such a translation would be needed, not least because the Executive Board had also seized on the idea of reform and was following its own strategies: "The Reform Commission has no monopoly on reforms. Reform is the task of the entire ETH," announced Rector Heinrich Zollinger.[49]

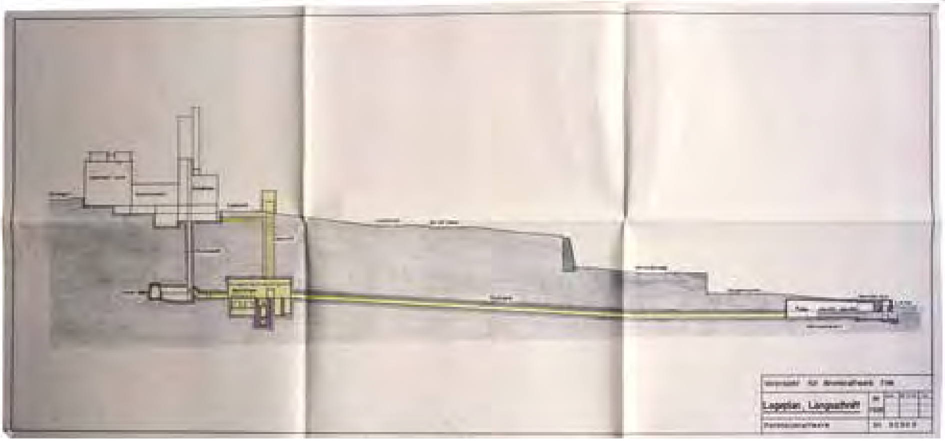
Ultimately, the question of who was responsible for reform and how it should be enforced was resolved unconventionally. Johannes Fulda, ETH Council secretary; Eduard Freitag, the ETH's administrative director; and Ursprung sat in on all of the Reform Commission's plenary meetings. "Endless, unproductive discussion was thus avoided," stated the annual report for 1981. "Numerous personal discussions with Prof. Ursprung were a source of important information and suggestions" for the president of the Reform Commission. This reversal of stimulus motion – now the Executive Board was directing the Reform Commission – made the reform a permanent fixture on the president's agenda.[50]

The art of the project-centered approach

The failure of the Reform Commission most certainly lay in the fact that its objective was too broad, too utopian, and too speculative ever to end happily. Nevertheless, the commission did in some way symbolize the relaxation of university structures that would prevail in the 1970s and 1980s. In terms of the ETH's development, the project orientation of the Reform Commission had a paradigmatical character. It suggested new options for trying out organizational scenarios before anyone even thought to describe the fundamental review of the institution's structures as a "project." Indeed, the evolution of a dynamic and expanded concept of project was both a condition and consequence of the ETH's increasing flexibility. A brief look at the long history of the idea shows why "the project" became so popular and why its results endured.

In an essay published in 1697, Daniel Defoe described a project as "a vast undertaking, too big to be managed, and therefore likely enough to come to nothing,"[51] the dubious business of swindlers, agents, and speculators. For Defoe, himself an experienced and hapless schemer, the biggest drawback of projects was precisely their failure, which he attributed to the fact that – as evidenced by the Tower of Babel – they relied on incorrect assumptions.[52] The projects of the late seventeenth and eighteenth centuries were more or less speculative, sometimes slightly skewed descriptions of lucrative lotteries, attractive and profitable insurance deals, and businesses whose predicted future earnings were so extreme as to border on the fantastic – short stories whose fictionality somehow managed to add up to something by virtue of the accompanying tables.

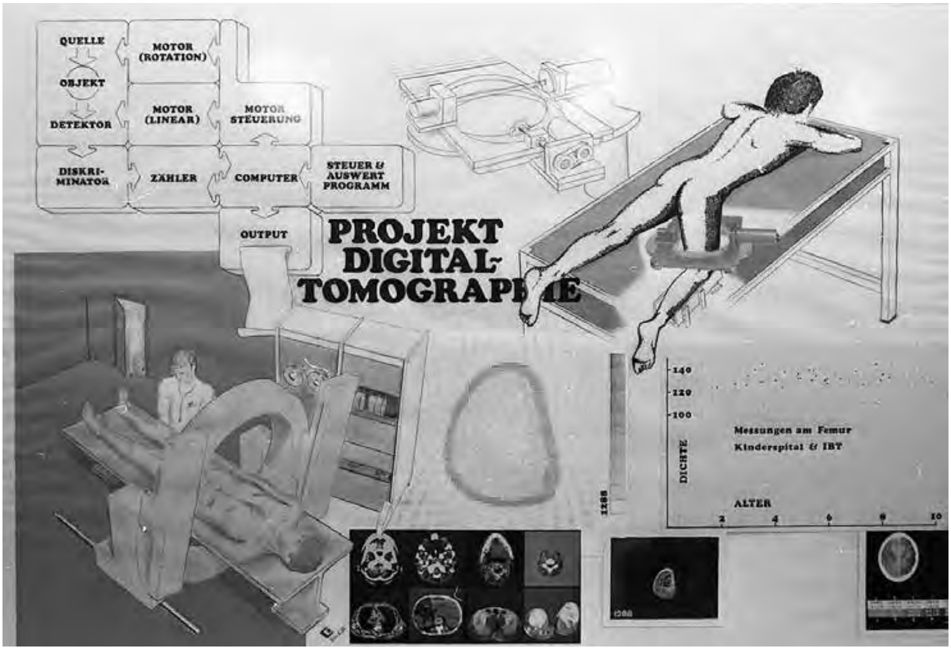
Toward the end of the Ancien Régime, and above all in the nineteenth and twentieth centuries, it was most probably this common denominator of annexes and supplements that chronicled the goals of projects, not in a narrative nor tabular fashion, but via the medium



The nuclear power plant for the ETH on Clausiusstrasse: a project conceived in 1956 and never realized.

of aesthetic, geometrically interpretable, and verifiable graphics. These projects thus anticipated their success visually. The so-called project plans of their engineer authors for military fortifications, roads, sewers, houses, gardens, bridges, factories, and machines could continue to be speculative. To avoid unnecessarily damaging outcomes, the plans were kept separate from their implementation. Despite the scale drawings, the painstaking financial reports that supplemented the drawings, and the accompanying opinions, which were all intended to underscore the serious nature of a project and to testify to its feasibility, a contract still had to be issued for a project before construction could start.[53] Neither Defoe's speculative concept of projects nor the graphical concept beloved of civil engineers and builders played much of a role in eighteenth- and nineteenth-century science, for the simple reason that there was no market for scientific ventures. Apart from academic awards, scientists had little experience of bidding for jobs. This state of affairs changed only with the emergence of (national) science policy at the turn of the twentieth century, and even later in Switzerland, in between the two world wars. The then incipient trend toward simplifying scientific research, which is closely related to the transfer of assumptions about science policy decision making from people and roles to programs and values, paved the way for short, accessible forms of papers, contributions, and articles. The increasing importance of research programs led to the division of objectives into separately fundable bits. Accordingly, project plans and drawings had to be submitted with cost breakdowns before contracts or allocations could be awarded.[54] Projects in the sense of grant applications were important for the ETH, especially in cases where research was so expensive that it required additional financing outside the regular budget. In response to such requests, the *Jubiläumsfonds* (from 1930), the industrial research center (AfiF, from 1937), the government's job-creation program begun after the First World War, and the Swiss National Science Foundation (1952) all began contributing to ongoing institutional research. In contrast, industry continued its tradition of financing research and development contracts through contributions to foundations or institute directors, who could thus, for example, upgrade laboratory equipment. In the late twentieth century, the industrial, political, administrative, and university concept of project came to include the idea of a comprehensive project. The speculative anticipation of Defoe's concept and the graphic project plans of engineers, with their detailed information on feasibility, were merged and expanded to include the organization's mission and the project implementation. The concept became more comprehensive, and at the same time, projects themselves became more modular and flexible.

As an expression of the mechanization and scientific transformation of the social sphere, particularly in the form of the booming field of operations research of the 1960s, in the 1970s the project concept came fully into vogue.[55] "Project" now connoted not only formalized speculation but a detailed plan, social organization, practical implementation, and finally (self-) governance. Discussion of projects in this comprehensive sense became so widespread that it constituted the defining work of standards committees.[56]



The digital tomograph: A research group at the biomedical institute proposed this project in 1975. Beginning in 1971, workers at the institute included members from both the University of Zurich and the ETH.

That during this time projects were a subject of increasingly frequent discussion at the ETH, and in ever wider contexts, was not especially surprising. Industry was still an important partner of the technical university, and for enterprises projects were very popular as cross-departmental forms of interaction. The construction industry had begun to establish business partnerships and project consortia to help build the nation's highway network.[57] This was also a time when implementation of federal science policy through fixed-term national research programs was flourishing. They supported projects that often created new research contexts which could transcend even existing institutional and disciplinary borders.

If one assumes that projects (in their broadest sense) are targeted, time-limited, and promote participation, then the Reform Commission was clearly a project. It had set itself the goal of developing and modernizing the organization of the ETH and making it more flexible; its timeframe was temporary and therefore experimental; and, like the joint commission before it, its members had equal status. Flat hierarchies, self-determined procedures, efficient communication channels, and autonomous allocation of resources are other elements that testify to the project character of the Reform Commission.[58]

Not only was the Reform Commission flexible in its procedures. It also sought a similar approach for the university. The commission was guided by the deep conviction that even "the definition of education and research … [must] remain flexible, … so the ETH [can] keep pace with developments."[59] This goal was emphasized in the case of research, a critical factor in the competitiveness of the university: "The organization of research must be *very* flexible, so it can keep pace with *global* development."[60]

In this context, "research project" was the crucial expression, for it illustrated very well the effectiveness of flexible research allocation and supple organization. Although research could be carried out by individuals, "a research project generally requires the efforts of an entire group," stated the Reform Commission. The group itself, however, had no fixed size: "Research groups exist only temporarily; their number, size, and composition are continually adapted to the research."[61]

This extreme pliancy of research groups, which could include members from different institutes and even whole departments, promoted the thematic, organizational, and structural adaptability of university research. "Research groups work on specific topics within the areas of research of the institute. They should be sufficiently flexible to adapt quickly to developments. The internal organization of the research group is determined by the members themselves."[62]

In the 1970s, the "project" – in research, teaching, and administration – became a tool for adapting to university structures, scientific organization, and administrative research allocation. The comprehensive project concept enabled the transformation of the hopes of the 1960s into a mechanism and opportunity for university reform. These developments had profound consequences for the university.

A new research commission

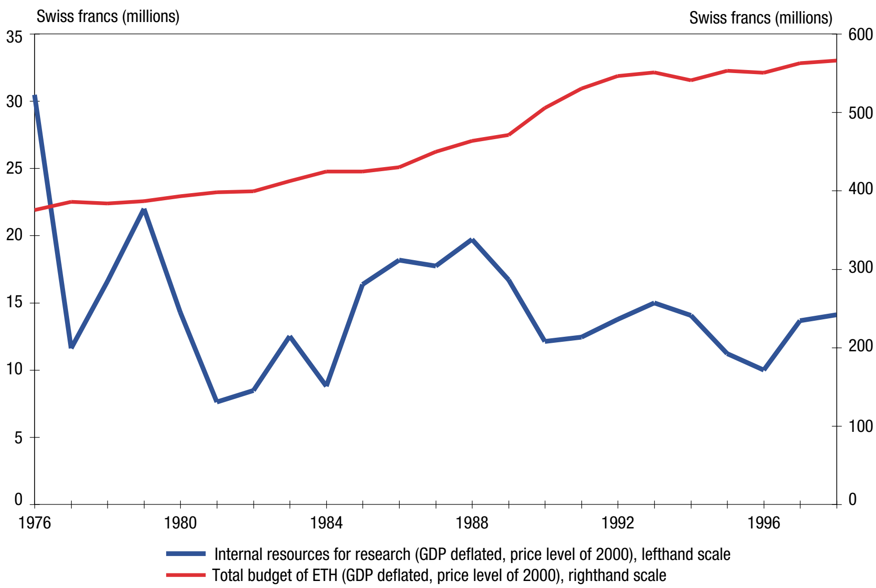
On 28 June 1973, president-elect Heinrich Ursprung appeared before the ETH's general Professorial Conference and gave a short account of his policy platform. His main objective was to give the faculty an idea of how he intended to handle an anticipated reduction of budgetary growth. "Our current human resources and financial means together with our facilities and institutes represent a high degree of stability, by which I do not mean stagnation, even without further increases," he said. Ursprung's focus was actually not the decrease in funds but rather the university's existing means, which he wished to redeploy.[63] For "we can only speak of stagnation when we make the mistake of insisting that good, new projects have to be implemented with new funds. I am not prepared to make this mistake." His object was "to encourage support-worthy new projects either by reorganizing staff and material resources, by streamlining existing institutes, and by increasing cooperation with other universities."[64]

Redistribution, rationalization, and cooperation were the cornerstones of the program; together with the administrative director, the Research, Reform and Planning Commissions were the crucial, authoritative bodies qualified to judge the matter. "My intention," said Ursprung, leaving no doubt that he would transform intention into action, "is to increasingly deploy the Research Commission for this task by tracking existing ETH projects, thus creating a decision-making basis for comparison with new projects that come our way. This assessment will also provide the basis for deciding allocation of resources within the ETH. In this matter, I will be guided less by an institute's past than by the present and especially the near future."[65]

When one year later, in May 1974, the federal government ordered a general hiring freeze to "balance the federal budget," and the Federal Finance Department set growth of the ETH's budget at virtually zero, the university, like other parts of the federal machinery, was instructed to better use the allowed "total inventory" of personnel through "more flexible practice, i.e. through internal [rearrangement] ... This will increase pressure to streamline and restructure," stated the Federal Council.[66]

Restructurings are opportunities for organizational change, even when they are dictated by constraints. Ursprung had already taken steps to exploit these opportunities, as the example of the reconfiguration of the Research Commission shows. This commission had previously been functioning as a local arm of the Swiss National Science Foundation. Just a few weeks before the Federal Council's hiring freeze, the commission was whipped into shape and turned into a vehicle for flexibility and restructuring.[67] As a first step, it was assigned to serve as a sort of elite consultant and expert witness to the ETH Executive Board and was sheltered from outside intervention. This meant that, unlike the administrations of the institutes, the Research Commission could not be paralyzed by disagreements over decision making.[68] According to the Federal Council's very formal line of argument, the ETH Council would not be delegating its research policy competence to the president but rather to the Research Commission, which would then advise the ETH

Figure 12: Development of internal resources for research compared to the total ETH budget, 1976–1998



In comparison with the ETH's total budget, the resources available to the research commission for distribution in the 1970s varied widely. Data: ETH Jahresberichte.

Executive Board as deemed appropriate. "The rules adopted by the president of the ETH grant no voice to any of the members of the traditional functional groups of the university, not even the faculty. [It] implies, if you will, a new group: the technically competent scientist with a broad outlook. Whoever fits that description is eligible to serve on the newly restructured Research Commission."[69]

It is telling that such a de facto class could only be recruited from among the faculty: "From the general description of the task of the Research Commission as advisory and approval body for the ETH Executive Board, it follows that it must be composed of individuals who, on the basis of their knowledge and research experience, are in a position to provide the desired expert advice, to evaluate individual research projects according to aims, methods, and estimated budgets, to recognize (coordinate!) links between different projects, and to judge the success of the research. The scientists who fit this bill can be described as technically competent, able to demonstrate the success of their own research, and with a track record showing that their scientific interest extends beyond their own fields of teaching and research. The criterion of independent research makes students unsuitable as commission members."[70]

The Research Commission, whose composition was politically homogeneous from the vantage of both university and research, now enjoyed greatly expanded powers. It could prepare research policy decisions, coordinate all research within the ETH, monitor research costs, and assess research activity and progress. Above all, it had a general mandate to qualitatively evaluate scientific projects, independent of who was paying for them. Like the president of the ETH, the ETH Council was convinced "that it will be to the advantage of the commission itself as well as the ETH Executive Board to have the Research Commission be primarily responsible for all research projects performed at the university, regardless of whether such projects are financed through the budget, funds and foundations, or third parties (including the [National Science Foundation] and the government's job-creation subsidies). In this way, their assessment and advisory activity will not be restricted by the caprices of funding."[71]

The homogenization of applications processed according to the motto "A project is a project," and the refusal to allow assistants and students any voice in research policy would not in itself have inflated the Research Commission's importance. But at the same time it was an authority charged with distributing resources that the ETH Executive Board had withheld by systematically reducing the regular payments to the departments and institutes. The president explained the mechanism of distribution in two terse sentences: "Unfortunately, we must once again impose a de facto reduction of the ordinary allocations to the institutes by keeping them at 1976 levels. This is the only way we can obtain the monies we need."[72] In other words, compensation for the inflation-induced decline in the real budget was not passed on to the institutes. Since 1975, this inflationary adjustment, withheld by ETH Executive Board, had permitted the Research Commission to dispense on average 12 million francs' worth of research funds internally, on a competitive basis.[73]

These repeated internal redistributions provided the ETH with an additional, versatile mechanism for funding research beyond its many foundation sources. The expert group comprised 15 to 18 relatively like-minded members and enjoyed broad protection from pressure to act as representatives. With the commission's help, funds were distributed within the ETH's "republic of kingdoms" fairly quickly and regardless of history. Because the Research Commission only made recommendations that could only be turned into decisions by the Executive Board, the ETH's resource allocation was scientifically sanctioned, regulated by policy, and yet flexible, that is, independent of the funding source and recipient. That the Board used the system to gradually disempower the departments and institutes goes without saying.[74]

Commission members were chosen by the Board based on a documented record of successful past research. A complementary feature was that applicants for research grants had to make a case to the commission for their continued research success in the future. The originators of proposals, the sources of research funds, and the fields of the evaluating peers were blurred in this major university policy restructuring process through the concept of scientific quality. Individual members of the Research Commission acted as scientific authorities and not as representatives of the institutes. They could no longer be obligated to represent interests.[75]

Thus, in the 1970s, evaluation of internal research fund applications was among the first university procedures to benefit from the new flexibility. Big decisions were of course made by the ETH Executive Board, which based its research policy decisions neither on the authority of a political representative nor with the aleatory authority of sponsoring organizations but on the recommendation of a third party, which was also responsible for supervising research efforts and gauging research success.
It took several years for the ETH to come to terms with this system. But in 1978 the president was able to report to the ETH Council that disquiet had eased and that a certain consolidation had taken place. The academic departments and the research institutes had gotten used to the budgetary restrictions. "I have the distinct impression that most of our institutes and departments have internalized quasi-zero growth. I also feel that our system of short-term project financing will be judged to have proven itself by most of our institutes and departments."[76]

A project-based curriculum?

The project concept also played a prominent role in the so-called core curriculum, to which substantial effort had been devoted in the 1970s and even up to the 1980s – though only as an either hoped-for or dreaded extreme outcome of a more flexible curriculum. The core curriculum had been introduced at the beginning of the twentieth century when it was "recommended" for students who "wished to obtain a diploma in as short a time as possible."[77] Now it was being fundamentally rethought in all the divisions of the ETH and flexibilized in the course of the process. The 1974 annual report stated that the curriculum had undergone "many changes," and that "new combinations of courses were introduced in the diploma and graduate programs."[78]
These reforms brought into conflict two totally different approaches to higher education. On the one hand, students could be relieved of an overly narrow program of study by having greater freedom to choose among courses. On the other hand, the increased freedom reduced the likelihood that graduates would acquire sufficient depth in their field. Consequently, as part of the reform, the importance of preparatory subjects and the first semester was reemphasized.[79]
Increasing choices meant threatening a sufficiently large common denominator in the level of education of students in a given subject – the guardians of academic identity felt compelled to maintain strict controls.[80] Therefore, similarly suspect were the occasional extensions of the curriculum through humanities and social sciences. But their inclusion in the curricula also meant greater choice in general. "A radical reorganization took place in the area of electives for the final diploma exam, whereby the catalog of eligible subjects was greatly expanded and now permits inclusion of a humanities or social science elective in all degree programs."[81]
In the divisions and divisional councils, the tension between choice and choice restriction gave rise to a very lively negotiating arena that produced a "flexible academic nor-

"Grassroots instruction" instead of professorial chairs, assignments instead of lectures, interdisciplinary group exercises, voluntary seating, movable furniture, flexible curricula, and project-oriented programs of study – all typical of the approach to teaching in the experimental phase of the early 1970s.

malism" everywhere, where conditional freedom to choose courses was declared to be the routine.[82]

In its new course catalog for 1985, the electrical engineering division described as the "main feature of the curriculum ... the choice of three fields of study in the specialist subject ... By choosing one of three ..., the student receives more guidance than provided by the former curriculum. However, there is still considerable choice in all three fields, so that there is no question of specialization in the true sense of the word."[83]

In 1985, the electrical engineering course of study was overhauled, as were those of architecture, science, and forestry. Nearly 40 percent of all students at the ETH would be affected by the changes, stated the annual report with satisfaction.[84] A good ten years after the "many changes" to the teaching program in 1974, it was still being tweaked. Since the 1970s, and up to the conclusion of the reform, the university had been occupied ceaselessly with the trade-off between academic freedom and regimentation, between promoting student autonomy and basic scientific education, and between institutional permeability and administrative and academic control.

One of the most radical of the flexibility projects for the curriculum was a "project-oriented program of study" called POST, whose goal was "research-based learning in groups." POST led to suggestions similar to those submitted by the Reform Commission in its *ETH-Modell 1971*.[85] Since the 1970s, many ideas had been circulating at the ETH about how to move away from traditional lecture hall style of classical instruction and thus from the didactic factory-like conduct of the university. Learning in groups was a popular concept. Another topic of debate centered on replacing the dogmatic curriculum with the antiauthoritarian "à la carte program of courses."[86] Teaching that stuck too strictly to the periodic table, for example, was to be avoided. Some promised that learning success could be improved by beginning with "where chemistry actually happens," in other words, with concrete problems from real-life situations.[87]

Even better, according to the bold hypothesis of the time, instruction might be something students could do themselves, working on projects, like great explorers. How all-encompassing the project concept became in the meanwhile is evident in the phrase "project-oriented curriculum," which was consistent with POST's utopian-speculative character. It was based on a clear curriculum and set of rules and organized in a targeted, group-specific, and time-limited trial context that was intended as an alternative to the ordinary way of teaching.[88]

The less one expected that the radical new forms of study would actually be implemented across the ETH, the more POST emerged as a real *pièce de résistance* of the reform effort. Perhaps, from the vantage of the second half of the 1970s, POST was a nostalgic reminder of a former study on a capitalist residential housing project carried out by architecture students in 1972 and published in an infamous book titled "Göhnerswil" – an allusion to the name of the construction company that built the artificial village of Volketswil.[89]

Walter Schneider's lecture at the chemistry division's open house in 1976. The question he posed – "Whither chemistry?" – would prove seminal for environmental studies in the 1980s.

The project-oriented curriculum represented a reform objective that fundamentally challenged all stakeholders and affected parties. The issue here was not simply adjustments to the core curriculum, which every division made from time to time, nor was it the upgrading of teaching methods, that is, the war of the overhead against the blackboard. POST would not have been content merely to flatten the hierarchies of teaching styles, or to replace the lecture hall's chairs and desks with movable furniture. POST envisaged more: the complete reconfiguration of the form and content of courses, as well as of research and teaching.

POST included the active transformation of the curriculum by the students and a reform of education aims, course content, and testing requirements. As an alternative curriculum, it also had implications for integrated instruction, research orientation, and didactics in general. Between 1976 and 1979, once they had passed the second intermediate examination, students were able for the first time to follow a self-organized timetable and, according to the principle of research learning, work on a scientific topic. Compared with the rigid core curriculum, this was revolutionary. For example, it was highly unusual to imagine learning the basics of a discipline not systematically but in a group, through questioning, that is, not to stock up on knowledge but to acquire it as needed.[90]

Very few groups actually completed POSTs. Some failed because not all the students could manage the intermediate diploma; others could not agree on a topic; and others could not get a work plan together, at least not one that the instructors considered feasible.[91] From the outset, the ETH Executive Board had been skeptical of the idea and made it clear that they held it in little esteem. Consequently, the Reform Commission had early on been quoted as saying: "The currently existing possibilities for alternative programs outside the normal diploma are not very well known and hardly ever used." That the problem wasn't one of supply was apparently evident to the president: "Obviously, the need for it is not very great." He also emphasized that the project had been authorized by the ETH Council and not by the ETH Executive Board. No wonder that it was intended to be carried out in a division whose identity was becoming increasingly indistinct: “The ETH Council has initiated a new possibility for an alternative curriculum in the science division in the form of a so-called project-oriented curriculum, which can be begun following the second intermediate examination.”[92]

Even the response of the students, articulated by Barbara Haering at ETH Day 1977 after a long official silence on the part of the student body, was critical. On the one hand, POST served as a “reform alibi” and “proof of reform.” On the other hand, students repeatedly found obstacles in their way: “The students are controlled and prevented from working.”[93]

Accordingly, enthusiasm was subdued. Some considered POST to be a needless concession to student participation, which threatened the power of the faculty; others saw it as a missed opportunity to finally introduce a modern curriculum. The desire for self-determination sparked both fears and hopes, and the very specific institutional design of POST could only satisfy one of them.

Naturally, by virtue of its structural proximity to the disciplinary canon and to scientific dogma, teaching was also a bastion of academic conservatism – typically cultivated by elderly professors. The gulf between students and professors vis-à-vis 1968 was one of the reasons for the conservative attitude of professors toward change. In addition, the cost of developing new lectures is high, and established lectures have the distinction of representing encyclopedic knowledge. Providing the basics gives subjects an aura of permanence. Thus, there seemed little incentive to argue in favor of permanent change and greater flexibility. Nonetheless, during the 1970s, nearly all the core course programs at the ETH underwent at least partial reform, and the academic canon was relaxed and expanded through choice and increased offerings, as well continuing education. For the professors, this did not necessarily mean new lectures and courses, but rather rearranging existing offerings within the course schedule and curriculum. For many participants, the most perceptible result was an increased administrative workload.

Databases and resources

In terms of research at the ETH, project orientation represented a means of redistribution inasmuch as it ignored organizational barriers (institutes) and dramatically revised structures (in the sense of expectations and decision-making processes). Teaching also became somewhat more responsive. The Fordist system that underpinned the core curriculum, with its maximized efficiency, began to develop toward an individualized mode of study that was fairly complicated to coordinate and supervise.

In the context of a research project or program of study, the world became more tractable and increasingly organized in a way that cut across the traditional structures of the university. For the university as a whole, however, the task of managing, directing, and planning took on greater complexity. This situation was aggravated by the fact that although the number of students rose during the 1970s and 1980s, the budget effectively did not.[94]

Flexibility is a costly proposition for an organization. The potential for recombining organizational elements and processes made looking for additional financing a priority for the ETH administration and the Executive Board. The administration in particular had to devise means of restricting the newly won freedoms so that the university itself would not be called into question. Arbitrariness had to be avoided at all costs, an objective that led to detailed discussions among the Reform Commission, a painstaking process of guideline revision for the Research Commission, and an elaborate consultation process conducted by the Executive Board in the divisions and institutes regarding myriad organizational issues.

The administration also tried to come to grips with complex structures through computerized information systems, which came to be viewed as guarantors of institutional security, capable of mitigating the consequences of flexibility. In addition, they carried a distinction that was difficult to beat. Around 1970, computerized information systems, databases, simulations, models, and increasingly also visualizations proved to be substantial sources of revenue.[95]

Already in the 1960s, computers had evolved from the oversized calculating machines used by the military and nuclear physicists into comparatively small, interactive, and programmable data processors of great versatility.[96] They were increasingly being applied in industrial manufacturing for process control and automation, where they gradually replaced conventional electromechanical solutions. At the same time, they were capable of calculating (for anyone who wanted to know) the limits of growth of the global economy, and consequently the end of the resource allocation that ever since Max Weber had been linked to the supply of fossil fuels.[97] Finally, computers managed payroll accounting, mailing lists, and reservation and ordering systems. Everywhere one looked, computers were at work. They even began to play a significant role in telecommunication. Increasingly, and ever more often, computers controlled civilian, industrial, and scientific life.

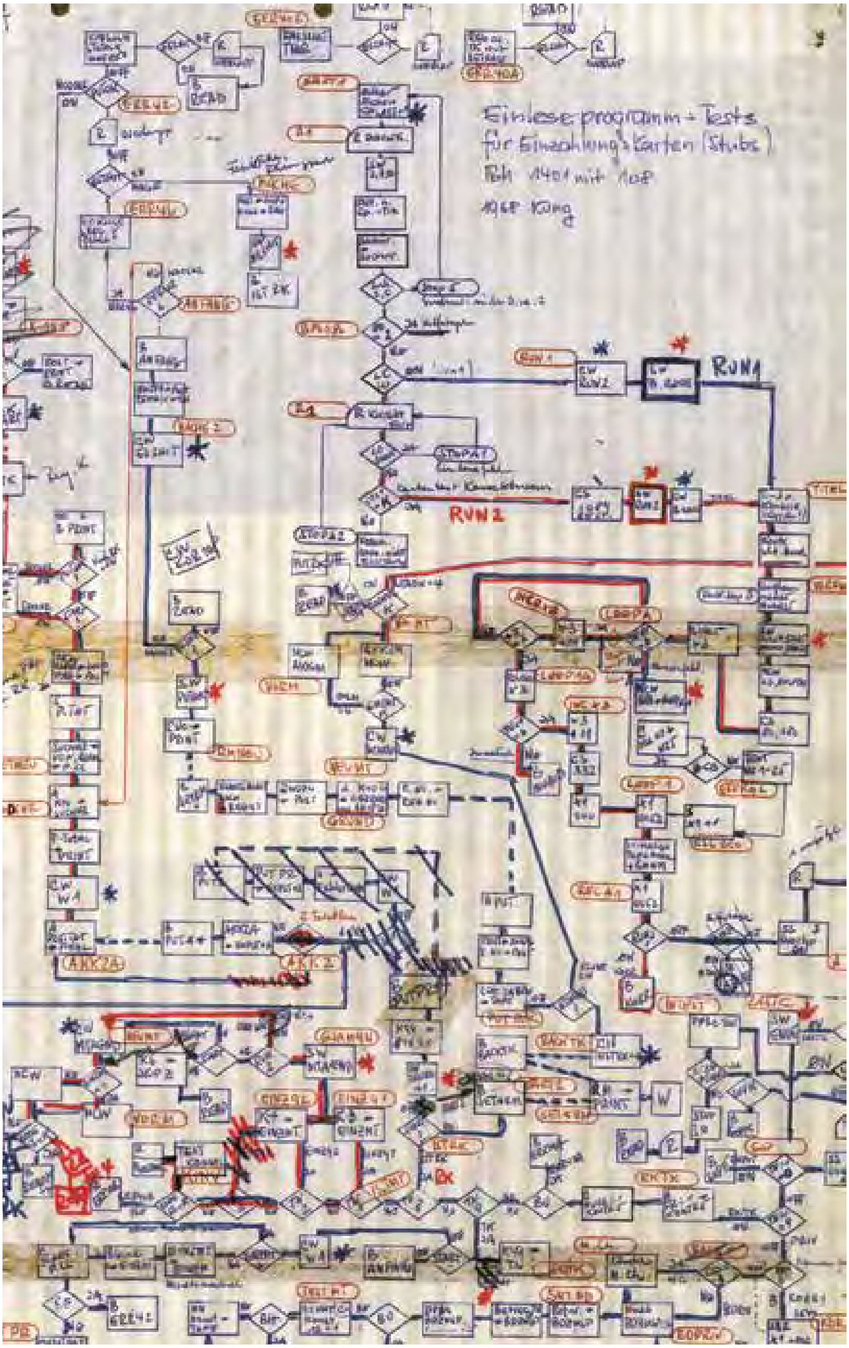
Supported by operations research methods, computers could be used to administer ever larger and more complex organizations. In fact, from the end of the 1960s, the ETH administration represented a typical case of high organizational complexity, and thus could enjoy the advantages of computers. “The rapid growth in enrollments, greater diversity, and increasing complexity of programs of study and examination guidelines, more and more expensive research (reactor technology, etc.) all require much better management and coordination of resources than is possible using existing methods,” wrote Robert Nussbaum in 1970 in his ETH dissertation on the use of data processing in university administration. Instead of focusing on future developments, one should strive to recruit all available resources “to prepare the means (space, instructors, funding, programs of study, etc.) for efficient operation of the university.” For this very reason, “university administration, like big modern industrial companies, must make use of systems analysis and the possibilities offered by data processing. This step will be made easier by the fact that nearly all universities have now installed computers for education and scientific purposes, and these can work together."[98]

Step by step, information regarding "space, instructors, funding, programs of study" and other resources was fed into linked databases, thereby becoming available for selective queries. As early as 1971, for example, President Hans Heinrich Hauri had established a data processing department and assigned its coordinating office the task of building a spatial database for the ETH. They should offer "a perpetually tracked inventory of the space at the ETH, ... which provides information regarding the type, quantity, and features of the existing space."[99]

In the ensuing redistribution of resources, the spatial database turned out to be an extremely important working tool. "For the first time, tables of all the usable floor space at the ETH Zurich provide a global view of the entire school. This should increase transparency for all the members of the university," boasted the annual report for 1975. The gains in efficiency that resulted from the computerized transparency were documented as follows: "According to the central planning for 1976/80, the strongly fragmented divisions and institutes remaining in the [city] center should be reconfigured in a way that enables them to fulfill their teaching and research duties as well and as efficiently as possible. Based on the president's discussions with user representatives, the planning staff developed six occupant scenarios. Out of these, a modified occupancy concept was developed in further discussions. The ETH Executive Board presented this concept for the use of space in the ETH center campus at the end of November. It enables reduction of the cumulative locations of the individual institutes to around one third."[100]

The report developed a discursive pattern that was used repeatedly in introducing new information systems. First, the old location had to be described. "Strongly fragmented divisions" that had to be "reconfigured" provided the justification for the Board's intervention. With the help of "tables" – detailing "all the usable space" at the ETH – the fragmentation was documented in a politically acceptable way and made analyzable as a "comprehensive review." This was the prerequisite for establishing new relationships, because the "transparency" produced by the "data bank" would reveal "variants," that could lead to "talks," and these in turn enable development of "concepts" that could be discussed in "consultations" and turned into decisions by the ETH Executive Board. The resulting efficiencies described and legitimized the new status based on the computer-based information system and its tables. The data bank became an integral part of the order that the Board wished to create and maintain.[101]

ELSBETH (a German acronym for the electronic administration system for teaching and study at the ETH Zurich) is a good example of this power of information to bestow order through sustained flexibilization of the resource-allocation rules. Developed between 1970 and 1974, the system aimed to provide administrative support to teaching. Information about students and instructors, accounts, examinations, and subjects "should be systematically collected and stored centrally in a data bank."[102]



In the 1970s, computers found ever-increasing areas of application, and submitted them to the strict logic of the programmer's flow chart. Draft of a flow chart from 1968.

The establishment of ELSBETH promised an advantageous increase in efficiency. “Through a data bank, the documents, accompanying papers, and transcripts required in teaching will be provided in a timely, efficient, and secure way,” stated the project description, which was published in 1974 by Gábor I. Ugron and Friedrich R. Lüthi. Second, “integrated operations” were to replace “island solutions” in each division, which would enable synergies and economies of scale. Third, in addition to operational tasks, ELSBETH was intended to support planning and administration processes as well as to separate routine from complex administrative decisions.[103]

The ability to separate data at their source and have them available at a single location was the most significant consequence of ELSBETH. “Among the objectives of the newly designed university information system is the idea that shared data not be redundant,” write Ugron and Lüthi in their report. “A common core value of several administrative areas must thus from the outset have a single information center. These considerations lead inevitably to the concept of a database.”[104]

Instead of a proliferation of card files, a single database was sought. In the face of the rapidly increasing number and diversity of projects at the ETH’s research institutes, together with the countless possible variations for programs of study, the ETH adminis-

Architecture benefited from spatial databases. The ETZ electrical building on Gloriastrasse, inaugurated in 1981.

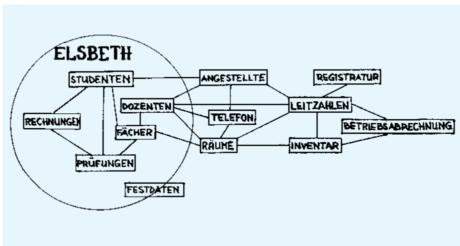
tration decided to homogenize the data situation. In this way, creating the information center also took on project dimensions (how could it not?), albeit of substantial complexity.[105]

The generalizable stages of the spatial database had consisted of taking stock of fragmentation, creating tables, establishing transparency, discussing variants, and deciding on a new allocation of resources. The development of ELSBETH involved four additional developments related to organizational learning processes at the ETH.

The first of these was the principle of transparent or even simulated recombination of resources attached to decision making by means of interactions between humans and machines.

Second, for the first time there was talk of “clients” at the university: “Thanks to the enormous flexibility of ELSBETH’s sorting, selecting, and generating programs, virtually any client requests can be met.” This profound shift in the self-perception of the university administration would shape the coming decades.

The third development was that the concept of “management” also entered the vernacular at the ETH, in the context of the information system. The term was initially used by computer specialists to connote “administration of an information system.” The introduction of computer-based information systems in the university setting necessarily involved projects that required project management. This idea in turn easily became “project management” in the strongly Americanized language of computers.[106] This was not least of the reasons why, in the 1970s, people were interested not only in managing information systems but also for “management information systems.” They thought about data processing as an organizational problem for an enterprise and its leadership, read the work of Hans Ulrich on the company as a productive social system, and consulted the literature on cybernetics.[107] This led, fourth and finally, to the cyberneticization of university’s administration. The university could “be viewed as a system of rules controlled by information processes,” represented by a “loop model.”[108]



The ETH Zurich’s electronic administration system for courses and teaching – ELSBETH – was intended to be the nucleus for university-wide computer-assisted adminstration.

The efforts to develop a comprehensive information system, begun in 1970, occupied the ETH’s data center and computing services for decades. Projects and databases followed in succession. A series of interdisciplinary, goal-oriented, and time-limited projects came and went whose names derived from their products: ELSBETH, GERDA,[109] PERETH,[110] and LISETH[111] were developed to manage students, equipment, schedules, and personnel. PLANETH[112] was intended as a programmable tutorial for teaching electrical engineering, whose link to EARN[113]

The ETH Library Information Control System (ETHICS), developed in the early 1980s, made remote querying possible for all the associated libraries. This view of the circulation desk (here a photo from 1997) illustrates the mechanized interface between the digital catalog and the users of the ETH library.

and KOMETH[114] enabled computer-based communication both across Europe and on campus, whereas ELAS and, later, ETHICS[115] helped the library to make its rapidly growing holdings accessible and available for lending. The systematic expansion of the ETH's computerized information system during these years represented one of the school's chief strategies in dealing with unintended consequences and developing a kind of collateral for the university. It will be shown below that this collateral became an integral part of the university's basic network, aided on the one hand by communication technology and, on the other, by academic cooperation and coordination.

BETTING ON INTERNATIONALIZATION

In the 1970s, the future seemed frighteningly open. Anything could happen. Like other institutions, the ETH reacted to this state of affairs by relaxing rules and procedures. It seemed the best way to approach an environment of increasing complexity.

A discrepancy between experience and expectations led to many possible developments were described as promising without considering precautions or safeguards. Precisely because there were no fixed ideas about what tomorrow would bring, wildly different designs about the future were blithely proposed. This or that development was simply described as a "clearly discernible trend" and reinforced with the aid of appropriate decisions.

In this respect, a few dominant lines of development emerged from the ETH in the late twentieth century, when it appeared to be constantly in the process of shaping the future. Similarly to trading futures on the stock market, which first became popular in the 1970s, the university had stakeholder with varying interests and varying expectations for the future that had to be reconciled. The risks of "forward contracts" – the typical university form of which were projects – had to be distributed and reduced. Regardless of whether the sum of such forward contracts arose from strategic considerations or ultimately was only the result of many small decisions – viewed historically, it left its mark and changed the university forever.

The following section describes the internationalization as a trend that resulted in a fundamental reorienting of science policy throughout the ETH. Its earliest manifestation was in the recruiting of faculty. "University policy is essentially recruiting ...; everything else is secondary," remarked the then ETH president.[116] The increase in foreign academics was thus naturally a part of the Executive Board's strategy. Recruiting from outside the country would ensure the university's competitiveness, a strategic advantage in an increasingly global market.

The universals of science

In 1968, the year he retired, Jean Rodolphe von Salis published his *Beiträge zu einigen Gegenwartsfragen* (Contributions on contemporary issues). A long chapter titled "*Schwierige Schweiz*" (Vexed Switzerland) dealt with university reform and science policy. As ETH professor of history, von Salis was a close observer of more than three decades' worth of Swiss science policy, which together with the law on the support of higher education, could have launched an entirely new national sphere of activity. Von Salis pulled no punches. Although the passing of the law had been a major step, it had a number of important deficiencies, such as the statutory role allotted to the Science Council. "The official language is so carefully worded as to give wings to this highest scientific body in

Internationalization as a focus and ideal for the scientific community at the beginning of the twenty-first century. The ETH's projected image in the annual report for 2002.

Reflections of an intellectual at the end of his career: Jean Rodolphe von Salis ruminating over "vexed Switzerland" in 1968.

the land, yet at the same time clipping those wings. Admittedly, the constitutional framework is respected. But could it not have permitted the bird to fly a little higher?" Von Salis was of the opinion that an opportunity had been lost to give the Science Council the competence it needed for continual planning and instruct it to "think about a basic science policy for Switzerland."[117]

At issue was the academic future of Switzerland, and thus a matter in which, in 1968, it was hard to find a unique position to defend. Accordingly, the distinguished historian foundered in his assessment. On the one hand, the government's law on the support of higher education seemed to him to be far too federalist and contained too few national elements; on the other hand, he also expressed his conviction that science is an international and universal pursuit. "Scientific knowledge is, generally speaking, nonlocalized. Research is conducted the world over on the basis of the same criteria and methods. There is no national mathematics, physics, engineering, chemistry, medicine, space research, and so forth ... these things transcend national and religious, and increasingly even ideological boundaries. Reality is converging the world over, global interests are increasingly interdependent, and virtually everyone is dealing with similar problems of scientific knowledge and its practical application."[118]

Internationalism has always been equated with the universality of the scope of scientific knowledge. This was neither a new nor even a purely Swiss phenomenon. Universality is used to counter all forms of isolationism, to invoke nonlocality, as a topos for "urbanity," the mutual dependence of "world interests," and for the growing "convergence of global realities." The history of the ETH was not alone in showing how the discourse on universality and the internationalism of science was frequently and successfully used to symbolic effect, even in the age of nationalism.[119]

A new feature of the debate on science police in "vexed Switzerland" was the oscillation of perspective and the uncertainty of the observer's position. Von Salis' perspective

The leftward drift of students in the 1970s was accompanied by a growing awareness of the wider world around them. VSETH buttons from 1974 protesting restrictions on foreigners.

changed several times, from that of the "man who [wished] to preserve the cultural diversity of Switzerland" to the scientist in the age of economic globalization, from the champion in the service of the *Geistige Landesverteidigung* to the citizen of the world, which he considered himself to be in any event. At the end of his career, von Salis evidently tried to analyze Switzerland as an intellectual and former Unesco delegate. He saw a country that avowedly neither drew clear limits nor was actively engaged in cooperation.[120]

What von Salis was after represented more than a personal quest for one true perspective. In 1965, André Labhardt too had maintained that, in the face of "tremendous" competition, a small country such as Switzerland – that in the field of science happened to be "between countries" – had to coordinate its efforts both nationally and internationally. In 1962, he had assumed the chairmanship of a government-appointed expert committee to consider whether the federal government could find some way of helping to finance the canton's universities. Labhardt was a committed and experienced university politician.[121] On the question of the proportion of foreign students, he was uncertain whether Switzerland should draw a line or cooperate. "We must point out that for the universities in general, a mean of 32 percent foreign students seems appropriate. If we massively reduce it, we will fail our international cultural task and expose ourselves to further retaliation from other countries; on the other hand, if we let it grow, we risk altering the character – that is, the level of education – of our institutions. Universities with a particularly high proportion of foreigners could find themselves in a difficult position if political or economic events were to precipitate a large-scale exodus of foreign students."[122] Here, again, the argument was peppered with inconsistencies, and opportunity costs had to be taken into account. Swiss scientists and science policy experts both have been plagued by similar, frequently paradoxical tendencies, even when they are obviously reflecting contemporary fears toward foreigners.[123]

For over a hundred years the decision makers of Swiss science policy had made use of international platforms to promote their national science program. The ETH was present at every world exhibition, and every academic appointment made repeated references to the international reputation of the appointee. This approach was essential to realizing the project of a major national university.[124] Just as the term "nation" had proved both charged and versatile over the course of the nineteenth and twentieth centuries, it was now very clear what it meant for science to be "international."[125]

The reason was that since the 1970s, every significant structural change in national science policy took place in response to an – apparent or dreaded – disadvantage of

Switzerland compared with the rest of the world.[126] Thus, in publishing its first research report in 1973, the Swiss Science Council acknowledged that the research environment of a small country could not aim to be "exhaustive." Rather, "the short-term priorities" were to concentrate on areas "where association with first-class international research is at risk, although the field (e.g. membrane research) is indispensable to developing our own strengths, or where we intend to offer a course in it."[127] This pattern of reasoning endured for decades. Twenty years later, the ETH's annual report carried an account of a priority program supervised by the ETH Council in conjunction with industry. The objective of a programe called LESIT was "to establish and maintain an internationally competitive academic and industrial Swiss center of excellence in selected fields of power electronics, systems engineering, and information technology (IT). These high-technology subfields are of vital importance to Switzerland as a place to study and work."[128]

The relationship between nation and internationalism changed radically in the last third of the twentieth century. "International" assumed an importance that went far beyond the claims of science to universality, not just in terms of organization, but also of epistemology and ideology. Indeed, it was such a major frame of reference for Swiss science policy makers that it became a criterion for evaluating and rewarding research.[129] The ETH Executive Board and the ETH Council, positioned the university as a sounding board for what was increasingly interpreted to be international science and technology. Nor was this shift reflected only in the scientific community's differentiation strategy. More important, it had enormous consequences for the structural organization of the university.

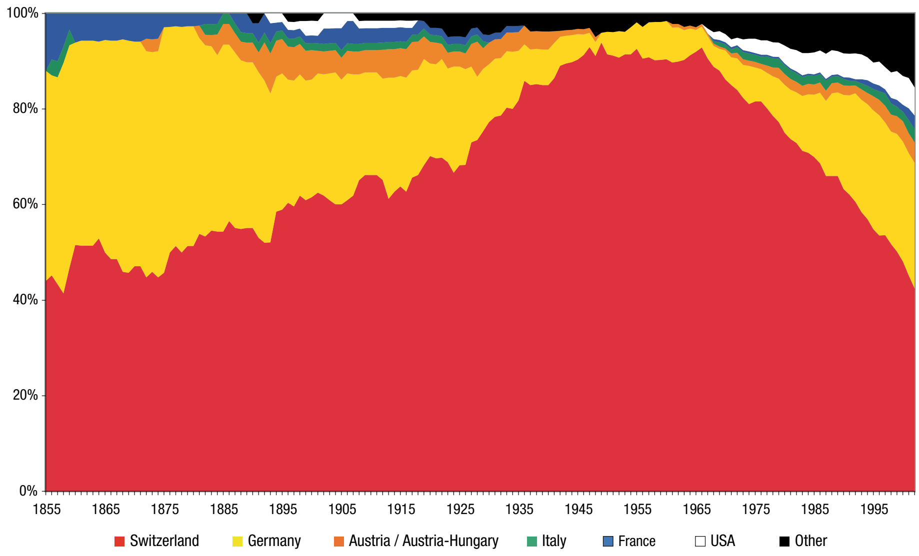
Appointments and university policy

The first impacts of internationalization were the changes in ETH's recruiting policies. As shown in the figure below, the proportion of foreign faculty has increased heavily since the 1970s.[130]

Whereas during the postwar period and into the 1960s, over 90 percent of ETH faculty was Swiss, between 1970 and 2002, their share sank to less than 40 percent, bringing the university back to the levels of the first decades after its founding. In so doing, the school's recruiting policy reversed a long policy of "Swiss first," introduced as early as the 1870s and reinforced in the late 1920s, with the result that, following the war, ETH instructors were virtually all Swiss.[131]

Like the "old internationalism" of the polytechnic, the ETH's "new internationalism" was strongly marked by ETH professors of German origin. At the end of the 1900s, these comprised roughly a third of the faculty. But the ETH's increasingly international character was due first of all to the proportion of faculty – today a good 20 percent – who came neither from Switzerland nor its immediately neighboring countries. About a quarter of this group (more than 5 percent of all instructors) are Americans. Thus,

Figure 13: Origins of ETH professors, 1855–2002



Beginning in 1970, a long period of Swiss predominance among faculty gave way to a marked trend toward internationalization. But the ability to teach in German remained an important selection criterion. Data: ETHistory.

in terms of faculty, the ETH's internationalism means several things at once. It can be understood as a very late onset of a return to normalcy and to the ETH's original policy of recruiting. The effects of the *Geistige Landesverteidigung* and the Second World War took a surprisingly long time to fade.

Second, internationalization was initially purely and primarily associated with an increase in the recruitment of German academics. The founding of the Federal Institute of Technology at Lausanne (EPFL) contributed in no small way to this development. A lower percentage of native French-speaking diploma students at ETH Zurich meant a higher percentage of native German-speaking students requiring instructors who could teach in German.[132]

Third, the internationalizing of the ETH also entailed an "Americanizing" component that is inadequately reflected by statistics of faculty. The role of North American universities in the socialization of young Swiss scientists, who later took up positions at the ETH, as well as the role model function carried out by MIT, Harvard, Columbia, Berkeley, Stanford, and Caltech in the post-war period, cannot be underestimated.[133] In the 1950s and 1960s, repatriation of Swiss academics – primarily postdoctoral fellows or young faculty members who had studied or graduated from the ETH prior to their stay in the United States – was standard procedure.[134] How routine this pattern had become was evident in the remarks of an ETH Council member in discussing the possible appointment of a radiation biologist with the Swiss-sounding name “Moos” from Illinois: “He is American, of German origin, and studied at Fribourg, Bern, and various American universities. Thus this is not a case of repatriating a Swiss scientist from the USA.”[135] The influence of the US model was already apparent in the immediate postwar period.

Finally, during this time the ETH was also beginning to become more international in its dealings with its non-Swiss collaborators. Since the 1970s, its faculty had been forming social, political, and economic networks at the international level. The old generation spoke of a shift away from what they had previously imagined to be a manageable, ideal world. Most likely in response to the remarkable growth of science, physicist and ETH professor emeritus Georg Busch wrote in 1980: “We published in ‘Helvetia Physica Acta,’ and when we thought our results were particularly important, in the ‘Zeitschrift für Physik’ – in German, of course. There were no international conferences in specialized fields with thousands of participants. Your colleagues at home and abroad – the ones who worked in the same or a similar field – you knew them personally, and you exchanged ideas through correspondence. There was an unwritten law that you respected the work of your colleagues and did not try and compete with them. None of this is true anymore. The Second World War represented a watershed not only for human, political, and economic affairs, but also for science. The defense activities on both sides of the ocean set new norms.”[136]

The rise of big science served only to increase this trend. The abandonment of the notion of “national sciences” in the aftermath of Nazism likewise contributed. Internationalism was probably also at the root of the Cold War assumption that the scientific success of political systems was an indication of their general performance. There was not much space for national differences between the two major power blocs. It fell to the kind of history of science inspired by Ludwig Fleck to point out again the significance of national and local styles of thought.[137] Finally, ever more frequently, new, high-technology systems required coordination efforts at the international level, which exerted a homogenizing effect that began with the military and extended into the consumer industry. From the Nuclear Nonproliferation Treaty and the Trans-Europe Express all the way up to color television and to digital telecommunication, from the European Power Supply Manufacturers Association to mobile phone networks: technologies were conceived and coordinated irrespective of borders. Correspondingly, technology became increasingly less a matter of national development.[138]

Deindustrialization and relative backwardness

The reasons for the ETH’s internationalism are not all that easy to convey, which perhaps also has something to do with the extreme allure of the concept. The development of science and technology in the period after the war explains only part of the phenomenon. The effect of the structural changes in the economic environment of the ETH cannot be overestimated. In particular, following the sharp economic downturn of 1974, Switzerland underwent a shift from industry to services that altered the stable relationship between the ETH and the "domestic" economy.[139]

In this context, there were interesting shifts in perception. In the early nineteenth century, Swiss engineering had turned toward global sales markets, and by the twentieth century was very active worldwide. However, both the crisis in the engineering industry of the 1970s and the subsequent relative decline in importance of the Swiss economy could be traced back to the lessening in trade barriers. The simultaneous increase in the service and financial sectors has also been interpreted as an effect of globalization on the Swiss economy. At the same time, partly through restructuring, partly through international recruiting, the formerly stable communication between the ETH institutes and the research and development departments of industry broke down. Economic globalization had consequences even in foreign relations of long standing to which the only appropriate response of the ETH was increased openness.[140]

Industry's old, persistent fear of missing the international boat, of not being able to keep up at the international level, and eventually falling behind – this deep-seated worst-case scenario of Swiss backwardness also became an overriding fear at the ETH. In January 1984, at a colloquium given by the *Schweizerischen Akademie der Technischen Wissenschaften,* Heinrich Ursprung said: "As soon as the current crisis has given way to recovery, the mechanical engineering, electrical, and metals industries must massively increase their engineering resources."[141]

The threat of a Swiss lag always attracts an attentive audience. In 1985, ETH Council member Ambros Speiser reported that "European technology" was increasingly at the risk "of being overtaken by the USA and Japan."[142] In the mid-1980s, Speiser was research head at BBC and had enjoyed a long career. He wrote influential reports on the status of industry for the *Vorort* and liked to see the ETH Council debate fundamental subjects.[143] Now he drew a gloomy picture. "We are ... in a position in which ever more fields of high technology in both America and the Far East are practiced at such an advanced a level that Europe, and especially Switzerland, face difficulties."[144]

Speiser described a world in which Japan and the United States presented two different threats to Europe, with Switzerland, at the center, particularly at risk. Both countries had different competitive advantages, none of which coincided with those of Switzerland – which in Speiser's narrative was thus at a double disadvantage. The United States possessed huge entrepreneurial flexibility and geographic mobility of employees, as well as a tight coupling between science and technology. Large companies had excellent research management and enjoyed a strong venture capital tradition that relied on a well-functioning interplay between startups, universities, and funders.[145] America was the undisputed leader in science with around two dozen elite universities. Moreover, it benefited from the influence of the national military and space research programs on the civilian sector. President Ronald Reagan's "Star Wars" program, for example, was expected to provide a new impetus to "high-technology areas such as microelectronics,

Two voices in the wilderness calling for more training in informatics at the ETH: computer pioneer and representative for industrial research, Ambros Speiser (left), and ETH computer scientist Carl August Zehnder (right) in an interview from 2000.

laser technology, and computer science." All of these benefits were further enhanced by the significant influx of scientists and engineers from abroad as well as a liberal attitude that was strongly averse to excessive demands on the welfare state.[146]

Speiser saw Japan quite differently. There, education was uniformly good at all levels. In terms of age group, there were twice as many engineers as in the West, and semiconductor technology was considered as the "national technology," for this strong area of growth was a significantly higher percentage of gross national product than in the West. In addition, Japan was a clear leader in mass production, and had little turnover of employees, who "worked diligently and conscientiously." Finally, Speiser attested that the Japanese population had a "basic technical talent," a positive public attitude to technological innovation, and a healthy sense of national pride.

"Any attempt to compare Switzerland with Japan leads sooner or later to the central theme of engineering education," said Speiser. "Switzerland has an acute lack of engineers that is concentrated in the electrical engineering and computer science areas. The fact that an increase in the number of engineers is of urgent national interest is not emphasized enough. The lack of computer scientists is such that tackling truly large software projects in Switzerland is well-nigh impossible."[147]

According to Speiser, a complete package of measures could combat against the dire situation: First, he called for more professor and research assistant positions for the ETH Zurich and the EPF Lausanne. Second, more work permits were needed for foreign engineers (especially electrical engineers and computer scientists). Third, the National Science Foundation needed to make more funds available for research in the engineering sciences. Fourth, a way had to be found of better handling the income from venture capital. Finally, it was necessary to improve "relations between university and industrial research."

Although Speiser's diagnosis of necessary catching up was clearly formulated, the recommended therapy seemed nonetheless paradoxical. The US model could only be followed at the expense of the Japanese model, for the two were simply not compatible. In fact, Speiser deliberately underplayed the hope of a rescue. The structure of his speech thoroughly supported his diagnosis, because the situation seemed drastic, and the problem unfixable. The board was nearly unanimous in its enthusiasm, and recommended that President Cosandey contact the science committee of the National Council so that Speiser could repeat his speech there.[148]

For all its weaknesses, Speiser's analysis was politically very satisfying. Consequently, the response that it produced must also be considered in a political context. First, the report was versatile. For instance, it was compatible with the speech that Ulrich Bremi, one of the leading Swiss industrialists, had given in the National Council. Referring to a ridiculously unsuccessful innovation project for the PTT, he declared: "What do we mean by Swiss electronics? Do we mean Swiss jobs? Swiss venture capital? Swiss intellectual property? Electronics knows no national boundaries. We must accept that, in this regard, our universities and our industries lead only in certain areas, and then only in close collaboration with foreign firms."[149] Second, and somewhat in contrast, the times were also such that a strongly partisan National Council with active support from an industry consultant was able to kill the military's procurement project for Leopard tanks simply by asking the German manufacturing company roughly how much their tanks would cost on the international market.[150] Third, banks were still in the throes of "electronics shock" and consequently were massively upgrading their electronic payment systems.[151] Fourth, the Swiss economic establishment was preparing the country for entry into the European Economic Area.[152] Finally, during the mid-1980s, the federal administration was taking its first steps toward new public management. The Federal Council initiated a "project to develop and implement cross-cutting measures to increase efficiency in the federal administration." In this great struggle for allocation of resources, the ETH, too, had the task of strengthening its position in the shape of forward-looking demands.[153]

At the time, Jean Rodolphe von Salis had called for political strengthening of national science policy to fulfill the needs of an international, universal practice of science. Meanwhile, the ETH Executive Board was recruiting faculty on the international market to stay abreast of international research and to ensure that both graduates and

The desktop computer Lilith was developed at the ETH between 1978 and 1980 under the direction of Niklaus Wirth. It boasted a graphics interface, Windows-type technology, and a mouse. With its WYSIWYG text editor, a relational database called LIDAS, and an information retrieval system (Caliban), Lilith was way ahead of the competition. Yet an attempt at commercialization in 1983 failed miserably. Thereafter, Lilith became a symbol for the "typically Swiss combination" of inventive talent and aversion to entrepreneurial risk taking.

Switzerland itself could "compete internationally." Analyses such as Speiser's exerted further pressure to internationalize by projecting on the wall the flexible specter of a Japanese, American, and European challenge.[154]

Talk of challenges and backwardness soon became more than just an inside affair. However, it would be a good ten years before the frightening scenario of a lagging Switzerland was transformed into a vision that could be brought to bear as a rhetorical device in various policy programs. In his controversial economic policy agenda published in 1995 under the title "*Mut zum Aufbruch*" (Courage for awakening), David de Pury wrote: "We live in a period of entrepreneurialism. Internationalization and computerization offer tremendous opportunities for growth that will be exploited around the world. So that our country can both compete and win in this global race, it is high time that we clear away obstacles of our own making. This challenge calls for a vision of Switzerland in a global context."[155] In the discourse of science policy, this device shows up in Barbara Haering's work as a need to "revitalize the scientific system." This was "critical ... if we also want to be able to remain first-class in the future, that is, if we don't want to see a gradual but persistent decline in the science budget of the government and the cantons, and consequently a creeping mediocritization of science in Switzerland as well as growing social disparities in our educational system."[156]

In the 1980s and the 1990s, the last remaining vestiges of the réduit – the still numerous "obstacles of our own making" – were dismantled, in industry as well as in the science and technical universities. Both were responding to their "international challenge"; both had to build their future in accordance with "international standards." "The extraordinary dynamism with which our world is changing requires that our education and research institutions be enormously flexible and adaptable to keep pace with the most important developments," declared Federal Councillor Flavio Cotti in 1987 on the occasion of ETH Day. It was true, he said, that the limited funds available had to be used "as optimally as possible" to enable teaching and research to meet the "needs

Switzerland's rapid deindustrialization was met with an aggressive technology policy to manage its system of innovation. The purpose of Technopark Zurich was to bring research and development groups from science and business together. It was brainchild of Albert Hafen (pictured), then vice director of Sulzer-Escher; Thomas von Waldkirch, then head of research and corporate relations at the ETH; and Thomas Wagner, mayor of Zurich in 1986. Unveiling of the model of the Zurich Technopark, 1989.

of the country" and "international quality standards." In this matter, the universities would have to demonstrate foresight and to focus "their objectives not simply on today's concerns but also and in particular on the future." Cotti then invoked the spirit of the future ETH legislation: "To fulfill these requirements, they will need a high degree of autonomy that will guarantee them sufficient room to maneuver quickly. Only that way can they exploit their independence to full advantage."[157]

"Internationalism" – in the guise of "international quality" – was inextricably linked with questions of the usefulness of the university, its efficiency, optimal allocation of resources, orientation toward the future, and academic autonomy. "Whither the future of universities and scientific research in Switzerland confronted with international challenges?" was the title of Heinrich Ursprung's lecture delivered in February 1991 at the Institut National Genevois, when he was still president of the ETH Council. It was only a matter of time before the international challenge was reflected in the self-image of the ETH. Indeed, in 1996, the first sentence of the ETH's mission statement, distributed by order of President Jakob Nüesch to all members of the university, read: "The ETH Zurich is dedicated to education, research, and service of the highest international standard." As an educational and research institution, the ETH Zurich had to cultivate its reputation: "We are aware that our scientific contributions are relevant only insofar as they are recognized by the international research community. Accordingly, the ETH Zurich promotes international cooperation in all fields of research and training. In the interest of our long-term strategy, we also devote special attention to structurally weak and underdeveloped countries."[158]

The internationalization of the ETH resulted in numerous structural changes in research, teaching, and administration. The recruiting policy was relatively easy to redirect, although, as we will see below, progress was slowest in research and in teaching. Globalization was apparent in research topics as early as the 1960s. But for the participating researchers, it was tied to a complex process of institutional, organizational, and disciplinary learning. New fields were imported through academic appointments, thereby altering the profiles of the institutes. For the university as an institution, however, these changes had structural consequences only secondarily, for instance, in terms of equipment.

The globalization of science

The internationalization process took on quite different meanings across the various individual disciplines.[159] Thus, the ETH's chemistry faculty always had a strongly international character, but at the same time remained very closely tied to the chemical industry in Basel. This bond began to loosen only once the pharmaceutical industry itself became more global.[160] The development of mathematics at the ETH, on the other hand, presented a rather mixed picture. Although Swiss mathematicians had predominated since the Second World War,[161] the discipline (by virtue of its formality) was universal in its outlook, and its academic influence and networking traditionally international.[162] Only in the age of globalization and with the aid of foreign academics were the contributions of ETH mathematicians increasingly applied to the Swiss economy. In the final third of the twentieth century, they focused initially on operations research, but gradually turned to financial and actuarial mathematics in Zurich-based finance.[163]

The "satellite view" showed the whole Earth and represented a new benchmark for the world – and for the university. Earthrise over the moon, Apollo 8, 1968.

Earth sciences is a particularly good example of the disciplinary effect of globalization on the practice and orientation of research. Here, the “global view” had already been preformed in the Geophysical Year 1957/58. Moreover, the scientific perception of the earth was altered by the US Landsat satellite program, which since the 1970s had provided a quasi-nonmilitary view of the planet. The new perspective and the satellite images from space strongly influenced interest in the discipline and in geological research.[164]

The “earth sciences revolution in plate tectonics” of the late 1960s consisted in modeling the upper layers of the earth as contiguous, newly formed plates, some of which descended into the deep mantel.[165] The arrangement of continents and seas was in flux. Entirely new research questions cropped up, and geological theories were radically revised. In experimental research, these developments led to investigations of “physical, chemical, and biological earth processes on a global scale” with the aid of marine science. The success of the new “global orientation of earth sciences” relied on international collaboration and coordination. Geologists at the ETH participated in innumerable international research projects, including deepsea drilling projects as well as the “European Geotraverse,” which also led through the Swiss Alps. Not all ETH geologists needed to be involved in research on the San Andreas fault or the Himalayas. But if they

A lecture at the ETH by Dennis L. Meadows in January 1973 on global balance and the dynamics of growth “in a finite world.” In the same year, at a public symposium at the ETH, Federal Councillor Tschudi declared: “On the subject of limited resources, our Earth is often compared to a spaceship. Indeed, the economic principles that apply to a spaceship are completely different from those that obtain for a system whose resources are unlimited and whose stresses on air, water, and soil can be discounted.” Fornallaz 1975, p. 15.

happened to be working on the Glärnisch, then this research was directly relevant to the European Geotraverse.[166]

As a rule, these disciplinary reorientations entailed new personnel appointments. In contrast, the internationalization of research organizations required somewhat more complex institutional arrangements. Switzerland's participation in CERN certainly europeanized Swiss physics, and since 1973, the ETH's computing center had been collaborating on the emerging European information network through the European research program COST-11.[167] It is obvious, however, that the ETH was not fully committed to the European research enterprise. The *Année Politique* referred to the "wait and see attitude" of the federal authorities and industry vis-à-vis European research.[168] The experience of the ETH Executive Board was that participation in COST and EUREKA was "mostly always entailed a considerable administrative burden," as Ralf Hütter – the ETH's first vice president for research and corporate relations – put it in a 1989 paper on independent research.[169]

It took some time for ETH researchers to become accustomed to the EU's way of working. European and other international research programs played an increasingly important role in the university. As a glance at ETH annual reports reveals, this process began in the 1970s, and lasted to the 1990s. Not least, anticipating the forthcoming incorporation of Switzerland into the European economy through a series of bilateral accords, the 1990 annual report titled one section "International Research Programs" and littered the accompanying text with acronyms: "The participation of the ETH Zurich in international research programs could be further strengthened. This applies especially to research and development projects within the Second Framework Programme of the European Commission, where we already have existing collaborations, such as BRITE/EURAM (industrial technology, development of new materials), BRIDGE (biotechnology), ESPRIT II (IT), COMETT II (university-industry training partnerships), SCIENCE (promotion of international cooperation and mobility, especially of young researchers), STEP (research and development for the benefit of the environment). Outside the European Commission Framework Programme, notable collaborations include the ESA (European Space Agency) as well as projects of the Russian space station MIR, ERCOFTAC (research in the fields of combustion and turbulent flows), COST (European research cooperation with a 'bottom-up' approach) and EUREKA (another bottom-up approach; pre-competitive, market-oriented research and development). Also worth mentioning are the continuation of the project known as L3 at CERN. In addition, ETH researchers participate in the World Climate Program, the Ocean Drilling Program (European Science Foundation), a geology program of Unesco, EUROMET (meteorites in the Antarctic; European Science Foundation and the European Commission), European agricultural programs, as well as in many university and industry projects both in Europe and overseas. A project financed partially by the European Institute of Technology (EIT) in the field of parallel computing is also ongoing."[170]

This variety of programs gave rise to entirely new interface problems. International collaboration between universities with totally different infrastructures, research strategies, employment laws, and European political situations required increasingly specialized management expertise. European cooperation in Switzerland, in particular, was promoted by various federal departments in different ways.[171] In 1997, in conjunction with the university, an EU advisory and information center was therefore set up in Zurich.[172]

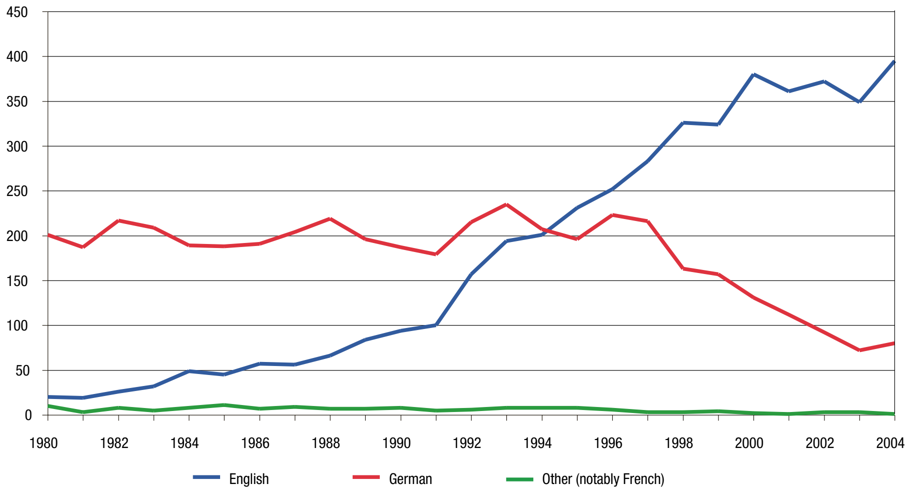
European-American compatibilities

The internationalization of the ETH was thus a sometimes spectacular but also often very tedious, time-consuming, and labor-intensive process. In the 1970s, it had introduced a few new foci (from COST to ESA[173] to INDEL,[174] an interdisciplinary postgraduate degree course for the problems of developing countries). This process of internationalization shows that structural changes did not happen linearly, but at times stalled or advanced more or less rapidly depending on the area. A statement in the annual report of 1988 that the "percentage of foreign students, graduate students, and PhD candidates" had "grown steadily from 11.7% to 13.1% over the previous 6 years" required charitable interpretation to be deemed a clear international trend.[175]

There were signs of movement, but it was hardly a landslide; many institutional and political hurdles remained to be overcome. "In the context of the European mobility support program, ERASMUS, the number of university programs for cooperation increased," the annual report announced. However, the EU ended participation of Swiss

The ETH's foray into international programs constituted a confrontation with an extremely dynamic universe. Navigating through its bureaucratic waters required the aid of specialized experts and colorful brochures. A publication of the Federal Office for Education and Science – "Switzerland in international research programs and research" – dated 2001.

Figure 14: Language of ETH dissertations, 1980–2005



German versus English. From the 1990s onward, dissertations were primarily written in English. The pressure of global competition produced cultural homogeneity. Data: ETHistory.

universities in ERASMUS because it was about to be folded into a successor program, SOCRATES. "As long as no substantial progress is made in the bilateral agreements, Swiss universities will participate in SOCRATES only as 'silent partners.'" In the meanwhile, for its part, the ETH strove to maintain "bilateral mobility with the European partner universities."[176]

In pursuing its objectives, the ETH adapted the European political vocabulary, while its PhD students wrote their science papers in the lingua franca of the late twentieth century. In 1990, 20 dissertations were completed in English as opposed to 201 in German. In the mid-1990s, the numbers were roughly comparable. By 2004, 395 dissertations were written in English, and only 80 in German.[177]

Under the head of "internationalization," the so-called Bologna reform constitutes the most recent structural change at the ETH. It was unfurled between 1999 and 2005 and sought to create a maximally permeable and structurally compatible European higher-education area. At the same time, the North American bachelor/master system was adeopted and the old system of pre-diploma and diploma exams discontinued.[178]

Accomplishing this goal required a highly complex harmonization of European curriculum structures, diploma terminology, credit scoring, and quality-assurance instruments that radically altered the previous methods of teaching.

The complex Bologna reform proceeded at a lumbering, inconsistent pace. While some departments were prepared for it because international compatibility was critical for them, others fixated on adapting the new system to the old curriculum. Others saw in the Bologna reform an opportunity for realignment and disciplinary profiling. On 12 July 2001, the ETH's course guidelines and administrative regulations were amended. The next day, the department of IT and electrical engineering, which had been seeking international compatibility for its programs since 1997, approved a new degree course.[179] "The goal of the fundamental restructuring is to improve course offerings and to make them more flexible," stated the guidelines for a comprehensive curriculum reform released by the ETH Executive Board in autumn 2001. The reform of all ETH degree courses based on the requirements of the Bologna Declaration was an international compatibility project that spawned many additional projects. In the winter semester 2004/05, all departments signed on to the new study model – numerous master's courses were either being planned or under construction. The ETH was now aligned with the rest of Europe in terms both of research and teaching.

COMPUTERIZATION STRATEGIES

At the beginning of the twenty-first century, the ETH has positioned itself as a university that is formidably equipped in information and communications technology (ICT). The numbers speak volumes. In 2005, the ETH's roughly 8,000 employees had over 10,000 desktop computers. Seventy-five percent of students have their own laptop computer; 1,000 work stations are available for 12,000 students. The campus is served by 250 wireless LAN access points, which by means of an additional 650 subnets provide all members of the ETH with access to several hundred computing, file, and Web servers, and to the Internet. Every member of the ETH has at least one personal e-mail address, and almost 80,000 active IP addresses are currently registered. With the help of this huge infrastructure, correspondingly large amounts of data can be saved, processed, and transmitted. The network-based backup service alone saves 4 terabytes (TB) daily; the ETH's "data silos" "store" 630 TB; and the data traffic between the university and the Internet for 2004 was more than 800 TB. Taking into account the cost of the data traffic for the national center for supercomputing (CSCS) operated by the ETH Zurich in Manno, the total information and communication technology costs amount to a proud 9 percent of the total ETH budget.[180]

In 1980, little of this development existed; the IT infrastructures of 2005 and 1980 are ultimately incomparable. There were no workplace computers, yet the local network of computers was rudimentary, and only a few diploma students had access to a terminal.[181] In 1982, a poll of "interested parties conducted by the ETH's computer committee revealed that, of 1,500 people, around a third of ETH personal spent 40 hours a month on "computer-related" activities. However, there are few such statistics, which makes the IT infrastructure of 1980 seem exotic in comparison with 2005. More striking is the then prevailing concentration of computing power into two separate poles: a pair of data centers set the tone for the entire ETH, although in different keys.

Computers, centers, and interactivity

One of the two poles of IT at the ETH was the computing center (RZ), which was responsible to the administrative director and the ETH Executive Board. The center was generously endowed in terms of both staff and infrastructure, and in 1980 possessed "a modern triple-computer system with an EMOS operating system," a "homogeneous high-capacity disk system," as well as a new magnetic tape device."[182] From 1970, the center occupied its own building on Clausiusstrasse.[183] This computer system had "clients," whose "orders" were arranged in "queues," to be processed by a specialized "operating crew." In 1980, around 1.4 million "jobs" were completed in this impressive, extremely powerful data-processing factory, whose nominal worth was around 64 million francs.[184]

The second pole was the center for interactive computing (ZIR). It was totally distinct from the computing center. "The ZIR-ETH has been established at the Hönggerberg campus, not as part of the computing center ... The ZIR has been designed as a laboratoy, and not as a service provider. There are no clients, only users."[185] This "decentralized center" positioned itself as an alternative and as an experimental laboratory of the highest order. Similarly, an apartment-sharing community was set up – an obvious necessity in view of scarce human resources – based on the cooperation and self-governance of the participants. "Normally, you can run a computer center of the complexity and size of the ZIR with two men (manager and systems analyst) and a half-time secretary/opera-

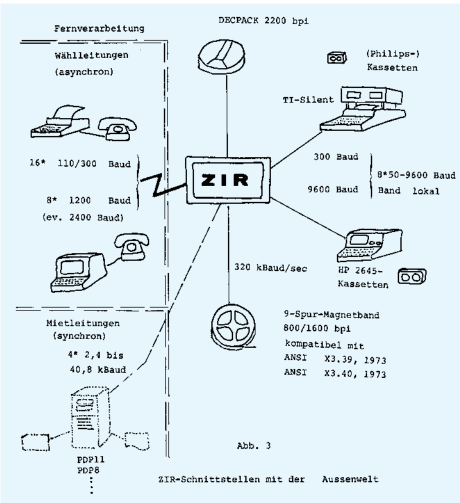
The "situation room" of the data-processing factory. The computing center around 1984.

tor. An 'insider' group of researchers tackles the varied work of the center in a cooperative fashion."[186] The ETH's annual reports portray the users of the ZIR as patient and engaged partners working not on contracts but projects, and who responded to system crashes with sympathy. They even helped in repair efforts, in the hope of gaining cheap, customized computing power.[187]

According to the Small Is Beautiful program on the founding of the ZIR in 1977, the ZIR was "designed primarily as a laboratory to be used by a few, on the order of 10^1 [sic] highly qualified research groups working at their on risk on long-term projects of a clearly interactive/graphic nature."[188] Thanks to its organizational structure and user-friendly VAX machines, the ZIR became wildly popular in a very short time.

As employees of the data center, Hartmut Frehse and Peter Staub were seasoned mainframe users. In their report on the development of the data center, they recall with a shudder how, with conventional mainframes, "complicated programming errors could only be isolated by a protracted procedure that involved interpreting octa- or hexadecimal dumps. With a turnaround of two jobs per day, persistent faults could take many days to resolve. An interactive midi-computer like the VAX, on the other hand, simply returned the type of error and the command line that had caused it. What a culture shock! The detection and isolation of bugs could thus be done within minutes."[189]

Three years after it opened, the ZIR had already developed 150 interactive soft- and hardware offerings specialized for scientific users and the introductory course to go with it, as well as their own manuals. In the meanwhile, even this "decentralized center" was being decentralized. An ETH annual report announced that the ZIR was operating a "full-duplex 1200 baud console over the switched network" and planned to expand the service in response to great demand. Now the ZIR counted not only one but four leased lines.[190]



Distributed computing and self-organization. Rough sketch of the many and varied connections to the Center for Interactive Computing (ZIR), 1977.

However different the objections, organizational structure, approach to technology, and customers or users of the RZ and ZIR, all computer-based efforts at the ETH were directed to one or the other center and its immediate satellites. Thanks to their specialized IT facilities, the RZ and ZIR were able to offer high-quality computing power. Anyone who wanted to calculate anything literally needed a computer.[191] The same was true of the big institutes – for example, electrical engineering, astronomy, communication technology, chemistry, mechanical engineering, and physics – which to some extent were able to acquire their own VAX computers as local copies of the ZIR.[192]

Given the rapid pace of technological development, the RZ soon began to feel overwhelmed. In the annual report of 1980, the weariness of the data center's rapporteur is unmistakable: "Computer technology continues to evolve ... at unabated speed, e.g., in the direction of a very powerful microcomputer or in a variety of techniques in the field of data communication, to the extent that the RZ is forced to continually adjust its computer design ideas to new conditions."[193] The lightning-fast performance of current hardware did not occasion euphoric commentary over future application possibilities. Rather, it

When using a computer meant going to where it was. Beginning in 1985, the CADETH in the cupola of the main building served to teach construction to mechanical engineers. Equipped with an IBM 4381 controller, the system was modular in design and both fast and adaptible. It supported six interactive graphics and four alphanumeric workstations.

dampened hopes of ever being able to pin down a successful design concept. Moreover, all observable trends now seemed to be heading in completely different directions.

It was difficult to see how all the constant upgrading and rebuilding, and perpetual reformulation of concepts could contribute to "consolidation and stabilization."[194] Consequently, the RZ representatives on the ETH's computer committee decided, first, to maintain the "existing operating system … as stable as possible and not to make any further changes to it until the current computer system is replaced." The computer committee wished to protect its investment in facilities and know-how, and agreed to bridge funding up to 1984/85. The expectation was that the interim period would be used to gather the "experience gained from distributed computing." During the same time, "new concepts for using computers, e.g. desktop computers, and local area communication technology would be consolidated."[195]

Developments adhered to no predetermined schedule. They also did not lead to any generally agreed goal. In the years that followed, discussions tended to focus on the relationship between centralized control and decentralized diversity, network problems, machine compatibility, and the future implications of investment decisions. When it came to concepts of IT at the ETH, the question of "What's next?" was posed over and over again.[196]

The decision to take a few years to observe developments before instituting new policy was a brave one. This – considerably risky – strategy was profoundly important to the emerging university change management. The RZ could save time by not having to continually synchronize concepts and devices with their environment.[197]

Differentiating services

In hindsight, it is possible to perceive a number of common denominators in the development of computer-aided efforts throughout the university during the 1980s. All applications were trending toward distributed computing and, thus, networks. Other developments worth remarking include interactivity as well as universal service offerings both at the peripheral and central level. These trends were due as much to differentiation as to the reintegration of ICT.

The creation of the ZIR and the decentralized installation of midi-computers in the institutes and departments gave a significant number of RZ clients an alternative to the previous central offerings. For the ETH, this emancipation constituted a functional and institutional differentiation of its ICT environment. A second important differentiation process was the surprisingly late introduction (compared with other universities at the international level), in 1981, of a self-study course for computer science at the ETH (Division IIIC). In the course of this "founding of informatics," computer scientists had to battle all manner of interference. Accordingly, they set themselves apart from their colleagues in applied mathematics and physics; defied the electrical engineers, who were biased toward their own computer expertise; ignored the accusations of student

IDA: Computing for all. The generous supply of computers to the ETH in the context of the government's specially authorized funds gave students access to workstations.

and other organizations that they were trying to establish a branch-specific elite of the engineering and telecommunications industry; extricated themselves (with difficulty) from the university administration; and, finally, broke away from the RZ as the ETH's central data-processing operation.[198]

A third differentiation process of ICT consisted in the proliferation of desktop computers, which occurred very quickly beginning in the 1980s. Desktop machines were soon used throughout the ETH for office automation as well as for teaching. They also permanently changed the cost and administrative structure of the ETH's internal computing system. This change was evident in the use of peripheral devices such as printers and plotters, as well as in the management of software. With each additional workstation, the circle of users was extended. Consequently, service needs increased, solutions became more varied, and problems multiplied. Desktop technology divided generations of university members. Up to that point, computers were perceived as machines that could only be mastered by "qualified technicians" or intrinsically motivated scientists. For everybody else, computers turned almost overnight into tools of automation that either made unreasonable demands or, alternatively, represented an opportunity for distinction.[199]

Reintegration and networking

These differentiation processes were accompanied by a series of developments that occurred sometimes simultaneously, sometimes with a slight delay. In 1986, the federal government introduced "special measures in favor of education and training, as well as research in computer science and engineering." These measures were intended to promote and strengthen the so-called reintegration of the universities' IT infrastructure.[200]

Substantial resources were put at the disposition of the universities. The federal government supported the purchase of workstations and planned to establish a center for supercomputing. By virtue of powerful networking, all Swiss universities would be guaranteed equal access to the center, their existing research centers would be interconnected, and the large "gaps in the [Swiss] research infrastructure" could be closed.[201]

The government's dispatch thus also had conceptual implications for the status and function of university research centers. "The traditional organization of a research center … [had to be] transformed into a real computer science service," capable of "operating an intricate system and advising the networked, very mixed community of users."[202] A university data center should also ensure connection to interuniversity, national, and international networks.

For the ETH, the decision constituted a major windfall. The university also realized that it was being entrusted with building a new center for supercomputing, which prompted much discussion about location, giving that Zurich already had a computing center. Should the existing one be expanded? The ETH Executive Board decided on a decentralized solution that was regionally and politically pragmatic. In a gesture to the Italian-speaking representatives in the federal government, the ETH attempted to turn the center for supercomputing into an unrelated specialized facility. The official phrasing of this strategy was fairly cryptic: "Subsequent to the ETH's decision to decentralize this national service, a center has been established in Manno that in addition to the above-mentioned tasks has another important function: in the context of Swiss universities, it will serve as nucleus for future research activities and as a bridge to international universities and research centers."[203]

By far the most important instrument of reintegration for IT at the ETH had its origin in the late 1970s. Sixth-semester students had long been learning with electrical engineers through "self-instruction" (PLANETH) over shared networks, when the local area network technology Ethernet began its meteoric rise in higher education. Network technologies were offered at the ETH beginning in 1981 in the form of a project prophetically named KOMETH: "To ensure continued provision of diversified computer services to all users in the vicinity of their workspaces," went the rationale, "a priority will be to build a comprehensive communication system (KOMETH). It will guarantee medium- and, later, also high-speed connections between any two connections (computers, terminals, etc.)."[204] "Between any two connections" was an ambitious claim, but hardly a distant dream. By means of appropriate protocols and precisely defined interfaces, KOMETH aimed at networking on the basis of reconfigurability.[205]

At the time, anything that had to with the university's agenda at the organizational or communications level brought the networks into play.[206] In the last quarter of the twentieth century, that meant infrastructure requirements, administrative guidelines, and communication methods. According to the former president of the GEP, networking was of vital importance: "No matter the area in question, whether research, technology and industry, business and energy, the school system, culture, health, or social security – only when all have been networked, and once we can capture their communications, their interactions, there interdependencies, do we have a chance to anticipate our future instead of always lagging behind events."[207]

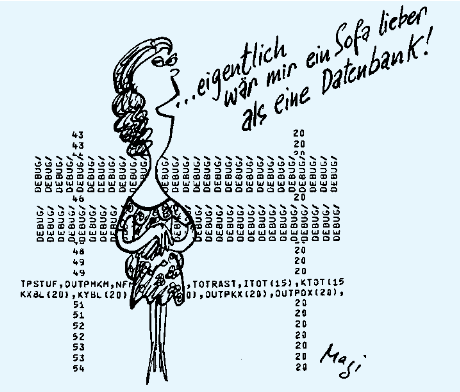
By the mid-1980s, thanks to computer networking, it was possible to have all kinds of computers interact ever more closely and at the same time over very wide areas. In 1984, the computing center reported two major developments: "The KOMETH communication system and the VAX service at the RZETH."[208] Wiring the Hönggerberg in autumn 1984 had brought KOMETH one step closer to the final stage. In addition, the connection between the ETH central, the University of Irchel, and the ETH campus was extended to the Hönggerberg. At the start of January 1985, the ETH and the University of Zurich announced that "the two schools now have access to a homogeneously connected computer network. The KOMETH system ... links 3,200 offices at the ETHZ."[209] In 1986, the ZIR announced the networking of all DEC systems via faster connections. Moreover, "thanks to the allocation of special KOMETH channels, these links extend from the Hönggerberg over the ETH central campus and up to Würenlingen/Villigen, and enable not only the coupling of diverse Ethernets but also intercomputer communication by TCP/IP and DECnet."[210]

Over the course of the 1980s, the entire IT infrastructure of the ETH was integrated into the ETH network, thereby achieving a university-wide IT and communications technology infrastructure. Consequently, the formerly pronounced differences between the ZIR and the RZ were ironed out. The RZ, too, was now operating only with VAX machines, ran a network of remote stations for the Versatile Printing and Plotting (VPP) service, emphasized interactivity, and offered its users highly specialized graphics software. "We have added routines for 3D graphics: wire models (wireframe objects), hidden-line algorithms for surfaces (grids) with the additional possibility of projected contour lines, 3D axis systems, 3D transformations, and various projection types, and raster image routines (full area and cell matrix).[211]

To some extent, the ZIR became always bigger, had more and more staff, was always processing "jobs" on machines operating at full capacity, or else handed them over to the RZ. Finally, it was forced to adopt "guidelines" for more restricted use. "To relieve the VAX 11/780, we must temporarily outsource some application-specific tasks to one of the two substantially larger VAX 11/785 machines at the RZETHZ. For all new VAX 11/750 machines, the operating guidelines ... do not provide for any public services, but rather the satisfaction of a limited number of institution-specific tasks."[212]

In this context, the government's special measures of 1986 were well received and supported the networking of computing capacity within and outside the university. In

A headline in a 1985 issue of the *ETH Bulletin* read, "Computer replaces wind tunnel." Computer-supported visualization was starting to simulate experiments – in both research and teaching.



Cartoon about the GERDA equipment database in the *RZ-Bulletin* of 1978. The *Bulletin* had about as much aesthetic appeal as the Samiszdat newspapers circulated among the dissidents of the Soviet bloc. Tricks for coping with programs, compilers, and machines were discussed with a great deal of irony.

terms of the national infrastructure, the measures probably had the greatest effect on the construction of the Swiss Education and Research Network, which was critical to the operation of the CSCS in Manno. Under the name SWITCH, the network was up and running in 1987, a good five years before the inauguration of the CSCS. SWITCH did more than make computing possible for chemists and atmospheric physicists in Ticino. It also enabled a more powerful connection to the European Academic and Research Network, and thus to the Bitnet and, from 1989, the Internet as well.[213]

In 1986, "IT Services" was founded, "with the goal of coordinating and optimizing computer science services and resources across the ETH."[214] The service was responsible for all centralized and decentralized IT services of the ETH. "This new organizational unit gathered together the centralized computing (RZ), decentralized computing (ZIR), administrative informatics (AI), the computing services group (CS), as well as a staff for coordinating, planning, control, and procurement."[215] The ZIR even gave up its perceived "anachronistic" exclusive right to interactive computing, "because today, working interactively is a feature of every modern facility."[216] The creation of a new organizational form, embodied by IT Services, was so clearly in line with the developments foreseen in the federal government's report on special measures, that one suspects the ETH had a hand in it.

Also in 1986, with the help of an equipment database, IT Services was able to carry out the university's first inventory of its IT arsenal. Called GERDA, the database listed all equipment, apparatus, and instruments at the ETH with a lifetime of over one year whose acquisition cost was at least 1,000 francs. The machinery was extremely diverse: among other things, 62 large digital electronic computers, 883 small and microcomputers, 393 data network connections, 108 analog/digital converters, 90 terminals, 936 video display terminals, 382 magnetic tape stations, electronic disks, and drum storage devices, 73 semiconductor memory devices, and 37 core memory chips. The count also included 5 card and paper tape punchers, numerous punch cards and tape readers, 288

The desktop-computer-based, audiovisual, interactive PLANETH teaching system was developed and introduced at the ETH in the second half of the 1970s.

data and 49 line printers, 146 matrix printers, and 159 plotters. This already confusing array expanded over time and became ever more heterogeneous.[217]

The IT Services "PC Group," formed at the end of 1986, managed the evaluation, ordering, and delivery of over 1,000 additional microcomputers, primarily Apple Macintosh, but also IBM personal computers and SUN and Olivetti desktop machines. Also worth noting is the Lilith computer, built under the direction of Niklaus Wirth at the ETH, which was replaced by the Ceres computer in the 1980s.[218] This juxtaposition of completely different generations of IT machines was utterly typical of the university. At the ETH, some of the most intensive consumers of computing power were PhD students. During their research work, which lasted for three to five years, they resisted any change in hard- or software, which exerted a conservative influence on developments. In the same institute, for example, it was possible to find several generations of computers sitting side by side.[219] In response, IT Services continued to believe in the reintegrative potential of networking technologies, secured ports, and learned to manage the indescribable diversity of the ETH's internal ICT infrastructure.[220]

In the second half of the 1980s, managing the university's own IT became easier because the special federal measures made it possible to launch the *Informatik dient allen* project (IDA, computers for everyone). Like the measures themselves, IDA was legitimized by the ETH's technological lag and triggered a sustained surge of innovation.[221] "We are convinced," wrote later ETH president Olaf Kübler in 1992, "that IDA has achieved more than is obvious at first glance."[222] IDA's project manager, Walter Schaufelberger, noted that IDA made it possible to ensure one workstation for every five students. Students now had access to computers for word processing, information retrieval, computer help, graphics, modeling, and simulation, as well as CAD systems and laboratory automation.[223]

The number of fields enabled by IDA is impressive: they range from computer-aided architectural design to planning, construction, and traffic engineering to mechanics and fluid dynamics, from electrical engineering to informatics and management and production sciences, and from there to physical chemistry to analytical chemistry, chemical engineering, and pharmacy. Mathematics and physics exploited the new computer methods as did environmental sciences and occupational psychology.[224]

The WWW and customized IT

In the early 1990s, the ETH was well networked, had invested substantial money and effort in desktop computers, and through the founding of IT Services, made the necessary associated structural adjustments. The ETH's IT systems, especially the campus-wide and national networks, had long been connected with the outside world, even before the first HTML browser appeared anywhere. Even more surprising is the fact that the World Wide Web (WWW) first became an issue for IT Services at the urging of students. The ETH did not have a convincing Web presence until 1997.[225]

Before that, protocols such as Telnet, File Transfer Protocol, and Kermit were all available, as was the Gopher information service. A science and engineering community of users generally was able to get along with it, and had no expectations of such exotic conveniences as computerized communications and distributed digital data. Also, unlike CERN, the ETH was not under threat – despite similarly rapid succession from one generation of graduates to the next – of a permanent loss of information. In a pinch, there was always Caliban, a data retrieval system developed at the Institute for Informatics in 1984 and based on the idea that information is often more complex and relational than can be represented by an hierarchical directory.[226]

"The problems of information loss may be particularly acute at CERN," wrote Tim Berners-Lee in a seminal paper in which he proposed a hypertext system at CERN as a solution. The ETH IT Services' rather muted interest in the WWW confirms the assessment that Berners-Lee's proposal concerned a specific problem at CERN, and puts into perspective the claim that CERN was "a model in miniature of the rest of the world in a few years' time."[227] In 1989/90, Berners-Lee had a particularly good justification for continuing his work on the hypertextsystem. Naturally, he must have realized that his idea had broader implications. That the WWW played an important role at the ETH during the 1990s is undisputed. But the story is a little more complicated than that.

In 1994, Reto Ambühler, then system administrator at the IT Services' computer center, attended a meeting in Geneva that attracted hundreds of attendees interested in http and

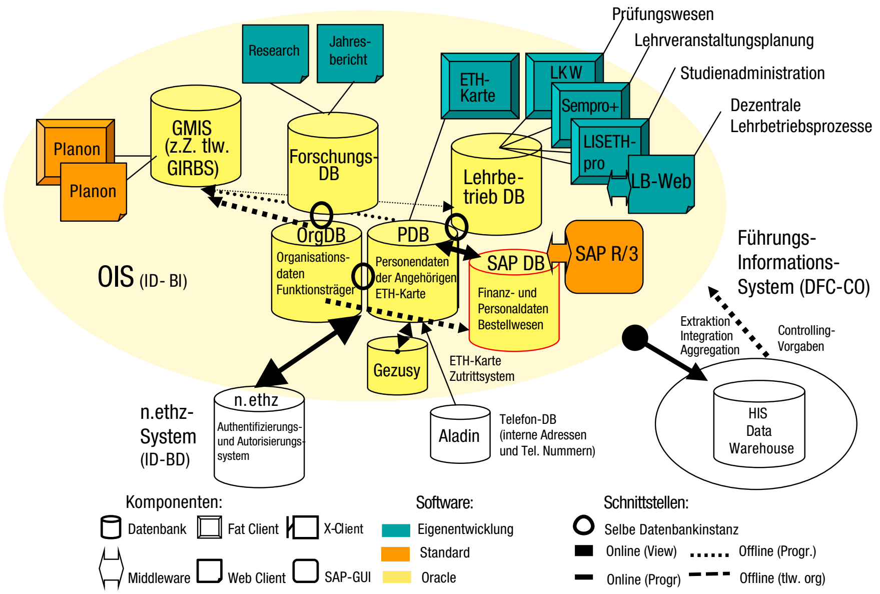
The ETH's presence on the Web began rather clumsily, despite the participation of "*Urwebmaster*" Reto Ambühler at the "Woodstock of the Web" in Geneva in 1994.

HTML. The meeting, known as the Woodstock of the Web, is now considered to be a catalyst in the global success of the WWW,[228] which became an information window that the ETH could use for external communication. IT Services at the ETH ran a Web server off its DEC machines. Ambühler installed a second server on "ezInfo." In addition, the semantically unique URL www.ethz.ch was reserved for the ETH. That this address was guarded like a jewel without the owners' knowing what they wanted to do with it is a rather amusing sideshow. Ultimately, it emphasizes the relatively weak institutional interest of the ETH in the WWW. During the course of a year, two ETH websites developed side by side, claiming for themselves the representation of the ETH to the outside world. In 1995, the expenses of upgrading forced the two sites to cooperate and to align their content. In 1998, ezInfo was shut down, and since then www.ethz.ch has served as the ETH's website.[229]

The introduction of the WWW at the ETH thus began as an experiment. Only relatively later was it exploited as a well-recognized information tool to the outside. As such it was most certainly not influenced by research practice or the debate over instruction; nor was it shaped by the ETH's internal administration. However, all this would change with the force of a landslide at the end of the 1990s when Olaf Kübler assumed the presidency. The WWW became an extremely important tool and enjoyed a resounding success within the ETH.

The services used and offered through Web applications are difficult to overlook. They range from campus-wide distribution of software to Web-based teaching to the daily Web newspaper *ETH Life*. They include Web access for personal e-mail addresses for all ETH members as well as interfaces to SAP-supported financial and personnel management. From its start as a presentation medium, the WWW gradually evolved to an interaction platform. The number of potential users increased exponentially.[230]

This development is particularly apparent in the electronic administration of teaching, where today, the courses offered, enrollment, space allocation, course-related communication, and exam management are all carried out largely electronically. Some 20,000 ETH members go online to search for information, register for courses, confirm room assignments, and construct individual course programs. The same data are used to



Toward the end of the 1990s, more and more of the ETH's "business logic" shifted to the Intranet. Applications have since been available to thousands of users. A schematic illustration of the ETH's operations information system around 2003 translates this application landscape into german.

establish exam schedules and to assess academic qualifications. Thanks to a specially designed Web application, students can see their test results and, whenever they wish, check their current status.[231] The WWW has become a tool for asynchronous communication and cooperation, anytime, anywhere, the repertoire of offerings being limited only by the specifications of the provider and the limits of the medium. The result of this institutionalization was its own kind of peer pressure.

Particularly with respect to the introduction of the bachelor/master system according to the Bologna model, academic administrative procedures were massively upgraded and adapted to the requirements of the internationalized academic enterprise of the future. Consequently, IT Services had to ensure flexibility in the administration of the rector's office, the curriculum, the faculty, and the students themselves, so that students and instructors would be able not only to use teaching- and course-specific data but also to update them. "Our leading idea was that the new IT applications should support administrative (sub-)processes comprehensively, not just allow for Web-based access to data. This means that part of the business logic had to be moved to the Web," wrote Giorgio Broggi and Armin Wittmann regarding the IT Services' concept for implementing this task.[232]

Indeed, by the end of the 1990s, an ever greater amount of the ETH's "business logic" was migrating to the Web. ETH World, an ICT-related strategic initiative launched by

"Neptun enables": Wireless LAN and the sale of inexpensive laptops through the Neptun project led to computer-based studying anytime, anywhere.

the university in 2000, played a stimulating, sometimes even visionary role in this context.[233] Combined with the increasing number of specialized applications for using IT, the program attempted to realize the "Vision of a University of the Future" in roughly 40 smaller development projects.[234] Thus, ETH World's Neptun project sold heavily discounted notebook computers to students. Following several sales promotions and together with the campus-wide wireless LAN, Neptun managed to connect students in a dense network of digital information services.[235]

Since the 1970s, discussions about IT and communications technology developments between the RZ and ZIR had also been concerned with the appropriate ratio of central control of processes and access, and decentralized use and peripheral access. The Web-based ICT service established at the beginning of 2000 largely ended these discussions, surprisingly uncontroversially, especially compared with the same debate at other technical universities, for instance MIT.[236] One reason was that most of the centralized technical and administrative processes were either invisible or confusing, and in any event were barely perceptible, because for those affected they represented attractive possibilities for self-determination and individual opportunity. For example, although the ETH rectorate's power to define and control academic administration reached a zenith in early 2000, at the same time, the students and faculty had never been so free to determine the form, content, time, and location of their teaching and learning interactions. In this context, control and opportunity form a symbiotic relationship; conformism and individualization walk hand in hand as rarely in any previously known process of mechanization.

From electronic registration to "blended learning," from the "dynamic learning Content Management System" (CMS) to the Web-based production environment for video streaming, from individually usable WebCMS to the group-specific portal to MyETH:

everywhere, individual training on local services is the norm, constituting a veritable customization of services.[237] Nor is use restricted to individuals. Today, the Web has become one of the most significant means of integrating the university.

CONSULTANTS, RESTRUCTURING, AND MANAGEMENT

The image of management consultants is a complicated one. In movies and plays, they are usually dressed in gray suits and hide behind a mask of corporate anonymity. And yet they embody the fascination and horror, and the hopes and fears of every restructuring process. The stage, the cast, and the task are set. The role of the management consultant is to shed light on a dark tragedy.[238] Rarely do they deliver good news, and they often end up in the twilight themselves. They are commissioned by the powerful to deliver an oracle, to spell out its meaning, and to be the bearers of long-dreaded tidings.[239]

As a result of recommendations made by management consultants, in the second half of the 1980s many of the routines and assumptions of the scientific enterprise were changed. Wherever management consultants were called in, no stone was left unturned, throwing the affected staff into a state of chaos. It was small consolation that the painful restructuring did lead to a new order with more efficient management rules.[240] Conventional ways of dividing labor between the university and federal administration were called into question, longstanding relationships between science and politics lost their meaning, and new initiatives for intensifying cooperation and targeting noncompliance had to be established. Undoubtedly, the above-mentioned processes of internationalization and computerization supported the university's investment in new public management. It both liberated the ETH from the old federal networks and made available the administrative tools essential for neoliberal management of an increasingly flexible institution.[241]

Given that the federal administration was being examined for its rationalization potential and the suitability of new management tools, it is hardly surprising that the same was happening with the federally supported universities and research institutions.[242] What is surprising is how much time and energy it took to complete the analysis of the resulting structural changes. From the appearance of the first consultants in the offices of the ETH Council, to the wide-reaching management and organizational restructuring of the ETH Zurich, and finally to the subsequent cutting loose of the university's budget and departments required a full two decades.

It is of course possible to criticize the efficiency of the process and to argue that the restructuring only took as long as it did because those involved refused to cooperate in the managers feu sacré and because they suspected them of fanning the flames of purgatory. But it is also possible to see the restructuring process as a politically far-reaching and technically demanding process that simply required a lot of time. Or maybe both views are true. It is this last assumption that we will pursue below.

The restructuring process can be thought of as a transformation of the future-transforming machinery in action. What happened to the university is comparable to what was going on nearly simultaneously with the "government machine" in Great Britain under the regime of the "Iron Lady."[243] The ability to govern the future-transforming machine – that is, its political institutions, its detailed scientific workings, and its subjective configuration – was fundamentally altered in the process.[244]

A series of preliminary and detailed analyses conducted by management consultants at the ETH in the mid-1980s were the basis for the changes that occurred. Although the recommendations were not implemented as originally formulated, they nonetheless enabled introduction of a new, essentially more complex organizational structure at the university, at least in distinction to the clearly defined and consecutively numbered scenarios of the analyses produced by the consultants. In the 1990s, these new structures themselves were further restructured, and the ETH was divided into departments. Bolstered by a newly revised ETH law – the university now managed its own budget as an autonomous government institution – parts of the budget could be delegated downward.[245] This process was accompanied by a steady and inexorable ascent of professional university management.

The Hayek report

The news hit like a bomb, and the echo of its impact reverberated widely. On 25 July 1985, the president of the ETH Council held a press conference in the main auditorium of the Swiss National Science Foundation in Bern. Together with management consultant Nicolas G. Hayek, he announced the results of "a preliminary analysis cum optimization and design study" that Hayek Engineering AG had carried out in the foregoing months of the ETH and its associated research institutes. "Hayek's bombshell stuns officials. Swiss research bankrupt. Old professors to go!" trumpeted the tabloid *Blick* the next morning.

Some 250 newspapers as well as many radio and television carried reports of the analysis. *Schweizer Illustrierte* wrote of a "day of reckoning" for all the perpetrators; some of the press reports questioned whether Swiss competitiveness was in danger, and whether Switzerland was "turning its back on technology."[246]

Some outlets were slower to respond. When the provincial *Werdenberger und Obertoggenburger Zeitung,* the liberal, left-wing *Tages-Anzeiger,* the conservative *Neue Zürcher Zeitung,* and the stoically calm *Basler Zeitung* weighed in with their own critiques, it was either from the relative safety of the periphery or at least the distance of a few days. But in the end, the press was generally agreed that Hayek had more or less gotten things right.[247]

There were many reasons for the unanimity and decibel level of the reception to the Hayek report. First, and quite simply, the announcement was preceded by a letter Hayek


Beamtenschreck Hayek lässt ETH-Bombe platzen

Schweiz vor Forschungs-Pleite – weg mit alten Professoren!

Headline in the tabloid *Blick* of 26 July 1985: “Swiss research bankrupt: Out with old professors!”

had written to the president of the ETH Council summarizing the study in clear and readable form. In many areas of teaching and research, the ETH as a whole had failed to keep pace with technology; the administration was running large deficits; and in both Zurich and Lausanne, the main schools and the research institutes could all stand some streamlining. That said, there was also a great need for investment – in Hayek’s estimation, amounting to several hundred positions. Naturally, this summary made the detailed report easier to interpret.[248]

Second, and significantly, the “background” – that is, the general diagnosis – that had led to commissioning Hayek Engineering AG in the first place was undisputed. In 1985, the ETH Domain’s lag in technology, the crisis of innovation, the inefficiency of the administration, and the competitive failure of industry and research were all topics of concern. That public administration was less efficient than private industry was in a sense axiomatic and indirectly confirmed by the government’s optimization studies, even before the results were announced.[249] In a succinct statement of the context, the *Tages-Anzeiger* wrote, “In recent years, advances in science and technology have accelerated. New technologies – biotechnology, gene technology, microelectronics, informatics, to name but a few – have been introduced. The number of students continues to grow.” Against this background, the ETH Council had tasked Hayek Engineering with determining whether the facilities of the ETH Domain “were fulfilling their functions effectively, whether all their operations were necessary, and whether there were new activities they should be taking on.”[250]

Third, the great communicative impact of the report was due to the fact that Hayek and his company enjoyed a very good public reputation. This reputation may also have been one of the reasons why the ETH Executive Board insisted on going with Hayek Engineering as opposed to McKinsey, traditionally the favorite of the federal administration in such efforts. At the time, Hayek stood for creativity, audacity, and to a certain extent, the kind of nonconformity typical of academics. He took great pains to distance himself from the conventional image of a business consultant, and preferred to think of himself as an entrepreneur. Hayek was known especially for not always following the instructions of his clients and for flirting with conflicts of interest, for example, in his optimization study of the Swiss railways (1982) and in his near-legendary "rescue of the Swiss watch industry" that same year. Shortly before taking on the ETH job, Hayek had evidenced his independence in full public view when investigating an arms deal by the Federal Military Department.[251] But Hayek also had a personal reason for advising the ETH: it was good publicity for his company. The ETH had made no progress at all, Hayek recalled later. The "ETH's message to the outside world" was "pretty bad." Hayek considered himself hired not as a management consultant, but rather as a "complex systems specialist." As such, the job was an opportunity for him to advertise the broad applicability of his entrepreneurial activities. "Whether a steel mill or the city of Zurich, the German government or the universities or a canton: these are all complex social systems. How do we help them to move forward and to develop a strategy? That is what we accomplished, not only in words but also in the way we took over the Swiss watch industry, developing a proper strategy and ensuring that it became number one in the world."[252]

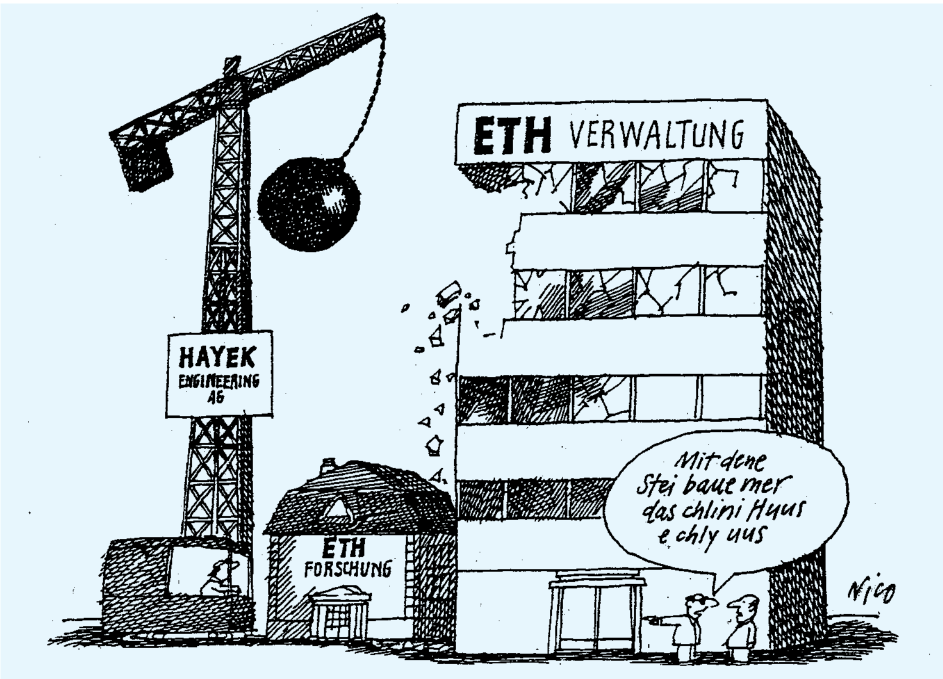
By the mid-1980s, thanks to its prominence, visibility, and potential for publicity, the ETH commission had put Hayek Engineering AG on the map in the field of public services, a development confirmed impressively by the press.

Moreover, the effect of the Hayek report was ultimately amplified by his successful balancing of the desires of his client, on the one hand, and his trademark unorthodox recommendations, on the other. "A saver argues – among other things – for more positions and money; a respected independent expert urges technological catchup. Is such a contradiction workable?" Hayek asked.[253] Heinrich Ursprung later recalled that it became clear to him after a while "how clever [the question] was."[254] Most probably, Ursprung – like many others – initially perceived Hayek as an inquisitor of efficiency who "would count the number of keystrokes a secretary made on her typewriter" in the interest of rationalization. But Hayek turned his education and research naiveté to advantage: putting himself in the shoes, as it were, of this specialized "enterprise," he gradually became its advocate. According to Ursprung, "A lot of what he discovered ... we had known for a long time. And he realized that and also appropriated many of our insights ... once he was convinced of [their utility] as a management consultant."[255] In this respect, Hayek's reputation was crucial. "No one would have dared disagree with Nicolas Hayek. What came out of the consultation wasn't news to us; but we could never have implemented it," recalled Ralf Hütter.[256]

A charge that Hayek was in cahoots with ETH management was already rumored in 1985, and could have undermined the value of the report. Hayek's call for a major increase in investment and his recommendation that the hiring freeze be lifted had been mooted many times previously by the ETH itself.[257]

The accusation of partisanship in the analysis, however, had two credible counterarguments. First, based on his observations, Hayek had identified many potential savings opportunities (especially in the administration), and subtracted from that number all the positions to be newly created. The *Tages-Anzeiger* referred to the "stick in Nicolas Hayek's gift box."[258]

Second, Hayek's report included a critique of the weak leadership of ETH Council. Of course, this scolding could not really have hurt. The Council was ineffective because it was simultaneously tasked with acting both as a general directorate and as an administrative board. Thus – according to Hayek – it could not really be compared with an industrial leadership structure and consequently suffered from too little entrepreneurial freedom. That the university might have anything structurally in common with industry was not obvious to everyone at the time, and could be chalked up to consultant bias. "As far as the structure of the ETH Council is concerned, I am not entirely convinced of the comparison with private business," one Council member was heard to say.[259] On the other hand institutional representatives would have had no objection to acquiring additional and more clearly defined competencies. If Hayek's criticisms of the ETH Council were at all unpleasant to hear, it may have been for this reason. "In reading the report," stated another Council member, "I kept wondering, How can the Council enforce these



A cartoonist for the *Tages-Anzeiger* captured the popular objective of the Hayek study: eliminating the fat from the ETH Council to the advantage of research.

recommendations without political backing?" – in effect complaining precisely about the minimal influence of the ETH Council.[260]

The Hayek report was a huge success, clearly aided by the earlier communication. Equally important was its confirmation of general assumptions and the strengthening of the existing consensus among the public regarding the state of the nation. Finally, the process worked by skillfully exploiting Hayek's reputation and preserved the balance between confirmed expectations and surprising recommendations. Nevertheless, a few days later, a number of criticisms did arise. Under the headline "The 'Japan shock' approach to university policy?" the *Neue Zürcher Zeitung* reminded readers that whether resources were really called for depended on the objective. The ETH Council was going about things backwards. It had taken the parliamentary budget as a given and then asked the consulting group whether the current goals were reasonable, and then finally asked them to look into new tasks for the ETH Domain to assume in the future. It is striking how quickly the ETH Council adopted Hayek's hiring goal (investment needs minus savings potential) in its application to the Federal Council. Only for proposals regarding staff reductions, streamlining, and restructuring did the Council request additional time and clarifications.

The *Neue Zürcher Zeitung* was especially skeptical about the Hayek report's championing of the university's computer-supported cybernetic future, though not on account of the computers. "One might ask whether the recommended 'information system for collecting, planning, control, and monitoring of quantitative and qualitative teaching and research output' makes sense in a field that relies on personal creativity." The newspaper remarked even more provocatively that the ETH Council had already made clear "what it considered to be more flexible hiring practices" when it asked that two-thirds of jobs be made permanent. There could be no doubt that "greater autonomy for the Council in financial matters and personnel policy" was needed, but only on condition "that appropriate structures were in place internally, as well as at the policymaking level." Overhauling the future-transforming machine would inevitably entail a remaking of the "government machine."

The newspaper went against the grain in concluding that investing in the federal university would not guarantee a more successful economy, "in particular because the promised innovations would depend on multiple, and especially human factors, which are difficult to predict ... The perpetual references to Japan, which graduates twice as many engineers per year as Switzerland, is similar in some ways to the 'Sputnik shock' – among other influences – that 25 years ago sparked a rush to education whose traces linger still."[261]

The commentary of the *Neue Zürcher Zeitung*, which was typical of others, made clear that no "shock initiatives" were required to restructure the ETH Domain.[262] Rather, it was going to take a costly project in design and implementation. Christoph Wehrli, the *Neue Zürcher Zeitung*'s special editor for higher education at the time, had already made this connection at the press conference of 25 July 1985, and promptly wrote: “The ETH Council has already … decided to carry out most of the recommended measures – including those of external experts … Among others, structural changes are foreseen, in particular a revision of the Council’s guidelines, first adopted in 1983.”[263]

The creative chaos of the matrix

On the basis of the Hayek report, the ETH Council decided to embark on a further package of detailed analyses. Called Avanti, the project was farmed out to a number of different management consultants. The entire ETH complex, including the ETH main schools in Zurich and Lausanne, as well as the research institutes, would be assessed against more than 40 parameters. The process was clearly conceived, highly differentiated – and unbelievably expensive. The basic questions were reminiscent of the work of the reform commission and its *ETH-Modell 71*. For example, the subproject “Avanti 8” included enhancement of research, continuing education, teaching methods, and the impending reorientation of teaching and research. While this project was investigating common problems at the universities in Zurich and Lausanne, other projects were examining coordination between the two schools (for instance, in civil engineering) and future training courses, for example, for industrial engineers.[264]

Many of these very different projects tackled topics that normally would be debated in major symposia, incorporated into higher-education-policy programs, or shortsightedly left for the next generation to deal with. Some of the subprojects that analyzed the entire ETH Domain from a technical and administrative point of view, such as Avanti 7 (on IT problems) or subproject 9 on the administrative regulation in the area of finance, procurement, and construction.

Some of these studies dealt exclusively with the ETH Zurich. “Avanti 1.1” was intended to develop a new structure for the school. “Avanti 1.2” sought to improve the travel office, “Avanti 1.3” the management of storage areas, and the goal of “Avanti 1.4” was to optimize operational services. Setting in motion a veritable “expert” machinery was the ETH Council’s response to the Hayek report. People still remember the management consultants from Häusermann & Co AG, known somewhat derogatorily as *Häusermänner*, who were responsible for Avanti 1.1. And for good reason. This so-called ETH Zurich organizational study became a poster project for the hazards of excessive zeal, culminating in a serious case of overdocumentation.[265]

The ETH Executive Board was obviously shocked. The copy of Avanti 1.1 in the ETH main library has biting comments pasted into it: The report – without supplemental volumes – was read and thoroughly discussed. In the view of the Board, the report in its original form was unsuited to publication and consultation. Weighing in at 400 pages with annexes, it was far too long. It also contained “extensive chapters that were totally unconnected to the mission of the consulting firm … and useless for evaluating different forms of organization.”[266] The appraisal of the three proposed options was “vague, unsubstantiated, barely comprehensible," and in many cases simply irrelevant. "The Executive Board thus advises that the entire report be provided with a detailed commentary, and be made available for inspection in this form only."[267]

People were incensed. Although Häusermann had interviewed almost all the faculty at the ETH, it had not stuck to the program. Instead, the interviews had been transformed into a "collection of grievances against the ETH Executive Board ... Individual interviewers were obviously not in a position to assess and to weigh the validity of such claims."[268]

Worse than the anger was the disappointment. The contrast with the Hayek report could not have been starker. From the point of view of the Board, the follow-up analysis was worthless. Even the comments on the potential for streamlining the institute secretariats fell short of expectations. Neither the Häusermann report nor its accompanying documents, neither the commentaries of the faculty nor the operational analyst's recommendations on how to improve efficiency seemed to promise any great utility. Especially appalling was the Häusermann experts' minutely detailed claim that the university's savings potential was not between 17 and 20 percent, as Hayek had estimated, but 5 percent at most. The Hayek report had considered "only the benefits of the measures ... The drawbacks and thus the feasibility assessement are largely missing."[269]

The release of the "comprehensive report" was as catastrophic as that of the Hayek report had been carefully controlled, just a year earlier. The only thing Häusermann was not accused of was imprecise data. Indeed, the meticulous execution of the work was as obvious as the ETH Executive Board's own disregard for details. Nonetheless, even a thorough reading of the Häusermann report would have changed little in the Board's estimation of it.

The Board also had little appreciation for the scientific rigor of the Häusermann report's operational and organizational analysis. The far too accurate factual hubris of the Häusermann report fatigued the respondents, angered the accused, and confused the higher-education-policy audience. It also provoked a totally unintended consequence of the operational restructuring process: the re-emergence of the basic questions on Swiss science policy thought to have been relegated to the 1960s. To the Häusermann report's call for clearer tasks and responsibilities for science policy, the ETH Executive Board not only responded hostilely ("A model for advice without any basis in reality") but also argued from first principles: "Who will build the platform? Who will decide who is competent to create science policy in an overall framework? Who best knows the needs of universities, of society, of science, and the environment? ... Is a national control function really desirable? Are there examples of the successful central control of science?"[270]

Naturally, Hans Häusermann was also disappointed and angry. His response to the Executive Board's criticisms followed by return mail in a nearly sixty-page document. "We, too, have decided to protest," he wrote, "that the Executive Board wishes to condemn our report and its recommendations because it confirms in no uncertain terms an earlier report's findings of the inefficiency of the current ETHZ leadership and structure

Management consultants saw potential in streamlining the information system, whose efficiency was difficult to assess. The housing committee's hanging files, December 1981.

and also because it cannot confirm that report's claims of savings potential for the institut secretariats and workshops, and in the storage areas."[271]

The upshot of the detailed analysis of Avanti 1.1 was a communications fiasco. The management consultants had done their job so thoroughly that their client was at a loss to deal with it. The problem was partly one of culture. "We should have done stock inventories, analyzed decision process, and observed daily operations to have a better grasp of the situation," recalls former Häusermann employee and later GEP president Jürg Lindecker. That would have led naturally to suggestions for structural changes.[272]

What nobody expected was the contrasts between the Häusermann and Hayek reports. Hayek's report was welcomed by the university. Häusermann's probing and precision, carried out with good documentation and at enormous cost, had precisely the opposite effect. Worse: the accusation of weak leadership once lobbed only at the ETH Council as a governing body now encompassed the entire administration of the ETH Zurich. Not even the measures aimed at the inefficient leadership structure could satisfy the Executive Board, as the restructuring recommended by Häusermann would have altered the administration's existing balance of power.

Faced with this situation, the Executive Board took recourse to a consultation within the ETH Zurich. The object of discussion would not be the Häusermann report but rather different scenarios. The Board obviously believed that no clear consensus would result, which would necessitate a "management decision." Ironically, the various organizational structures presented for discussion were based entirely on the Häusermann report, supplemented by one of the Board's own (favored) options. However, all the options – each in its own way – were so at odds with the traditional operating mode of the university and its administrative and governing bodies that all of them ended up being controversial. If structures are taken as expectations about the performance of a system, then in the consultation on restructuring the ETH Zurich, each option had the potential to disappoint many expectations.[273]

Within a very short time, the consultation provoked a clamor of opinions. Was it useful to have an Executive Board consisting of the president, vice president for education (rector), three additional vice presidents representing new areas of science supported by recent institutes and faculties, as well as a vice president for finance and administration (Häusermann's preferred option)? Or would it be better to have a four-man Board and then a good dozen department and division heads between the Board and a reduced number of institutes (50 to 60)? Should the administrative functions be vertically defined, or would there be an advantage to organizing it along mixed vertical and horizontal lines? Should heads of centers of excellence, departments, and divisions be members of the Board, or should they answer to a vice president, and if yes, which one?

"The divisions here – the departments here. And the professors here." Hans Bühlmann explains the "creative chaos" of the matrix structure at the ETH. "Not only did we have individual superiors to answer to, but we were also horizontally and vertically accountable. In this sense, accountability was three-dimensional."

Hierarchically speaking, should institutes report to a teaching division or a research department, and should the teaching divisions report to the rector? Such differing opinions converged in a well of misunderstandings, conflicts, and complicated deliberations especially as, over the course of the consultation, the options kept multiplying and changing.

Ultimately, it proved impossible to clarify the situation of the ETH, and yet the Executive Board was scheduled to render its verdict on the Avanti 1.1 project to the ETH Council at the end of February 1987. Heinrich Ursprung did his best by presenting the Council with a revised variant of the Executive Board as a solution. "Following the university's internal consultation," he suggested a fifth option. "It consists of a purely functional Executive Board composed of five persons. The Board would be presidential, and no longer collegial. In addition to the current four functions, there will be a new 'research' function and support given to the teaching and research units, the real structures of the departments."[274]

The Executive Board had long been advocating a simple departmental structure based on the American model. It would consist primarily in reducing the number of partners from 140 to 16–18 departments heads without decision-making authority. It represented the last opportunity to establish such a structure. To bring the Board's proposal more in line with the others, it was even suggested that the organization of the ETH would "remain matricial," although the new departments would be subordinated to the divisions. According to Ursprung, one axis would comprise "the divisions, which will develop and implement the curricula and the teaching content for approval by the ETH Council, at the request of the other dimension of the teaching services, the departments, which represent the unity of teaching and research in everyday life."[275]

That Ursprung said "after the consultation" and not "as a result of the consultation" was not lost on those Council members who were well informed. Not accidentally, the Council president immediately presented a letter from the ETH lecturers' committee and explained that their position was significantly different from that of the Executive Board.[276] Hans von Gunten, the ETH's rector and also present, conformed this during the meeting. The range of opinions at the ETH could not hide the fact that Ursprung's proposal had no internal consensus: "Academic opinion was divided among the four options," von Gunten tried to explain, "and they changed over time. An initial vote was divided between options I (Häusermann) and IV (Executive Board). In a later vote, the administration's option was the better favored, and ultimately option I won out. Many members of the lecturers' committee just looked at the Executive Board's proposal, found it to lack the Häusermann features, and thus came out against it. But they were given no time to consider the document more deeply."[277]

It wasn't only the lecturers who were confused. The members of the ETH Council were, too. For example, one said he was happy that "here business-type organizational principles could be adopted without much ado." The characteristics of the teaching and research enterprise would be preserved. On the other hand, the retention of the old divisions made little sense: "The real structural unit of the ETHZ should be the department with essential functions. I have some difficulty understanding the point of the divisions." He wondered whether it wouldn't be better "to transfer the tasks of the divisions to the departments." This would have the great advantage that the divisions could be abolished. As a result, the structures would be "simpler and more transparent."[278]

That was grist for the ETH Executive Board's mill, but getting rid of the divisions would have led to noisy protests from the university. They would have to stay, said the president, but their influence should be as small as possible. Ursprung finally had to acknowledge that no single opinion about one or the other organizational structure predominated. "I think that it will not be possible to reach consensus on this issue. I assume that many members of the ETH expect at least a letter of intent or an executive decision from the ETH Council."[279] This expectation was met. The ETH Council handed down its "executive decision," in which it foresaw a future "structuring of all the academics at the ETHZ into some 16 departments." However, in one important point having to do with the position of the rector and the divisions in the organizational chart the ETH Council decided against the request of the ETH Zurich president. Although the Executive Board

Meeting of the ETH Council in early 1988 in Bern. Left to right: Christine Lenzen, Johannes Fulda, Heinrich Ursprung, Georges-André Grin, Peter Siegenthaler, Rodolphe Schläpfer, Urs Meier, Wilfred Hirt, Walter Stumm, Heinrich Gränicher, Pierre Immer, Bernard Vittoz, Hans Bühlmann, Hans-Rudolf Denzler, Albert Fritschi.

would consist of five members and the president would generally be in charge, the rector would still be responsible for the teaching divisions, whereas a vice president would have oversight of the research-oriented departments. In addition, the ETH Council's decision envisioned a vice president for planning and development as well as one for administration.[280]

The solution was obviously a compromise. The ETH would be restructured yet the old structure would be maintained. For the ETH Council, it was nervewracking enough that the reorganization entailed having to revise the ETH Zurich's official guidelines just before the consultation on the new ETH law was to begin. Now it made sense to carry out the restructuring as quickly as possible and to emphasize all the positive elements of the solution. The matrix structure gave equal importance to research and teaching.

Shortly before the change in administration from Heinrich Ursprung to Hans Bühlmann, the line of approach was approved. It would be up to the incoming Executive Board to implement the newly defined matrix structure. "When you want to change something about a university, you first have to create a certain kind of chaos," remarked Bühlmann in retrospect. Accordingly, Ralf Hütter and he had agreed that in implementing the matrix structure they would introduce "a little chaos." But they were confident that "from this chaos" something would emerge "that again became recognizable as unidimensional."[281] For Hütter, another reason argued in favor of the matrix: introducing the departments while simultaneously dissolving the divisions would be "too big a step ... What then is the rector to do?"[282]

Memories of past implementation difficulties were still fresh in people's minds. As late as September 1988, a good year before the ETH Council's decision, Bühlmann announced to the Council members that clarifying the issues had not been easy. To his surprise, he said, he realized "that even in the school a certain unease and confusion existed because the idea of departments had not yet quite sunk in."[283]

Restructuring required a lot from all the parties concerned. But even those who are for it need a while to appreciate where exactly their own decisions are taking them. "The departments are going to require not only a leadership structure but additional leadership resources. I now understand why things had to be done carefully," remarked an ETH Council member in September 1988.[284]

Even from a safe historical distance, the temporary introduction of a matrix structure at the ETH Zurich is difficult to judge.[285] The sociology of organizations tells us that the matrix is not a panacea for structural problems and that it is more costly than a conventional linear arrangement. Yet it is useful for companies that have at least two target objectives that are contradictory though both critical for survival. In other words, the matrix structure is an attractive organization model where development and sales – or perhaps research and teaching – operate simultaneously. However, the business or Humboldtian combination of the tasks at the level of administrators or professors has long been an illusion.

The ETH Zurich's daring experiment with the matrix had four very different motivations representing very different university-policy positions. The first is the already mentioned new public management wave in the federal administration, which by 1984 was already planting the seeds for reorganization and efficiency. Here, too, the idea was to increase "coordination, coherence, and networking" either through a matrix or "cross-functional project organizations." The matrix was also popular with those who wished to transform public administration through "change management and new methods of governance."[286]

Second, in the 1980s, matrices were popular in industry. They were seen as guarantors of flexibility, and flexibility was needed when you didn't know how you would survive the Japanese miracle, European integration, and North American potential for growth.[287] But an industry based on project organization and matrix structure no longer had a simple relationship with development units in the ETH's research institutes. In industry, project organization had robbed the university of its most loyal and trusted partner. On the other hand, matrices allowed the university once again to think organizationally like industry.

The third reason for a matrix structure had to do with the increasing importance of research in funding for academics, science, and university policy. Research still tended to be organized at the level of individuals or relatively small institutes that often comprised no more than three or four faculty. The president's span of control, which included around 110 direct subordinates, was much too great; individual faculty formed too small a body for research that was linked to big institutes; and institutes often proved too inflexible. The research boom had led to an appropriate organizational structure: departments under the care of a vice president for research seemed a good solution.

Fourth, the 1980s coincided with increasing demands from teachers for flexibility. No fewer than three new course programs (informatics, materials science, environmental science), numerous post-graduate and employment-related continuing education courses, a fundamental restructuring of the natural sciences division, the POST intiative, as well as reforms to the core curriculum made it clear that a university had to be willing apply change management to its teaching activities. The growing conviction, not confined to the rectorat, was that divisions had live up to their education-coordinating function.[288]

The creative chaos that ETH president Bühlmann had wished to infuse the matrix structure with was already a factor during the internal discussion of Häusermann's proposals. Opinions ricocheted off one another. Creativity had become popular at all levels and to the point of exhaustion. The ETH Zurich's successful introduction of the matrix structure in 1987 reminded the school of its own organizational malleability. It came as no great surprise when, in May 1992, President Jakob Nüesch established a task force to consider yet another restructuring – in effect, the dismantling of the matrix.[289]

Not to be overlooked is that fact that, for the few years in which it prevailed, the matrix structure represented a major shift in the power structure of the university. It was accompanied by negotiations during which some departments underwent improvements to better exploit the matrix and cement their autonomy. The collective organizational intelligence required in these efforts was unequally distributed. Those who experienced the matrix remember it with fascination or dread, depending on how successful their divisions or departments were at dealing with the system's creative chaos.

Management everywhere

In *The Visible Hand,* Alfred D. Chandler Jr. described the managerial revolution of the early twentieth century. At the time, it was difficult to imagine that within just a few decades the idea of management in university life would be taken for granted.[290] In the meanwhile, it was becoming established at all levels of academic practice. From teaching to research to management, from the administrative boards to the academic departments and institutes, faculty, and the curriculum, an increasingly sophisticated degree of time, research, quality, and self-management was pervading every area of the ETH.[291] Even the university's restructuring was described as change management, its operations understood as a control problem, and its administration discussed as a matter of university management and governance or of effective leadership.[292]

The temporal, hierarchical, human, and financial context of the different management activities varied substantially. Sometimes they covered a budget period, sometimes a semester or a course, and could relate to the curriculum, research projects, institute funding, academic celebrations, or the introduction of a new design for the annual report. Despite differences, with respect to responsibility, execution, and topic, dealing with loans, equipment, space, and people was generally and eventually everywhere labeled and modeled as "resource management." This development could not be put down to cynicism or linguistic hat tricks. Rather, it signaled a profound change in the "academic market," that is, the university's social relations and its "academic portfolio." In the final quarter of the twentieth century, universities underwent nothing less than a managerial revolution.[293]

At the ETH, the idea of management was linked to planning. As early as 1974, the Executive Board's new staff unit was tasked with handling academic, operational, and physical issues "as a general basis for the Board's decision making." The duties of this staff included "project-managing" a study "for the project-oriented financing of research."[294] Within the planning office, "management" also came to mean "all-purpose project-oriented troubleshooting" in resolving bottlenecks – a process known as "management by exception."[295]

Despite the growing popularity of project management at the university, the 1985 Hayek report criticized the insufficient use of "fulltime project management methods." As the report recommended, their systematic introduction would "ensure the participation of users and the efficient use of resources."[296] This was still rather problematical, and in particular in the aftermath of the Häusermann report, unleased a defensive reaction.

Consequently, in his "*Acht Leitmotive für die ETH Zürich*" (eight leitmotifs for the ETH Zurich), President Bühlmann deliberately avoided "both military and management language" because it was not befitting the university.[297]

His self-censorship notwithstanding, by the end of the 1980s, the president could not prevent the rapid spread of management semantics. Prior to taking up his position in 1988, Ralf Hütter even attended management courses to prepare for his new job. After all, he would be running "a large operation with thousands of employees and a budget of several hundred million francs." In addition, being the vice president of the ETH also involved dealing with businesspeople, who used a different vocabulary from that of the academic faculty.[298]

Almost simultaneously, in 1989, the establishment of a Department of Scientific Management (described within the ETH as the beginning of an engineering business school) made management academically acceptable. In addition in April 1991, the Swiss Society for Project Management held a large international symposium at the ETH on "promoting and managing projects without failures in a technological and natural environment."[299]

Management was in style, and as a concept it repeatedly spilled over from the field of informatics services into general administrative parlance. At the beginning of the 1990s, system administrators spoke quite naturally of "resource management for magnetic tape use and submitting batch jobs," or of "building a software environment for network management."[300] Under the heading "Data Management," the annual report of 1992 described a "software project that would accelerate data transfer between individual divisions and the rectorat ... especially in the area of grading." Data transfer, data management, and grade and student administration were converging, and gradually became synonymous.[301] That management and IT had a symbiotic relationship was already clear in the 1970s, with the development of research-based databases for the central administration.[302] In the 1990s, this was also reflected conceptually to the fact that people began to refer to financial management and personnel management.[303]

Like its industrial predecessor, the university's managerial revolution can be traced to accelerated growth that led to processes of functional differentiation. In industry at the outset of the twentieth century and at the university at its end, more sophisticated business and academic coordination tools became necessary.[304] Procedures had to be developed that were both more professional and more technical, procedures that ultimately would prove more efficient than the traditional forms of the family firm, on the one hand, and the hierarchical university, on the other. In historical comparison, the separation of ownership and management in the managerial revolution of the early twentieth century and the separation of scientific practice and university management in the research-oriented university of the twenty-first century could be described as functionally equivalent. The growth-induced managerial revolution was associated with an increasingly professional administration. The ETH of the 1980s experienced not only a fundamental restructuring of its Executive Board but also a marked expansion of the presidential staff as well as those for research, planning, and controlling. Thus, for example, President Hans Bühlmann and his successors no longer personally handled recruiting issues. The chairmen of the hiring committees were now assisted by a member of the president's staff, who remained a part of the recruiting process from beginning to end.[305]

A development similar to that in the president's office could be observed in the rectorat as well as among the staff of the rector and vice president. Since the end of the 1980s, all had been expanding their increasingly academically trained staff. At the same time, positions were expanded or newly created that concerned the specialized management for the university's external relations. As of November 2000, the former department of public relations was transformed into a "centralized coordination, competence, and service center" while public relations, documentation, and the Web office were put under the management of a "TV person." That the ETH had named Rolf Probala, then head of Swiss TV's *Tagesschau,* as head of the newly created department of "Corporate Communications," was a strong signal. It represented a commitment to public relations, a statement of corporate identity, and it meant that the self-image and administration of external relations would be as professionally handled as the most important news show on national TV. The reconfiguration of the relationships and forms of communication at the university at the start of the twenty-first century were evident in products such as *ETH Life,* the school's daily webzine.[306]

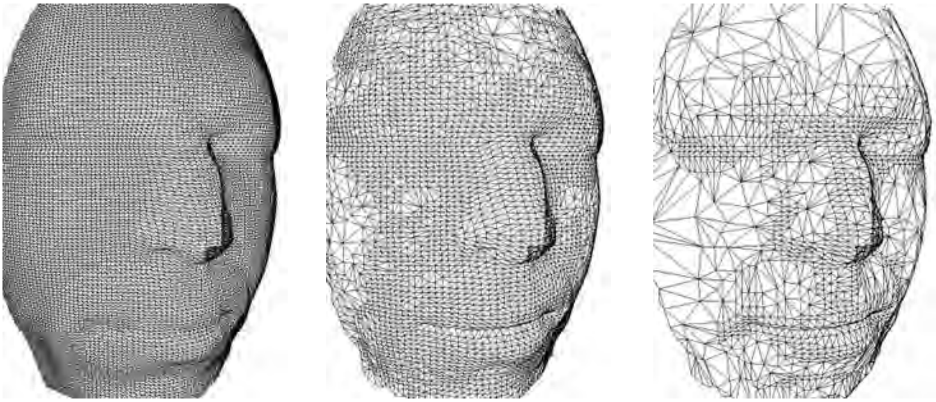
President Olaf Kübler opens the jubilee year 2005. The ETH made heavy use of corporate communications and promoted the cultivation and support of internal networks through special events such as the president's "New Year's Reception."

The familiar claim of management is that it was synonymous with transparency, competence, and efficiency. For universities, this viewpoint is attractive because it suggests that conditions are not so different within and outside of the university, and ultimately because the concept of management makes it easier to assimilate and integrate the university's fairly opaque "core business."[307] This, however, necessarily clashes with the academically influenced, elitist self-image of members of the university. In 1995, President Jakob Nüesch's naming of the director of the CSCS in Manno as administrative director of the ETH led to a violent but very brief overheating of the management cult. What Hans Bühlmann had managed to avoid in his leitmotifs, namely, the explicit use of buzzwords from the management literature, was now celebrated and incorporated into programs. Alfred Scheidegger's credo and reform program were influenced by the European Foundation for Quality Management's principle of total quality management and were intended to bring about "more effective and efficient strucutres and processes" at the ETH.[308]

At the same time, the image of the administration needed improvement. "Accordingly, changes will be made in the administration," Scheidegger announced in 1995, "based on the use of modern technology and the design of the organization. The use and development of staff qualifications will be jointly optimized." In addition, the administration would have to learn "to recognize new customer needs." Finally, in future, the presentation and development in particular of "change motivation" would constitute a central task of leadership.[309]

Scheidegger immediately launched a large-scale quality-management project for the administration.[310] "Action Q" was unsuccessful, which doesn't necessarily mean that Scheidegger's "shakeup from within" was simply too great a challenge for the ETH. It was even less likely that the failure originated in the ETH's "insufficient capacity for autonomous change," as the executive directly claimed in his own defense. Rather, Action Q very quickly became a battleground between the previously unsuccessful "service provider" of the university administration, on the one hand, and an overzealous reformism of the administrative director on the other. It fairly quickly became clear that workable reforms would require trust among those affected, as the annual report of 1996 sheepishly stated. Neverless, Action Q would not be canceled, but expanded. Changes would consist "not only of restructuring, process optimization, and quality management," but should also aim at "altering the range of services."[311]

Still, in short order (by 1997), neither trust nor a forward-looking strategy could save Action Q. Evidence of "globally recognizable trends" would have required reference to management techniques from private industry as legitimacy. But in the meanwhile, it had become clear to all that the change processes sought by Scheidegger "[were] not washing gently over the participants. On the contrary, they can hurt, for they call the 'tried-and-true' into question." Obviously, for once, what could be called the "self-healing powers of the ETH," that is, a re-evaluation of authoritarian decisions in terms of their



How exactly do you measure *Homo academicus*? In the aftermath of the analysis of the ETH done by management consultants and decried as bean counting, this has been a controversial topic. A drawing from the 1997 annual report of a head covered with grid lines from the Visible Human Project illustrated the administrative director's rationale for applying private-sector management techniques to the university. Sophisticated algorithms, developed at the ETH's Institute for Information Sciences in the 1990s were able to greatly reduce the triangulation density – only for the structure of the enterprise, however, not for its products.

practicality, was stronger than the sometimes not just authoritarian and radical but rather totalitarian concepts of total quality management.[312]

Notably, following the failure of Action Q, the post of administrative director was abandoned. The professionalization of the central services and the expansion of staff functions in the overall management of the school continued. At the end of the 1990s, the professionalization of the administration at the periphery was growing strong. Since then, all the ETH departments have begun to delegate management of their personnel, finances, communications, and material resources to professional coordinators. These coordinators exert considerable presure on professors to formalize their resource management. At the same time, they support the departments in the struggle for budget share, the distribution of which is determined through annual negotiations with the ETH Executive Board. Even academic practice is increasingly recognized as a special form of management.[313] One of the most complex institutions of modern times, whose complexity is an integral part of its creative functioning, is subject to the transparency imperative of management culture. In the growing, differentiated university market, anything that is supplied or demanded must be salable and "managed" efficiently and professionally: lectures, exams, papers, evaluations, research projects, course credits, positions, space, equipment, books, vehicles, sporting events, catering facilities, phones, computers, cleaning services, publications.

This constituted a crucial turning point. Instead of trying to reduce the complexity and contingency of teaching and research through administrative restructuring, at the turn of the twenty-first century the approach was rather to carefully control them through management. "Uncertainty is no longer exclusively a threat to be regulated through rational planning, micromanagement, and prescribed conduct but rather as scope for freedom, and as such, a resource to be welcomed."[314] The world is open, wrote President Olaf Kübler in his first annual report in 1997. "Never have there been so many opportunities, and never before have we had to deal with such rapid change."[315] These words gave a new tone to the old question whether a university should model itself as a company. In the "scientific enterprise," the combination of entrepreneurial courage and scientific creativity should be encouraged.[316] "The ETH Zurich shares with all excellent universities and businesses a common characteristic: an enthusiasm for, and pure joy in, what we do. Such an atmosphere gives rise to a special brand of creativity that puts the ETH on the path to the future."[317]

In fact, that appeal of the managerial revolution for the universities may well have been the ability to recombine resources to creative effect. Openness, flexibility, talent, and institutional perfectibility constitute a compelling recipe for academic success.

The approach had two drawbacks: First, management culture is typified by a compulsion to formalize that places a lower priority on content, or even acts as a disincentive. Second, a higher degree of complexity and its creative consequences make some university managers nervous. As a result, they search for alternative sources of security

In the 1980s, the maxim "a healthy mind in a healthy body" was adopted as fitness training to meet the challenges of the future: calisthenics in the ASVZ as self-management of the performance-optimized academic body.

and find them (once again) by ratcheting up formalities: meticulously prepared policy papers, procedures, reports, applications, regulations, and the ubiquitous evaluation forms. This paradoxical pressure to formalize brought on by more flexible conditions puts a damper on creativity and lessens the effectiveness of decision making.

Autonomy as a management mandate

“The autonomy and self-governance of universities is coming to an end,” declared the conservative German philosopher Helmut Schelsky in 1969. Thirty years later, universities were proudly celebrating a resurrection of their economic independence, the ETH among them.[318]

Autonomy can mean very different things: academic freedom in teaching versus dogma or the ideological demands of the state; freedom of research versus support that comes with strings attached; freedom to learn versus an imposed program; and finally budgetary freedom, which could be described as the entrepreneurial freedom of university management.[319] Equally diverse are the possible applications of the term. Cultural pessimists like Helmut Schelsky long assumed that autonomy interpreted as the “solitude and freedom” of academic study would eventually end. For in the twentieth century, every single area of research was affected by the increasingly “operational character of the university.”[320] Sociologists were completely in accord with this view of things, and played a hand in negotiating the decline of autonomy and academic freedom of university research in the guise of politicization, commodification, and mediation of the university.[321]

Others, in contrast, spoke not of an impending loss of autonomy but rather set their hopes on gaining it in the future. The advocates of new public management, for example, considered budgetary autonomy as a criterion for entrepreneurship at the university. Because they equated the 1990s neoliberal trend of entrepreneurial freedom with efficiency, autonomy thus also stood for flexibility and appropriate use of resources.[322]

In any event, the ETH Council left little room for interpretation. “New public management is to be enforced and lived by,” stated the strategic plan for the ETH Domain for 2000–2003.[323]

One topic was allowed to be dropped, though it had been part of the university since the referendum opposing the ETH law: participation. In the mid-1980s, the ETH Council was still calling it one of the “disputed terrains” of the future legislation.[324] Here, autonomy offered an elegant solution. In an independent institution, consisting entirely of partly autonomous, subordinated organizational units (departments, institutes, academics, service branches), the autonomy of the granting authorities was such that decision-making efficiency could be determined on an individual basis. Under such a system, general demands for participation dwindle into ineffectiveness.

Given the many ways in which the concept of autonomy was applied, it seems less than productive to ask whether the university’s being determined by others necessarily

Since the 1990s, international rankings and assessments have played an increasingly important role in the competition for graduate students and research funds. In 2004 the ETH placed tenth in the *Times Higher Education Supplement*'s worldwide rankings.

Right: In 1998, the old "ID card salad" (pictured) was replaced with a credit-card-type standardized card that served as both entry badge and cash card. The "customer card" gave the members of the ETH community more flexibility.

entailed collapse of its autonomy. One might do better to think of autonomy as a broad, contradictory, and ambivalent mode of discourse appropriate for regulating and shaping the decision-making and dependency functions of the university both within and without.

The concept was probably most successfully used in speeches in which autonomy was presented as a threatened commodity. Whether the debate turned on the emergence of big research, which would require the coordination of many stakeholders; whether the subject was contract research, departmental collaboration, or consulting services; whether the objective was to refute accusations from this or that industry that wanted to lay its structural problems at the foot of the national education system; or whether the problem was perceived to be the growth-induced, increasingly complex business of administering a university or the predominance of government science policy – one could always fall back comfortably on the notion of autonomy at risk to protect oneself from attack. Autonomy was a very handy concept.

For the ETH, which since its formation had been run as an arm of the federal administration, autonomy had always represented future promise. It became equated with self-determination, self-actualization, and self-reliance, and, it is fair to say, entrepreneurial initiative, and was formulated as a positive goal. "The extraordinary speed," proclaimed Federal Councillor Flavio Cotti on ETH Day in 1987, "with which our world is changing demands a great flexibility and adaptability of our educational and research institutions, to enable them to keep pace with the most important developments. It is essential to

put our limited available resources to best use so that teaching and research can meet both the needs of the country and international standards of quality … Fulfilling these requirements will take an enormous degree of autonomy to give us room to maneuver quickly."[325]

Spoken shortly before publication of the federal report on the new ETH law, these words had a new sound to them. They suited the recommendation of the management consultants for more flexibility, more efficient allocation of resources, and "broad autonomy with room to maneuver." Here, Cotti was hinting at emancipation from Bern and local decision-making power (that is, in Zurich). However, his speech resonated with the high point of the Thatcherism-inspired efficiency programs that were traversing the federal administration in waves, under the buzzword NOVE.[326]

The law was scheduled to take effect in 1993. It described the ETH as an autonomous legal public institution that regulated its affairs independently and guaranteed freedom of teaching, learning, and research. The autonomy, which the university has since radically altered, consisted of budgetary independence that was delegated from the government to the ETH Council, from the Council to the ETH Executive Board, and thence to the departments and the other organizational units. This did more than establish a cascading system of performance contracts and agreements, reporting procedures, and evaluations.[327] "The new university freedom," which "gave universities operational autonomy in teaching and research," also called for massive administrative and IT upgrades for administrators at almost levels of the university.[328] The decentralized corporate structure of the university, with its relatively flat hierarchy and small, increasingly autonomous administrative units, need appropriate IT systems.[329] “No one doubts the major role that reporting will play in the future,” explained Gerhard Schmitt, vice president for planning and logistics, in 1999. “Without a well-developed reporting system, without well-compiled parameters, indicators, and graphical and statistical analysis, universities and university systems cannot be run, nor can a proper accounting be given to the authorities and the public.”[330]

An SAP project accordingly adopted in 1997 and introduced in 1999 was intended to support the planning and budgeting process. The project placed high priority on financial transparency, and broad autonomy in budgeting at the department level within specified annual targets and a multiyear plan. SAP would provide “cost information in all areas to facilitate management of the global budget, permit more exact personnel planning, and optimize all transactions related to personnel.”[331]

The comprehensive way in which SAP was introduced reflects the hopes that were placed in these technological endeavors. The entire central administration could be mapped in SAP modules: finance, financial management, controlling, human resources, materials management, billing, and facilities management. At the same time, the SAP project processed part of the upcoming push for autonomy. Many additional tasks, such as budgeting, were assigned to the departments; services such as contract process-

In 1999 SAP accounting and human resources software was introduced. Just as in large companies in the private sector, it supported the ETH’s planning and budgetary processes. SAP software and manuals for training users.

ing, which had previously been located in the federal administration in Bern, now had to be performed in Zurich.

The flood of rules and regulations unleashed by budgetary autonomy poses one of the paradoxes of the university vis-à-vis its newfound freedoms. ETH Council president Jakob Burckhardt, who retired in summer of 1978, had written prophetically: “We often ran up against the contradictions of the transitional arrangements that we imposed, on the one hand, to bring the schools together, and on the other hand, to preserve their identity. Similar inconsistencies arise … in the confrontation of the principles of autonomy, academic freedom, efficient management … Again and again, these contractions call out for solution by you, dear colleagues. They will not be silenced.”[332]

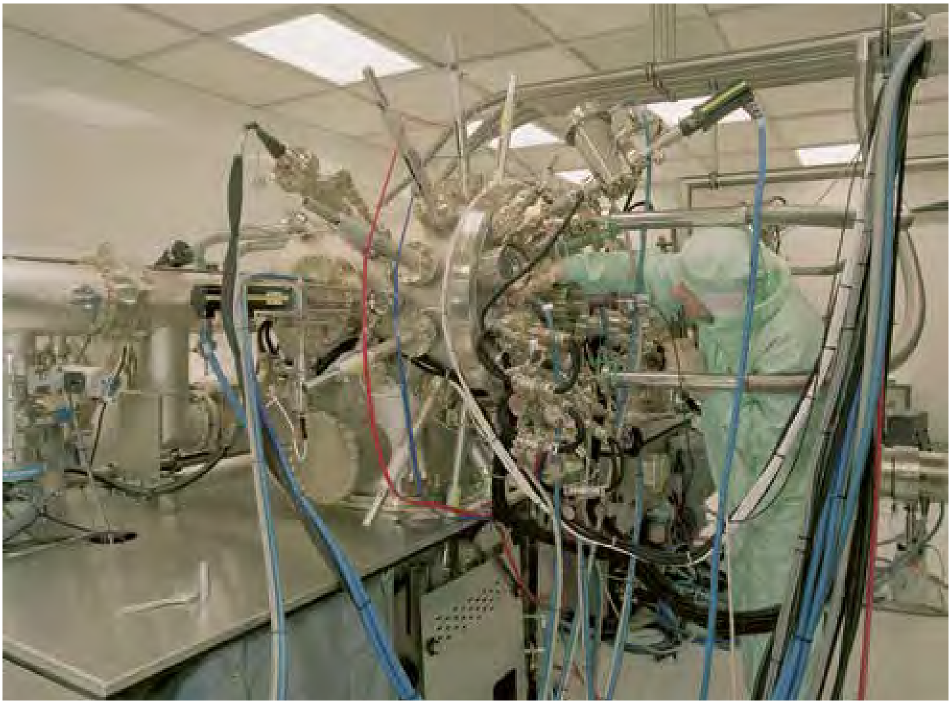
THE DEMISE OF DISCIPLINES

Disciplines influence the self-image of academia by defining research problems, setting courses of study, and by recognizing or ignoring certain areas of intellectual focus. Disciplines govern access to scientific communities, ensure their cohesion, and ensure interfaces with their environment, in other words, with other disciplines or with their political and economic context.[333] According to Michel Foucault in his 1970 inaugural lecture to the Collège de France, disciplines define themselves “through a range of objects, a set of methods, a corpus of sentences regarded as true, a play of rules and definitions, of techniques and tools.”[334]

In the 1970s, one reason to be interested, like Foucault, in the power of disciplines, lay in the growing importance of program research. Understanding how disciplines worked was of paramount political importance, because disciplines existed in a permanent state of tension vis-à-vis research programs. Even strong disciplinary patterns of activity sometimes found the financial allure of research programs to be an irritation. The focused attention of disciplines on the initiators of program research often posed conundrums in science policy. The thematic priorities of science policy run counter to those of prevailing disciplinary rules.[335]

For a number of reasons, the development of the disciplinary landscape in the last third of the twentieth century was extraordinarily dynamic, even at the ETH. As described in previous chapters, the academic modus operandi was increasingly influenced by the idea of modular recombination of resources. For disciplines that had to keep an eye on how and why resources were being allocated in a certain way, this had a far-reaching impact, because it also changed how the disciplines worked.

In teaching, for instance, all disciplines had starkly differentiated curricula and fundamentally new, more flexible, and thus diverse forms of organization for teaching the young. According to the annual report of 1986, to take just one example, the ETH Council had approved a new postgraduate science program based on the credit system



Bringing the university's research equipment in line with the twentieth century continued with the opening of the FIRST lab for nanotechnology research in July 2002.

that permitted "individual combinations of courses, internships, seminars, and reviews of the literature."[336] The right claimed by the disciplines to determine the canon in a single area lost its relevance. Disciplines had to learn to deal with individual preferences. They gradually became threatened as flexible curricula opened options for individual study design.

But even for research, the recombination of forms of knowledge could be considered both as challenge (for instance in pure mathematics through informatics) and as formula for success (for example, young, dynamic biochemistry versus venerable systematic botany): "In research, the networking of different disciplines is becoming more pronounced," stated the ETH annual report of 1989 under the headline "Research." The report did reassure readers who feared a loss of scientific security and stability, by explaining that "the traditional fundamental displines of the natural and physical sciences, namely, mathematics, physics, chemistry, and biology," still constituted "the cornerstones of basic research at a technical university." But the "interactions and the focusing on common practical objectives" would no doubt increase. "Materials research, biotechnology, and environmental sciences are interconnected fields, and their practical application is only fruitful when networked with the engineering disciplines."[337]

In three of the four fundamental fields, not much store was set by working across disciplinary borders. Physics, chemistry, and mathematics (about biology, more later), each considered their own discipline to the "cornerstone of basic research." Abandoning or even broadening disciplinary identity was out of the question. It was enough that the Swiss Science Council referred nonstop to interdisciplinarity, and as early as 1973 had pronounced that chemistry was following "the general trend to working with other disciplines" and would "increasingly be influenced by research from physics, electronics, biology, informatics, and computer and engineering sciences."[338]

It was not primarily the diminishing stability of individual disciplines that made the unversity receptive to talk of interdisciplinarity. The more important driving force was the disciplinary heterogeneity of the ETH in general and the practical orientation of the engineering sciences in particular. Before long, the university was even referring to its own integration with a certain degree of pleasure. The rhetorical pattern was simple and comprised three steps. First, interdisciplinarity was good and thus should be encouraged. Second, there were forms of interdisciplinarity that had no scientific (or disciplinary) credibility. Third, and consequently, bogus interdisciplinarity was to be shunned.

The subtext to the rhetoric was that, since there was no authority that could distinguish between genuine and false interdisciplinarity – including individual themselves – anyone could call the shots. The consequence was a fantastic proliferation of interdisciplinary this and that, especially public symposia, informational events, and lecture series, in which issues of interdisciplinarity were offered as a panacea against the charge of disciplinary narrowness, academic shortsightedness, and scientific delusion.[339]

Calls for interdisciplinarity seemed already fulfilled, fortunately, in areas where application- and problem-oriented research, program research, and nonspecialist courses, were present. This development led to the paradoxical distinction between the natural sciences and interdisciplinary fields, which was generally taken to mean the humanities and social sciences.[340] Interdisciplinarity suited many interests and stood for many things. It was a scientific criterion, a colorful addition to the disciplinary monotony of curricula, a challenging research strategy, as well as a lip service paid to resource-poor fields. When it came to issues of more obvious social relevance and utility, interdisciplinarity was advocated.

Since the mid-1970s, the Swiss National Science Foundation's major research programs had required cooperation between disciplines and institutions. The ETH's own targeted research projects, which it began funding in 1988, included many collaborations. From the outset, these "polyprojects" were labeled interdisciplinary or integrated, and not the least of their objectives was to raise the visibility and communications potential of university research. "Polyprojects consist of current interdisciplinary research projects that involve different research groups within the ETH and external partners. The projects are intended to serve the education of future scientists and to promote collaboration with foreign partners as well as an interdisciplinary mode of research."[341] These objectives were fairly reachable, as the themes of the polyprojects were generally broadly conceived, for example, "Cooperating robots with visual and tactile skills," one of the first polyprojects. The more concrete the title, the easier it was to form a collaboration between institutes, departments, and outside partners.[342]

Autonomy also forced the ETH to launch an internal targeted research program, which involved defining "strategic success factors" (*Strategische Erfolgspositionen,* SEPs). Only on this condition would the ETH Council release a portion of its "autonomy dividend" to the ETH Zurich. "The ETH Council called on all the institutions in the ETH Domain to propose collaborative projects and to apply for competitive funding for them. The money that makes these projects possible comes from the ETH Council's autonomy dividend, which is part of the reserve funds of the ETH Domain."[343] Now, all the conflicts of interest between the motives of the applicants and those of the SEPs defined by the ETH Executive Board became conflicts between bottom-up and top-down strategies for research. As a result, they constituted communication problems within the ETH, and were treated as such.[344] Applicants were increasingly confronted with interdisciplinarity and had to come to terms with it if they wanted to obtain research funds.[345] For the disciplines themselves, interdisciplinary programs represented financial but also political resources for demonstrating their general utility. Conversely, for the program designers, interdisciplinarity was a science policy tool for influencing disciplines despite their considerable autonomy. Which explains why university policy was so concerned with interdisciplinarity: it required more resources and greater cooperation. In providing additional funding and vehicles for collaboration, targeted research answered both needs.

The growing importance of targeted research shows that interdisciplinarity was more than just expediency or rhetoric: it had structural consequences. For example, in 1974, electrical engineering introduced an interdisciplinary degree course focused on "man, technolology, and the environment." Later, as already mentioned, many integrated polyprojects benefited from the ETH's internal funding measures. Moreover, in the 1980s, many postgraduate courses were cross-linked with already existing programs of study. In 1996, the ETH founded the Collegium Helveticum, a center for science-related dialog. Led by Adolf Muschg, Iso Camartin, Yehuda Elkana, and Helga Nowotny, the center housed a postgraduate program whose very purpose was to shake up disciplinary assumptions. Social sciences gradually increased in importance to the point where, in fall 2000, all ETH students were required to take one core elective per year in humanities, social, and political sciences, further illustrates the structural effects of interdisciplinarity. As existing forms of recognition for research and academic performance expanded, the earlier degree developed into a "cross-disciplinary doctorate" that could be organized among different departments.[346]

Federal Councillor Ruth Dreifuss, ETH president Jakob Nüesch, and Adolf Muschg opened the Collegium Helveticum on 18 April 1997. As a forum for dialog between scientists, it was intended to promote understanding between the natural and engineering sciences as well as the humanities and social sciences.

As the twentieth century rolled to its end, the old disciplinary structure of the ETH was repeatedly called into question as a combined result of the research program and the popular demand for interdisciplinary offerings. In response to such pressure, disciplinary borders had to be porous. The antidisciplinary development of environmental sciences and biology, however, represents a special case meriting a separate discussion. The following section provides a brief glimpse at the respective paths taken and how these fields coped with their precarious disciplinary structure in comparison with chemistry, physics, and civil engineering.

The introduction of environmental sciences was a result of a multiyear curriculum reform in science. In the natural sciences, problems kept cropping up as a result of efforts to keep the discipline under one roof despite its rapid differentiation and specialization. In 1979, the annual report announced optimistically that a milestone had been reached: from 1980, Division X would be offering three major concentrations in biology, molecular science, and environmental physics, as well as earth sciences. These disciplines were subdivided into further subdisciplines. For example, Aa-Ad comprised systematic and ecological biology, behavioral biology, experimental biology, and technical biology. Geology, petrology, geophysics, and geography respresented subdiscipline Ca-Cd. In between was a "B domain" that offered nearly as many educational concepts and curriculum variations for physics and chemistry as there were instructors to teach them. A chemical biology subdiscipline competed with a chemical physics option, physical crystallography with environmental physics, the latter offering the possibility to combine atmospheric physics with geophysics.[347] Well-informed contemporaries described this B domain as an "agglomerate" with no clear objectives, as "tutti frutti," and a "Babelonian confusion" of one-off professorial events.[348] "In principle, like an asymptote, each professor wanted to have his own version of the course plan."[349]

Course planning was further complicated by the possibility of acquiring a certificate of competence for *Gymnasium* instructors in biology, chemistry, physics, and geography. Such certificates were not issued for teaching gymnastics and sports. "The changes in basic cources and examination subjects related to curriculum reform has resulted in a completely new organization of basic, subject-specific lectures," stated the annual report of 1979. In addition, elective subjects for the final diploma were reorganized to enlarge the range of choices. Finally, "reasoning response to a justified request," a division head could even "approve specific combinations of subjects for the preliminary and final diploma exams."[350]

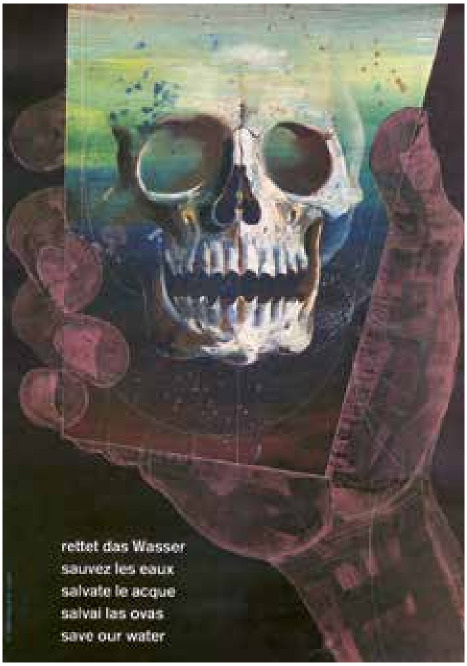
The fact that a multiyear reform program had done little to alleviate the confusing range of "science" offerings did not augur well. Now the issue was once again to "rework" the core curriculum "from the bottom up" to take into account all the subdisciplines, providing explanations, eliminating overlap, adapting the diploma exam rules for 1979 to identified needs, and to draft a "general guide for students in the natural sciences division."[351]

Long lists generally imply much work and little consensus. Division X was under substantial pressure to address the independence aspirations of the biologists and the earth scientists, and was at loggerheads with chemistry and physics over the issue of cooperation. Finally, it was fighting a losing battle for money with molecular biology, which was located in Division VII (agriculture).[352]

No one doubted that Division X's structural problems would ultimately lead to crisis, and in 1989, things came to a head. In a divisional conference, the discussion over who was responsible for environmental lectures grew so acrimonious that the session had to be terminated. Perhaps it was the division's long history of travail that precipitated a new division of enviromental sciences. In any event, after ten years of debate, the curriculum "crisis" ended happily.

Contemporary witnesses speak remarkably consistently of the dramatic consequences of the crisis. The first step was to found a commission. Theodor Koller, the acting head of Division X, arranged by phone with Walter Stumm, director of Eawag (aquatic research institute), to set up a small, four-person commission. The group was tasked with determining the feasibility of developing an environmental program. Appointing a commission was not out of the ordinary, but its composition was. The members were young. As academic greenhorns, they had no territories to defend. They convened under the chairmanship of Dieter Imboden, who as an employee of Eawag could act extraterritorially. Having Theodor Koller as a contact gave them substantial room to maneuver, as by his own admission he had nothing more to prove in the way of academic publication to

Ecological development at the ETH was able to build on a consensus regarding the importance of conserving water that crystallized during the 1960s and 1970s. "Save the water": a poster designed by Hans Erni, 1961.



remain a professor of the ETH. It was Koller who directed the flow of information to the ETH Executive Board. "I knew the Board very well, and knew exactly which channels to use for which purpose."[353]

The commission members were supported by a variety of circumstances and situations over which they themselves had no control. The goal of a subject-oriented, environmental, and thus genuinely integrated approach was clear. Even the schedules of the relevant actors were known.[354] The program slogan was "Advancing on the ground, the water, and in the air." Thanks to years of discussions regarding Division X's curriculum guidelines, both the needs as well as the deficiencies of the curriculum were no secret. In April 1986, the devastating reactor accident at Chernobyl catapulted the environment into public consciousness, "as if we had ordered it."[355] In November 1986, the fateful fire at a warehouse belonging to the Sandoz chemical company at Schweizerhalle, near Basel, similarly increased the awareness of local university politics.[356] The constant threat from the "Nobel Prize-winning" Division IV, as it was known, stimulated the competitive spirit of the environmental scientists. Even the interregnum in the ETH Executive Board had a salubrious effect: "Mr. Ursprung was on sabbatical," and Rector Hans von Gunten endorsed the project.[357] Finally, students supported the effort in the literal sense of the verb. In October 1987, 127 of them expressed their interest in a program of study that was still half-baked.[358]

Contrary to the initial assurances of the environmental scientists, the new program of study now had massive implications for the allocation of resources. Moreover, the consequences of the program for a disciplinary orientation that had previously been taken for granted were now glaringly obvious. The focus on the environment helped to bring different interests under one umbrella. Political issues, public concerns, and science could all now be reconsidered in a fresh light. This corresponded to a new educational emphasis that was manifest not only in teaching but also in political and ETH internal decision processes. The introduction of environmental science can be seen as the "greening" of the ETH. This ecological awakening was above all the expression of a disciplinary uncertainty on the part of the natural scientists; environmental science proved that defining and mastering courses of study wasn't only the province of the traditional science disciplines. Disciplines could even reinvent themselves on a continuing basis, without affecting the focus of instruction – for example, on environmental problems. The ecological development of the ETH was even institutionally scalable, for example, through the Alliance for Global Sustainability, established in 1997. Without disciplinary preconditions, a collaboration was organized between the ETH, MIT, and the University of Tokyo to consider questions of sustainable development. "The AGS today brings together hundreds of university scientists, engineers, and social scientists to address the complex issues that lie at the intersection of environmental, economic and social goals," stated the Alliance's mission statement.[359] Since 2003, ETHsustainability has supported the AGS in its efforts to create and communicate new knowledge "that crosses the boundaries of traditional research disciplines, as well as those of institutions, geography, academia, and industry."[360]

A distinctly "antidisciplinary" development was that known as the molecular transformation of biology.[361] Molecular biology was an experimental and theoretical approach to all of biology that included new imaging technologies, new model organisms, new forms of interdisciplinary cooperation, as well as concepts about molecular information processing. All this was too much to fit into a single discipline. As Hans-Jörg Rheinberger wrote in 1995 in his *Kleine Geschichte der Molekularbiologie* (Brief history of molecular biology), "People are dealing with an extraordinarily complex development that simply cannot be adequately described by merging already existing biological disciplines such as genetics, biochemistry, biophysics, and so forth. Nor do its findings simply represent an additional biological discipline to be added to the evolving canon."[362] At the start of the 1970s, it was nearly impossible to provide a distinct overview. "As a result of the interdisciplinary nature of research goals, bioorganic chemistry, molecular biology, biochemistry and biophysics, microbiology, and biology form a barely distinguishable complex," observed the Swiss Science Council with bemusement in a research report from 1973.[363]

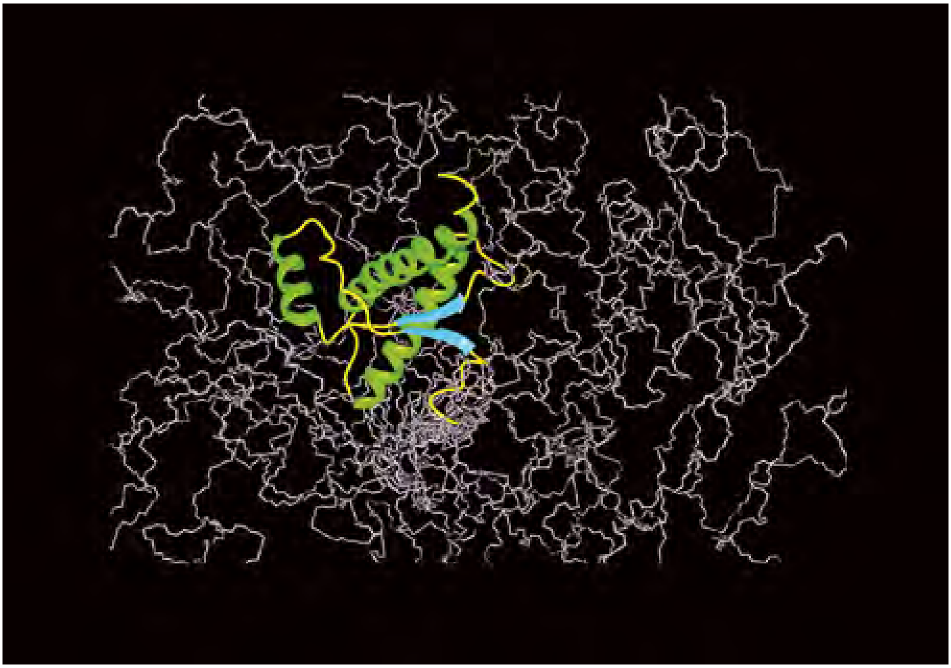
To speak of the "antidisciplinarity of molecular biology" in the final third of the twentieth century is above all to acknowledge the colonization of biology by the exact sciences.[364] In a 1963 report directed to the ETH Council, Vladimir Prelog – professor of organic chemistry at the ETH – already perceived a huge field of knowledge ripe for participation by physics and chemistry. Prelog noted that "successful researchers in this area … on the one hand, mathematicians, physicists, chemists, and biochemists, and on the other hand, biologists and geneticists" would, on conclusion of study of their own discipline, do well to specialize in molecular biology. The analysis of molecular structures went beyond the framework of classical biology, and consequently the capabilities of conventionally trained biologists.[365]

In 1964, as the first professor of molecular biology at the ETH, Robert Schwyzer was well aware of the interdisciplinary nature of his field of teaching and research. "Molecular biology," he wrote to the president of the ETH in 1980, requires training "that is extremely broad and difficult to master in 8 semesters … A molecular biologist must have a solidly based education (chemistry, physical chemistry, physics, mathematics, biology, medicine, and so forth). With this foundation, he can contribute in a major way to molecular biology." Thus, additional training was crucial. "In a group of molecular biologists who come from these various disciplines, each must be able to understand the language of the others and to be able to gauge the limits of each field."[366]

The incursion of chemistry and physics into biology was only one aspect of molecular biological developments at the ETH. In the mid-1970s, a process was set in motion that – despite many detours – eventually led to the veritable biologization of the university. Now it was molecular biology that colonized its natural science and engineering neighbors. Francis Crick's tautological joke, "Molecular biology is whatever interests molecular biologists,"[367] also applied to biology at the ETH. Biology was whatever chemists, physicists, materials scientists, biologists, process engineers, and neuroinformaticists found interesting in biology. Consequently, biology became omnipresent, occasionally to the chagrin of biologists, whose genuine interest in questions of development and reproduction was not shared by everybody keen to exploit biological knowledge.

The biologization of the ETH was influenced not only by molecular biology but also by biotechnology. It benefited from the fact that DNA could be manipulated with the aid of restriction enzymes and that macromolecules could be chopped up into defined fragments. In 1974, members of the ETH's Institute for Microbiology proposed a Swiss center for microbiological engineering. Unfortunately, the proposal coincided with the hiring freeze and a period of serious cost cutting, and consequently went nowhere. In contrast, a related process engineering group at the Institute for Microbiology under the direction of Armin Fiechter was systematically promoted. In 1975, other biotechnology research efforts at the ETH – some in connection with hydrobiological research at Eawag – were carried out within microbiology itself, in agriculture and food sciences, and in pharmacy.[368]

It wasn't long before the ETH Executive Board also realized the science policy potential of biotechnology. As early as 1976, the board decided to push biotechnology, thus giving it policy priority. With respect to the demise of disciplines, the question of location in this decision is particularly interesting. To successfully develop biotechnology – in other words, to realize its potential for integration – the disciplinary environment at the ETH



The development of nuclear magnetic resonance spectroscopy for determining the three-dimensional structure of biological macromolecules won Kurt Wüthrich the Nobel Prize for chemistry in 2002. NMR constitutes a disciplinary interface between physics, molecular, biology, chemistry, and computer-aided visualization techniques. Transformation of a protein structure over a period of roughly one nanosecond, shown by superposing twenty snapshots, 2002.

Zurich would be more advantageous than that in Lausanne. The ETH Zurich had ready access to high-quality chemistry, process, measurement, and control engineering, food sciences, and especially biology, biochemistry, and molecular biology.[369]

The early 1990s saw a return to these considerations. In the meanwhile, biotechnology had made further advances through DNA sequencing, which enabled "the propagation and analysis of such fragments for diagnostic purposes."[370] The transdisciplinary study of interactive protein-DNA complexes and the processes of selective transcription that regulated them represented the new promise of a biotechnological future.[371] In line with the European Federation of Biotechnology, biotechnology was now defined as "the integration of natural sciences and engineering science in order to achieve the application of organisms, cells, parts thereof, and molecular analogs for products and services."[372]

In spring 1994, President Nüesch told the ETH Executive Board that although biology was experiencing "a sharp political and social headwind, biotechnology products and processes had great potential for value creation. Biotechnology was also a soft technology that enabled "ecologically integrated production."[373] Under pressure from a popular

Symbol of the ETH's trend toward biology: neuronal networks connect on a microelectronic chip. Andreas Hierlemann, Institute for Quantum Electronics, 2005.

referendum against gene technology that was launched in October 1993, biology and biotechnology took a common position, at least rhetorically.[374]

The debates preceding the referendum on the so-called *Genschutzinitiative* (gene-protection initiative) raised political awareness among the faculty of the ETH. In the field of biology, it also resulted in a third surge of an antidisciplinary cooperation – the successful founding of Life Science Zurich in 2002. The stated goal of this collaborative platform, which involved both of the Zurich universities, was "strengthening the communication of Life Science activities, both internally and externally," making it a veritable "trading zone."[375] At the same time, it aimed to "combine the resources of the University and the ETH and use their synergies optimally." Life Science Zurich subsequently developed into a collaboration and communication network of biological research activities that proposes to "exhibit broad interdisciplinarity with no boundaries." The life sciences "encompass the experimental natural sciences, biology, chemistry, and physics, including the integrated methods from mathematics and information technology, as well as clinical medicine," according to the organization's website.[376] With the creation of Life Science Zurich, the long-term trend toward the biologization of the ETH found a provisional culmination point.

The fading away of disciplines in no way represented a dissolution of the university or a spread of academic anarchy. The days are long gone in which Paul Feyerabend, in *Against Method: Outline of an Anarchistic Theory of Knowledge,* caused pandemonium among scientists by pointing out the limits of scientific disciplines and extolling an anarchical approach to questioning scientific assumptions.[377] Long before most theorists noticed, science and the university had accepted an antidisciplinary and highly productive new confusion.[378]

At the close of the twentieth century, entire academic fields at the ETH stopped claiming theoretical purity, overcame their obsession with reductionism, and defined their research and teaching explicitly in terms of practical application. Environmental sciences were not alone. Even biology abandoned systematics and took a molecular perspective. At the same time, many other fields adopted the prefix "bio" and applied molecular biology, biotechnology, physical chemistry, and computer-supported manipulation and visualization processes to the study of "living material." Biology pervades the entire ETH. This development is particularly obvious in the use of materials science and biotechnology, for example, to engineer tissue or to plant a neuronal network on a CMOS chip. "Hybrid" no longer signifies something that natural scientists treat as artifact and that engineers manufacture. Technoscience hybrids blur the boundaries between engineering and science, making interdisciplinarity increasingly routine in research and teaching at the ETH.

SUMMARY

"A pillar of light that illuminates a more enlightened, more humane future for all humankind" – that is what the *Neue Zürcher Zeitung* expected in 1855 from the teaching of economics in particular, and what the federal polytechnic promised the young state in general.

The polytechnic was designed to ensure a more humane and practical future for Switzerland. Its curriculum needed to be able to detect potential, and to spot what was important, not only to illuminate a better future but also to shape it. Precisely for this reason, the purpose of the institute was to train students, make knowledge available, and combine both products to create the future.

Continuing the metaphor, the running of such a future-transforming device was a responsible undertaking. The machine periodically needed overhauling, and it experienced partial shutdowns, and both small and large expansions. All this work had to be done while the machine was operating. Modifications and revisions imposed themselves whenever the machine was no longer producing the future it promised, and on which students, professors, politicians, officials, and entrepreneurs pinned their hopes.

The ETH also went through long periods of structural clarity. Sometimes exhaustive debate year on year brought about only minimal change, but at least the rules under which the debates took place were clear to most of the participants. At other times the institution would be entirely remade in fairly short order. The debate over fundamentals arose with surprising regularity, every six decades from 1848 to 1908, and again after 1968.

A fundamental debate: Anchoring the Swiss vision post-1848

At the beginning of 1854, Switzerland's old dreams of a federal university were mothballed in a feat of parliamentary consensus. Instead, on 7 February 1854, parliament enacted a law on the "Federal Polytechnic School together with a school for advanced study of the exact, political, and humanistic sciences." The founding law was a new beginning, but it also marked the culmination of a long debate. Already in the eighteenth century, enlightened souls like Isaac Iselin had dreamed patriotic dreams of higher education, and at the time of the Helvetic Republic, Minister Philippe Albert Stapfer developed the concept of an all-Swiss university. With the founding of the federal state in 1848, these ideas took root. As early as its second meeting, the new parliament argued extensively about whether in addition to the existing cantonal universities, a national educational institution ought to be set up. As a result, the university issue was closely linked with the development of the state.

The academic issue was extremely controversial owing to Switzerland's multilingualism. In addition, Catholic and rural cantons wished to avoid cultural domination by the Protestant urban centers of Geneva, Bern, Basel, and Zurich. These in turn feared com-

petition from a national university because they had their own universities to support. The project only commanded a majority after it was refocused on technical subjects. Thus, the creation of the polytechnic institute in 1854 can be described as the polytechnic cornerstone of the old Helvetic dream of a national university.

The renunciation of the classical university canon was more than just a necessary precondition. It was also a deliberate decision directly connected to an emerging project of technical-industrial modernity. The federal polytechnic was expected to generate knowledge for building a future national infrastructure and to train a local, nationally minded and technology-savvy elite.

The great debate over the university's founding had three main benefits. First, it grounded the project in tradition and, even before its opening, gave the more sober polytechnic institute the aura of a university. Second, the debate explored the relatively narrow institutional context – between foreign models, cantonal guidelines, professional aspirations, and industrial-commercial demands – within which the university founding would somehow have to fit. Third, the debate established a federally secured program, thanks to which the polytechnic materialized as a national niche product for the training of engineers.

Nation, profession, middle class: Educating nineteenth-century engineers

After the fierce debate over its creation, the new institution entered a stable and productive phase of construction. Up to the turn of the century, it took its place in the political and economic landscape of Switzerland and in the realm of engineering education in Europe. The polytechnic and its graduates were able to enhance their social position on several interrelated and mutually overlapping levels. First, on the institutional level, the polytechnic became more like a university, and eventually transformed itself from a polytechnic school to a technical university. Second, through a complex, nonlinear process, the engineering disciplines were able to disentangle themselves from the natural sciences and to hold their own as independent engineering sciences. Third, the social standing of engineers with advanced education began to rise. They were no longer merely trained technicians but academic engineers.

The polytechnic was an important institution that could help to promote the young Swiss federal state nationally and internationally. Although the school did not, as was both hoped and dreaded, prove to be the training ground for nationally minded politicians, the technical elites in the cantons and – as the national administration slowly developed – the federal government were populated with graduates of the polytechnic. Secondary and higher education in Switzerland was substantially transformed by the federal institution, and national standards for secondary and advanced specialist training were established.

The polytechnic of the nineteenth century was primarily a training institution. The demands of school life, the needs of industry, and gradually emerging research interests all had to be carefully balanced. Owing to the tension between theory and practice, particular attention was paid to teaching. How should the curriculum be designed? With an emphasis on drafting, on measurement, on mathematics, or on practical matters of industrial production? The production, preservation, and last but not least, the applicability of polytechnic-generated knowledge depended on how these questions were answered. Teachers such as Franz Reuleaux were able to formalize, with some success, the practical construction activity they observed in industry. The real breakthrough of the engineering sciences, however, had to await the building of laboratories in the 1880s and 1890s. Their facilities made it possible to deepen theoretical and practical knowledge through scientific experimentation and to make the hands-on laboratory an integral part of education.

Trade and industry profited from the graduates of the polytechnic, although transferring knowledge from the school to the factory required a considerable amount of translation. The importance of the polytechnic institute varied by industry. While the influence of the Zurich institution on developments in the machinery industry of the nineteenth century was still modest, polytechnic graduates shaped the evolution of chemistry into a specialty industry of global significance.

The extremely fruitful development work of the first decades also had a downside over the long term. Corrections to the successful institution were increasingly effected only with great effort. At the beginning of the twentieth century, in view of the academic dynamics deployed by the cantons, the connection of the polytechnic to the federal state threatened to become a corset, and the success of earlier days was replaced with internal paralysis. Contradictions between demand and opportunity were not easily resolved, and it became obvious that the federal polytechnic was following its own special path. It became less and less like the German technical universities, which in 1900 were the measure of all things. At the turn of the century, when discrepancies vis-à-vis other countries were increasing and social conditions in Switzerland were starting to reveal symptoms of a crisis, the polytechnic entered a period that would be dominated by a controversial reorientation.

Setting a new course: The polytechnic becomes a “real” university after 1908

In 1911, the polytechnic was renamed “*Eidgenössische Technische Hoschul*e” (ETH) meaning “Federal Institute of Technology” in English. Thus ended an intense debate on reform that had gone on for several years. The polytechnic’s former moniker was very popular and would long continue to live in the affectionate term “poly”. But it had become a burden: To be a progressive polytechnic, you had to be called a technical university, along the lines of the long-standing German model. The name change formally acknowledged a realignment of the school, which in previous years had undergone three major changes. First, in 1905 and 1908, the ETH adopted the so-called separation agreements from the University of Zurich, the city of Zurich, and the canton. Buildings, collections, and facilities that up to then had been jointly administered and used jointly under both federal and local authority were now divided, and responsibilities redistributed. Simplifying the legal situation enabled the school board to embark on long-desired construction projects. Second, the ETH undertook a massive reorganization of the curriculum. Beginning in 1908, a so-called normal curriculum was developed for each subject to make programs of study as efficient as possible. These guidelines were no longer compulsory, like the old curricula, but allowed some elective courses already in the very first year. The polytechnic's pupils metamorphosed into university students. Third, in 1908 the ETH finally gained the right to award doctorates, thus putting the school on the road to becoming an academic research institution. Chemistry in particular benefited from the innovation, which it had consistently pushed for. Six chemistry PhDs were awarded already in 1909, the first year of the new system.

Business, politics, and research: New alliances for a new century

As a technical university, the ETH gained considerable academic autonomy and could then engage in sustained cooperation with government and industry. One key to the school's new relationship with its environment was the successful combination of theoretically formulated and experimentally controlled knowledge. Applied research and basic research began to overshadow teaching. This shift made the upgrading of the institutes and equipment a necessary precondition for scientific success, which in turn required new financing models.

The criticism of technology, which was fairly widespread after the catastrophe of the First World War, took a specific discursive turn at the ETH that served to uphold humanistic educational ideals in engineering education. The result was a technocratic humanism that influenced the self-perception of many Swiss engineers right up to the 1960s. Doubts about the imagined unity of science also increased. The process of specialization seemed to be driving not just the natural sciences and the humanities, but also various natural and engineering science disciplines farther and farther away from each other. The threatened loss of generalizability of methods and models was answered by the idea of a chain of forms of knowledge. In the opinion of one ETH rector voiced during the interwar years, such a chain would lead from the most abstract to the most concrete forms of knowledge, that is, from mathematics to crystallography and materials science and thence to the economic and cultural interests of the nation.

This chaining required considerable organizational imagination. Following the First World War, the ETH intensified its cooperation with industry on joint-financed institutes. Thus, the hydraulics laboratory (1930) and the institute of industrial research (1937) bound the ETH in a corporatist safety net of federal, cantonal, and industrial foreign relations.

At the National Exhibition of 1939 in Zurich, the ETH was omnipresent both in terms of physical equipment, and science and ideology. Since 1936 at least, the university had participated in the “national education” in the context of “intellectual defense.” At the same time, the expanding interpretive horizon of nationalism was also helping to push the idea that the university was economically useful – a new dynamic. The federal government’s job-creation program provided funds for the promotion of scientific research. In this context, Federal School Council president Arthur Rohn developed an innovative science policy approach, which led at least indirectly to the founding of the Swiss National Science Foundation in the 1950s.

In contrast, contacts with the army, in particular the war office’s War Technology Division, were disappointing for the School Council. Unlike the belligerent states, Switzerland possessed no significant military-industrial-scientific complex. The interdependence of such interests arose only in the wake of the Cold War.

Beginning in 1933, the racist policies of the Nazis destroyed German academic culture and set a wealth of intellectual talent in motion that could have benefited Switzerland. However, the country’s restrictive policy on refugees, which encompassed scholars living in exile in Switzerland and at times included a clearly anti-Semitic naturalization procedure, prevented the emergence of a “university in exile.” Luminaries such as Wolfgang Pauli temporarily fled to North America.

All in all, however, as the flagship of the state the ETH sailed with considerable success, propelled by the patriotic winds of *Landigeist* (spiritual homeland), *Reduitmentalität* (bunker mentality), and consensus democracy. The college was thus able to transform economic growth into academic growth – always with reference to its importance for the prosperity of all. In this way, the ETH also played the role of a national information center, carefully registering scientific and social signals. In the 1950s, the university was investigating the local costs of modernization, such as water pollution, and at the same time successfully initiated international research collaborations. By the early 1960s, however, it became clear that the Swiss model was no longer up to coping with the dynamics of the international scientific establishment, which was now unquestionably dominated by the United States.

The societal laboratory: Testing the bounds of higher education and politics post-1968

The orientation, growth, and structural crisis of the years between 1968 and 1973 affected the ETH on several levels. New forms of teaching and new course content were also the subject of debate, as were new regulations and laws.

In 1968, the federal parliament adopted a new ETH law, which entailed the takeover of the Ecole Polytechnique de Lausanne by the federal government. However, the text of the law left the question of student participation in administrative matters largely open, prompting the students to launch a referendum against it. In June 1969, the law was rejected at the ballot box. The referendum had many consequences for the ETH, not least of which was the bringing of reform issues to the fore.

The launch of the referendum by the students was itself a direct affront to the then political and academic establishment. But the victory of the student body also showed that the position of "the ETH" in no way coincided with that of the ETH Executive Board. Rather, it was now clear that student participation was a problem. Moreover, a whole series of transitional arrangements were necessary to negotiate federal higher-education policy in general after the surprise rejection of the law. Federal science policy became even more differentiated and abandoned its hitherto nearly complete fixation on the ETH.

This crisis was followed by a debate-fueled new orientation that developed in short order but under extremely difficult personal and political conditions. At the beginning of the 1970s, the Federal Council's general hiring freeze meant that structural problems could be solved only by redistribution, not by growth.

All about flexibility: Managing science and technology in the postindustrial world

The last quarter of the twentieth century will be remembered in history as an era of flexible exchange rates and life trajectories, as the age of computerized information processing, and finally as an era of globalization. Every university was affected by these processes – and nearly every one found a way to deal with them and to draw a benefit from them. At ETH Zurich, developments evolved in three stages. First, the institutional reforms and experiments of the 1970s tested the notions of more flexible resource allocation, curricular change, and information systems. The 1980s also gave rise to analogies between universities and business enterprises, which initially shocked many. Finally, the coming into force of a new ETH law in 1993 gradually gave budgetary autonomy to the entire university, which then passed it on to the departments.

Analyses conducted by the firms of Hayek Engineering and Häusermann + Co. had a catalytic effect on flexibility. As a result of these studies, the ETH was divided into a matrix structure, which at the time was popular in industry. Departments, which were responsible for research, combined with the old divisions, which were responsible for organizing teaching. The assignment of professors to the departments and divisions consequently became more flexible. This change was consistent with the increasing importance of research in academic financing and in the budget of the university.

At the same time, organizational requirements in teaching were also increasing, especially in the 1980s. Three new course programs (informatics, materials science, and environmental science), numerous postgraduate courses and continuing education, a reorganization of the science department, as well as reforms to the core curriculum made it clear that even a university had to adopt change management in teaching.

Although the matrix structure was already being dismantled by 1993, its introduction in 1987 had resulted in major shifts in the power structure of the university. The effect of flexibility proved sustainable.

Of course, flexibility requires a quid pro quo. At the ETH Zurich, this took the form of global networking, IT upgrades, and a stepwise evolution to a scientific-technical university. Since the 1970s, recruiting has become increasingly international. In the 1980s, evaluations and rankings proliferated, making the ETH competitive on an international level. And as the 1990s drew to a close, intensive work had begun on the Europeanization of degree programs in the framework of the Bologna reforms. At the same time, globalization was evident in the fact that the ETH was competing internationally for outstanding doctoral students. Finally, the verbal, argumentative, and media pressure of recent decades to unify the scientific publication system cannot be underestimated.

In any event, IT-based flexible structures and the changing world of the ETH mean that the university must come up with new coping strategies daily. In recent years, the ETH Zurich has evolved into a science and technology university whose members understand the laws of supply and demand very well, who know how to exploit sales and consumer markets for information as well as how to perform as experts on self-governance and change management.

In so doing, the members of the ETH are transforming the future even more radically than the founders of the polytechnic ever dreamed. The university administration is making decisions that are ever more far-reaching and forward-looking – both in designing programs of study and in appointing faculty. This is due to the fact that university research must remain clearly differentiated from the practical orientation of the applied sciences. Thus, research deals with things that may become manufacturable in an ever more distant future.

At the same time – and this is a new phenomenon – these days, planning and reporting in a context of change management happen very quickly; the future depends increasingly on the present. Not for nothing did the ETH welcome its jubilee year 2005 visitors to the world of "tomorrow." In the meanwhile, the university's reporting "sensors" are registering the smallest future changes at this very moment.

This highly flexible institutional machine is sensitive to today's database signals and media effects. The fine-tuning that it enables in real time, in other words, the university's IT-based, coordinated "listening," represents a delicate balance between shared governance and the principle of authoritarian control that we also call leadership.

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David Gugerli, Patrick Kupper, and Daniel Speich

NOTES

Introduction

1 Bundesblatt 2/1851, 568.
2 Rohn 1930, 14.
3 ETH-Life, 03/03/2004.
4 Parts of the website also appeared in book form: Burri and Westermann 2005; Schweizerische Akademie der Technischen Wissenschaften 2005. In addition, the jubilee also occasioned a new architectural history of the ETH: Oechslin 2005.
5 Rotach et al. 1985, 5.
6 Koselleck 1975; Fukuyama 1992.
7 "Bericht und Anträge der Majorität der nationalräthlichen Kommission zu den Gesetzesentwürfen, betreffend Einrichtung einer eidgenössischen polytechnischen Schule," Bundesblatt 1/1854, 1–44, here 7 f. On the concept of the future, see Hölscher 1999, 34 ff.
8 Similarly, Weber 2002, 9: "The university is an institution for the transfer and production of advanced knowledge of (not everyday, but complex, scientific) facts and methods."
9 On the symbolism and metaphor of machines, see Mumford 1970; Agar 2003; Jakob 1991, 234 ff. From the wealth of literature on the mutual dependence of technology and society see, for example, Lenoir 1992; Latour 1993; Gugerli 1996; Jasanoff 2004; Etzkowitz and Leydesdorff 1997. This approach runs counter to systems theory, which holds that subsystems such as politics, science, and economics can be clearly distinguished. See Weingart 2001.
10 The triad of power, knowledge, and subject runs through all of Foucault's work. Cf. the introduction to Foucault 1992. In recent years, Foucault's ideas have been productively applied in so-called governmentality studies. See Burchell et al. 1991; Bröckling et al. 2000; Krasmann 2002; Bratich et al. 2003.
11 Rheinberger describes a cycle as the "appearance of unanticipated experiences in the development of experimental systems …, which lead to solutions to problems one could hardly have initially expected the system to solve." Rheinberger 1994, 201. See Rheinberger 1992; Hagner, Rheinberger, and Wahrig-Schmidt 1994.
12 Schumpeter 1939; Siegenthaler 1993; Siegenthaler 1987; Koselleck 1979; Koselleck 2000.
13 See Hobsbawm 1979; Hobsbawm 1987; Kocka 2001; Bauer 2004.
14 See Szöllösi-Janze 2004; Vogel 2004a; Vogel 2004b. See also Raphael 1996; Ritter 1992.
15 van Laak 2001a; van Laak 2001b. See also Szöllösi-Janze 2004. For a history of science treatment of this period, see vom Bruch and Kaderas 2002, although they see no unity in the era. See Hobsbawm 2003 on the age of extremes.
16 See Raphael 1996; Weingart 2001; Kupper and Speich 2004; Gugerli, Kupper, and Speich 2005.

Chapter 1

1 NZZ, No. 289, 16 October 1855.
2 Constitution of the Swiss Confederation of 12 September 1848, Article 1.
3 NZZ, No. 289, 16 October 1855.
4 Deschwanden's diary entry for 26 September 1855, cited in Gyr 1981, 137. Westermann 2005b.
5 NZZ, No. 289, 16 October 1855.
6 On the Carolinum and the University of Zurich, cf. Gagliardi, Nabholz, and Strohl 1938.
7 Quoted in the insert to the NZZ, No. 289, 16 October 1855, 2. On the Swiss educational infrastructure in the eighteenth and nineteenth centuries, see Brändli-Traffelet 2002. On Stapfer see Guggenbühl 1955, 14, and Rohr 1998 and Rohr 2005. On the "Memorandum of the Swiss Directorate" and Stapfer's much-cited statement cf. Strickler and Rufer 1886, 604.
8 Gugerli and Speich 2002; Speich 2003.
9 Cited in the insert to the NZZ, No. 289, 16 October 1855, 6 ff. The NZZ printed the opening speeches in full.
10 Cited in the supplement to the NZZ, No. 289, 16 October 1855, 6.
11 Oechsli 1905, 35–222. An essential reference.
12 On Alfred Escher cf. Gagliardi 1919. See also Schnabel 1925, 49, who, based on Escher's contacts, showed that the Zurich polytechnic was an adaptation of the Karlsruhe polytechnic. Oechsli's (1905, 106–109) work on the parliamentary debate in particular bore the imprint of his painstaking research and strong personality. On Francscini see Calgari 1957. See also

Guggenbühl 1955, 13–78, who described Franscini as an "indefatigable" and steadfast worker.

13 Searching for origins is popular, but historically not particularly productive. For the ETH see Guggenbühl 1955, 13–22. In contrast, it may prove more fruitful to delve into the posthumous construction of beginnings in the sense of an "invention of tradition" (Hobsbawm and Ranger 1983). For the constitutional history of Switzerland, see Kölz 1992; Kölz 2004.

14 For the Linth correction see Speich 2003, and for its influence on the federal constitution of 1848 especially 220–223.

15 Wyss 1867, 10. For the history of the constitution see Nabholz and Kläui 1940; Rappard 1948; Bucher 1980; Studer 1998b; Mooser 1998; Ernst, Tanner and Weishaupt 1998; Kölz 1998; Winter 1998; Kölz 2004.

16 Cited in Guggenbühl 1955, 27. See also Fetscherin 1876, 764 and the legislative and executive council of the Swiss confederacy 1848.

17 At length: Oechsli 1905, 38–56.

18 See Jessen and Vogel 2002a.

19 Kölz 2004, 477–495.

20 Escher, 1 f.

21 Kölz 2004, 487.

22 See Kaufmann 1948; Böschenstein 1980; Altermatt 1991a; Altermatt 1991b, 293; Fink 1999, 169.

23 BAR, E80, Vol. 85, Folder 631, Departement des Innern an den Bundesrat, 21/4/1849.

24 See Waser 1775; Schinz 1783–1784; Franscini and Hagnauer 1829; Leemann 1839; Gonzenbach 1845. On Waser see Graber 1980. On the history of statistics in Switzerland see Kummer 1885; Jost 1995; Busset 1995; Busset and le Dinh 2001; Pfister 1995. See also Gugerli and Speich 2002, 64–68.

25 Responses came from Lucerne, Uri, Schwyz, Obwalden, Nidwalden, Glarus, Zug, Freiburg, both Appenzells, Graubünden, Thurgau, and Geneva. The five institutions were the high schools in Lucerne, Einsiedeln, Freiburg, and Chur, as well as the Academy of Geneva. BAR, E 80, Vol. 85, Folder 631, Federal Department of Home Affairs, 21/4/1849.

26 BAR, E 80, Vol. 85, Folder 631, Departement des Innern an den Bundesrat, 21/4/1849, 10 f. A synopsis of the answers was published in the government's report in the Bundesblatt (Federal Register). For the request of Nidwalden, cited here verbatim from the report of 1851, see Bundesblatt 2/1851, 558.

27 "Bericht über die Errichtung einer eidgenössischen Universität an den hohen Bundesrath erstattet von der hiefür niedergesetzten Kommission," Bundesblatt 2/1851, 31–69, quote 14

28 BAR, J 1. 67, Vol. 2, Folder 10, Bundesrat to Alfred Escher, 7/5/1851.

29 BAR, J 1. 67, Vol. 2, Folder 10, Bundesrat to Alfred Escher, 7/5/1851.

30 See their publications, such as those of the natural historian and numismatician Rodolphe Blanchet: Blanchet 1842; Blanchet 1843; Blanchet 1850; Blanchet 1856; Guillaume-Henri Dufour, the military engineer, topographist, and general of the federal troops in the Sonderbund War: Dufour 1820; Dufour 1822; Dufour 1823; Dufour 1827; Dufour 1830; Dufour 1833–1847; Dufour 1834; Dufour 1847; the Basel geologist Peter Merian: Merian 1821; Merian 1838, as well as the political philosopher Ignaz Paul Vital Troxler: Troxler 1829–30; Troxler 1835. See also the entries in the Historisch-biographischen Lexikon der Schweiz: Auguste Moschard directed education in Bern, the classical scholar Rudolf Rauchenstein was principal of the high school at Aarau, and Alexander Schweizer was a professor of theology at the University of Zurich. The teacher and Catholic priest Josef Anton Sebastian Federer was a highly distinguished commentator.

31 See Oechsli 1905, 63.

32 On the first committee report see Bundesblatt 2/1851, 3–169. For the reaction of the Federal Council see the Bundesblatt 2/1851, 557–603. See Oechsli 1905, 67–82.

33 "Bericht über die Errichtung einer eidgenössischen Universität an den hohen Bundesrath erstattet von der hiefür niedergesetzten Kommission," Bundesblatt 2/1851, 31–69, quote 9 and 23.

34 On the minority report, see Bundesblatt 2/1851, 109–116.

35 "Bericht des Bundesrates zu den Gesetzentwürfen, die Errichtung einer eidgenössischen Universität und polytechnischen Schule betreffend," Bundesblatt 3/1851, 557–603, quote 568

36 "Majorität der nationalräthlichen Kommission zu den Gesetzesentwürfen, betreffend Errichtung einer eidgenössischen Universität und einer eidgenös-

sischen polytechnischen Schule," 4/8/1853, Bundesblatt 1/1854, 31

37 See Oechsli 1905, 95. "The polytechnic was treated as a satellite that was barely talked about." Here Oechsli is referring to the press poll of January 1854.

38 On the development of the telegraph in Switzerland, see PTT 1952–1962; Pieper and Künzi 2000. On the railway legislation and development of the railways in Switzerland in the nineteenth century, see Balthasar 1993; Bärtschi 1997.

39 In August 1851 the National Council appointed Escher, Castoldi, Blanchenaz, Stämpfli, Trog, Steiger, Pioda, and Kern to a committee. On their motion for postponement see the Bundesblatt 3/1851, 203–209. Oechsli 1905, 83.

40 In summer 1852, petitions were leveled especially at the Federal Assembly, see BAR E 80, Vol. 85, Folder 631 as well as for a schedule Bundesblatt 1/1854, 42–44.

41 Oechsli 1905, 89 f.

42 NZZ, 9/2/1852.

43 Law covering the construction and operation of railways in the regions of the confederacy, 28 July 1852. See also "Bericht über die Finanzverhältnisse des eidgenössischen Bundes, veranlasst durch die zur Prüfung der Frage über Errichtung der höhern Lehranstalten niedergesetzte nationalräthliche Kommission," Bundesblatt 1/1854, 63–97.

44 Bundesblatt 1/1854, 7 f.

45 Oechsli 1905, 92. On Keller, see Lang 1998, and on Federer, Zeller 1964.

46 On the bourgeois public sphere, see Koselleck 1959; Habermas 1986; Im Hof 1983; Braun 1984.

47 "Religious differences are only dangerous when they secretly churn up the foundation of national life; they are not dangerous when they venture openly into the scientific arena," Federer, cited in the NZZ, 24/9/1853. See also BAR, E 80, Vol. 149.

48 Augsburger Allgemeine Zeitung, 3/1/1854; Basler Zeitung, 4/1/1854, cited in Oechsli 1905, 93. Oberländer Anzeiger, 8/1/1854, cited in Wehrli 1983, 15. Le Pays 1854, No. 4, 5, 6; Nouvelliste Vaudois 1854, No. 5, 6, 8, 9, cited in Oechsli 1905, 95.

49 NZZ, No. 16, 16/1/1854.

50 NZZ, No. 22, 22/1/1854.

51 Oechsli's description of the debate is rich in detail, but the content is less convincing. In particular, his explanations of the positional shifts of members of parliament are somewhat quixotic. Oechsli 1905, 97–136.

52 Cited in Der Bund, 20/1/1854. See also NZZ, No. 19, 19/1/1854.

53 NZZ, No. 21, 21/1/1854; Der Bund, 22/1/1854.

54 NZZ, No. 24, 24/1/1854.

55 Der Bund, 24/1/1854 and 27/1/1854; NZZ, No. 28, 28/1/1854.

56 Kölz 2004, 478–484.

57 BAR, E 80, Vol. 148, "The undersigned ... request urgently that the draft bill concerning the fed. university be thrown out," NZZ, No. 26, 26/1/1854.

58 NZZ, No. 33, 2/2/1854.

59 NZZ, No. 33, 2/2/1854.

60 Oechsli 1905, 123–124.

61 NZZ, No. 36, 5/2/1854; Oechsli 1905, 123–127. See also ibid., n. 77, in which Oechsli attempts to minutely reconstruct the days between 1 and 3 February.

62 Oechsli 1904, 122–136.

63 Oechsli 1905, 133; Der Bund, 24/1/1854.

64 Oechsli 1905, 145–162, 382 f. BAR, J 1. 67, Vol. 2, Folder 12.

65 Deschwanden was not selected at first, though he subsequently succeeded. "I was especially annoyed that Deschwanden was passed over. I can only attribute it to the fact that, though he may not be considered fully a Zurcher, he is at least perceived to represent Zurich interests." Jonas Furrer to Alfred Escher, on 19/3/1854, cited in Gyr 1981, 101.

66 See Bolley's report to the Federal Council, "Hauptinhalt der Verhandlungen der Eidgenössischen Commission zur Entwerfung der Reglemente für das Polytechnikum," of 17/4/1854, BAR, E 80, Vol. 85, Folder 634, as well as the highly self-contradictory rationale in "Bericht über den Entwurf zu einem Reglemente für die eidgenössische polytechnische Schule," Bundesblatt 3/1854, 184–187. See also Oechsli 1905, 145 f. as well as Straumann 1995, 77–108.

67 Bundesblatt 3/1854, 231–235.

68 "Bericht über den Entwurf zu einem Reglemente für die eidgenössische polytechnische Schule," Bundesblatt 3/1854, 143–236.

69 NZZ, No. 109, 19/4/1854; cf. Oechsli 1905, 139–144.

70 Deschwanden's diary entry of 24/4/1855, cited in Gyr 1981, 122 f.

71 Oechsli 1905, 171–221; Zetti 2005. See also below, Chapter 2.

Chapter 2

1 Koristka 1863, Foreword, 23. Regarding the report, see Wurzer 1965, especially 31–35.
2 Lexis 1904, 11. See Guagnini 2004, 500–504; Manegold 1989, 216–221; Dienel 1995, 330; König 1981b, 51 f. On the influence of Semper's main building on the architecture of German universities, see Hildebrand 2005, 85.
3 See also Manegold 1970; König 1981b; König 1998b.
4 See Brändli-Traffelet 2002.
5 For statistical data see Leemann and Speich 2005b; Leemann and Speich 2005e; Speich 2005b. Regarding teachers, see also Oechsli 1905, 272 ff.
6 Scheffler 1891; Ebering 1905.
7 On historian Theodor Mommsen's clearly ambivalent feelings toward Zurich beginning in 1852, see Rebenich 2002, 72 ff. Regarding the intellectual openness of Zurich during the second half of the nineteenth century, see Tanner 1995, 449 ff.
8 Comberousse 1879, 307–312.
9 See Guagnini 2004; König 1998b; Manegold 1989; Torstendahl 1993.
10 See Mooser 1998; Tanner 1998a.
11 Germann 2004. See also Fink 1999.
12 Schweizerische Bundeskanzlei 1854, 12.
13 Wehrli 1983, 14–20. On political elites in the young federal state, see Tanner 1998a.
14 See Gugerli and Speich 2002, 61–74. The federal civil service, including general administration and customs, grew as follows: 1849: 489, 1875: 1093, 1900: 4684, 1915: 5298. Germann 2004.
15 Halbeisen and Lechner 1994, 36; Siegenthaler 1996, 946 f. From 1900, contributions to the polytechnic and its affiliated institutes constituted the overwhelming portion of the government's education budget. Smaller amounts went to archives, scientific societies, and committees. Halbeisen and Lechner 1990, 27 f.
16 For more on this liberal idea and its influence on gender roles, see Tanner 1998a.
17 See Mooser 1998, 56 f, which also contains references to the older literature. There is no consensus on whether federal education policy represented a compromise within the liberal victors of the Sonderbund War (Mooser 1998) or a concession to the losers (Jorio 1997).
18 On the development of elementary schools (Volksschule) in Switzerland in the nineteenth century, see Criblez and Hofstetter 1998; Criblez 1999. See also Zimmer 2003, 177 ff.
19 See von Greyerz 1980, 1063 ff.; Ruffieux 1983, 669 ff.; Halbeisen and Lechner 1994. On the "Schulvogt", see Stadler 1984, 561 ff.; Widmer 1992, 283 ff.
20 Fueter 1928, 62 f.
21 Gottschall 1991. On the Federal Council House, see also Studer 1998a, 8–12. For Semper, see Nerdinger et al. 2003.
22 NZZ, No. 214, 1/8/1880.
23 Cited in Oechsli 1905, 368 f.
24 See Gugerli 1999a; Gugerli and Speich 2002, 61–74. On forestry, see also Pfister and Brändli 1999, 303–312; Schmid 2001; on hydraulic engineering, see Speich 2002, 47.
25 Kappeler 1873; Kappeler 1878; Eidgenössische Polytechnische Schule 1889. On the Swiss presence at the World's Fairs, see Meile 1913, 133–136, and on the history of world expositions in general see Kretschmer 1999; Radkau 1989, 148–155.
26 Oechsli 1905, 368.
27 Leemann and Speich 2005b; Speich 2005b.
28 On nineteenth century nationalism, see Anderson 2006; Winkler 1985; Hobsbawm 1992.
29 On 1871, see Urner 1976, 208–222. On the bomb incident, see BAR, E 80, Vol. 86, No. 657. See also Gruner and Dommer 1988, 225 ff.
30 See Gnehm 1904. The phenomenon of overproduction occurs repeatedly in the discourse of higher education. See, for instance, Erb 1943. See also this volume, Chapter 4, 202 f. Charle's claim that Swiss universities relied on the fees paid by foreigners (and women) (Charle 2004, 47, 72) does not hold, at least for the ETH. In fact, proceeds from tuition fees constituted on average roughly 15 percent of the entire income of the school (Eidgenössische Polytechnische Schule 1889, 69–71). On the other hand, higher enrollment did help to justify requests for higher government subsidies.
31 See Albrecht 1987, 479–485; König 1990, 36. An overview of the fee schedules for German and Austro-Hungarian technical universities is provided as an annex to Schweizerischer Schulrat 1908a.
32 BAR, E 80, Vol. 88, Folders 665–667, Schreiben der Finanzdelegation der eidgenössischen Räte, Nationalrat A. Eugster an das Departement des Innern, 17 February 1908. On the contemporary debate over the

"foreigner issue," see Arlettaz and Arlettaz 2004, 55 ff.

33 Schweizerischer Schulrat 1908a, 7–10. See also the speech by Director Gnehm at the opening of the 1904/05 schoolyear: "Several years ago, we declined to seriously entertain such a proposal [obstructing or forbidding admission to foreigners]. Since then, a curious change in opinion has taken place in certain circles, largely induced and nourished by events in neighboring states. We consider it to be a symptomatic phenomenon that will soon pass." Gnehm 1904, 9. On the issue of higher tuition fees for foreigners, see also this volume, Chapter 4, 202 f.

34 For more on this subject, see Jessen and Vogel 2002a.

35 Tyler 1906, 6.

36 See "Bundesgesetz betreffend die Errichtung einer eidgenössischen polytechnischen Schule, vom 7. Februar 1854," Oechsli 1905, 69 f. On 1881, see below.

37 National Councillors Augustin Keller (Aargau) and Andreas Rudolf von Planta (Graubünden) as well as Neuchâtel States' Councillor Aimé Humbert were named as alternates.

38 See Lang 1998.

39 Cited in Altermatt 1991a, 63.

40 The catalyst was the massive popular rejection of a plan to nationalize the railways. See Degen 1998, 146–148; Altermatt 1989, 140–146.

41 However, in the nineteenth century the federal president still stood out from the rest of the Swiss cabinet. He acted as a "shadow king," representing the government both at home and abroad. Altermatt 1991a, 26.

42 Enshrined in the founding charter, in 1857 this provision induced Glarus States' Councillor Johann Jakob Blumer to turn down his appointment to the School Council presidency. Instead, Thurgau States' Councillor Karl Kappeler was named Kern's successor. Oechsli 1905, 269.

43 Tyler 1906, 6.

44 Guggenbühl 1955, 83; Schmid 2000, 1129. Guggenbühl's division of the history of the polytechnic by presidential term of office, while hardly original, does give his account a certain authority.

45 It did not escape completely unscathed, however. In January 1889, for example, in a report on the polytechnic, the Nidwaldner Volksblatt accused the government of anti-Catholic behavior. NZZ, 8/1/1889.

46 NZZ, No. 255, 12/9/1855; NZZ, No. 294, 21/10/1855.

47 See Speich 2005b.

48 Cited in Gagliardi, Nabholz, and Strohl 1938, 613 f. See Burri 2005d.

49 See "Botschaft des Bundesrathes an die Bundesversammlung über die grössere Berücksichtigung der französischen Sprache am eidgenössischen Polytechnikum, vom 4. Juni 1887," Bundesblatt 3/1887, 136–145, especially 139–141. See Grelon 1994, 447–450; Schivelbusch 2001, 201–205.

50 Bundesblatt 3/1887, 136–145. See also Oechsli 1905, 347 f.

51 Antoine-Elisée Cherbuliez occupied the chair in economics from 1855 to 1869. In 1855, several attempts to hire a historian from French-speaking Switzerland failed. Consequently, history was not taught in French. Bundesblatt 3/1887, 137 f. Armand-Albert Petit (professor of history, 1887–1890) and Georges Rossignol (1891–1894) were followed by Geneva native Antoine Guilland (1895–1929). Negotiations during 1888–1889 with Paul Piccard, former professor of mechanics at the Academy of Lausanne and co-founder of the firm Piccard-Pictet, came to nought. EAR, SR2: Schulratsprotokolle 1888, meeting of 9/3/1988, 52 and EAR, SR2: Schulratsprotokolle 1889, meeting of 12/3/1989, 84.

52 Eidgenössische Polytechnische Schule 1889, 9.

53 See this volume, Chapter 4, 202 ff.

54 Such requests were approved by parliament in 1859, 1863, 1873, 1881, 1886 and 1887. See "Botschaft des Bundesrates an die Bundesversammlung über den Bestand und die künftige Behandlung des Schulfonds der eidgenössischen polytechnischen Schule, vom 29. August 1910," Bundesblatt 5/1910, 67–74. Eidgenössische Polytechnische Schule 1889, 69–71.

55 See "Botschaft des Bundesrats an die Bundesversammlung, betreffend Erhöhung des Jahreskredites für das eidgenössische Polytechnikum, vom 27. Januar 1893," Bundesblatt 1/1893, 360 f. For the tally of professors at Berlin, see Technische Universität Berlin 1979, 605. Enrollment figures in Lexis 1904, 44–46.

56 Zöller 1891, 137 ff.; Lexis 1904. Among the less-common subjects taught at the technical universities, only mining science and metallurgy were not offered at Zurich. This

was due to the lack of a corresponding national industry. The existence of a forestry division persuaded Schnabel that Zurich had copied the structure of Karlsruhe's polytechnic (Schnabel 1925, 49). Zurich's forestry division, however, was a contingent result of the parliamentary university debate of 1854, as shown in Chapter 1, 32 f.

57 Agricultural and rural engineering were organized as subdivisions V B and V C within the division of forestry.

58 Rothpletz 1917, 156 f. For the full quotation, see Oechsli 1905, 275–279 and 295–306. In 1862, 1868 and 1874 the School Council opposed the military science offering. EAR, SR1: Schulratsmissiven 1862, No. 15, Eingabe des Schulrats an das Departement des Innern, 7/5/1862; EAR, SR2: Schulratsprotokolle 1868, meetings of 17/12/1868 and 1874, meeting of 4/8/1874, 118. Fuhrer 2003 erroneously refers to Hermann Bleuler being professor and president of the School Council in 1875. He was never professor, and was appointed head of the School Council only in 1888.

59 ETH Jahresbericht 1883, 18 f. The discussion triggered by the question led to the founding of the rural engineering division. See "Botschaft des Bundesrates an die Bundesversammlung, betreffend die Erweiterung der landwirthschaftlichen Abtheilung am eidg. Polytechnikum, vom 5. Juni 1886," Bundesblatt 2/1886, 645–655. Requirements for admission to to the agricultural school were far less stringent. EAR, Hs 9113:12, Regulativ für die Aufnahme von regulären Studierenden and Zuhörern an die eidgenössische polytechnische Schule, vom 7. 11. 1908, Art. 5. In these years, the federal government was also a popular addressee for grant seekers. See Halbeisen and Lechner 1994; Hauser 1998.

60 Fifty pupils attended the preparatory course; three or four of them were turned down by the divisions. In total, there were 87 applications for the first-year course. Oechsli 1905, 225–231.

61 Oechsli 1905, 273 f. The count of auditors for 1856–1858 was 125, 128, 137.

62 Oechsli 1905, 273 f.

63 Oechsli 1905, 273 f.

64 Koristka 1863, 12. See EAR, Hs 9113:5, Bedingungen, welche von den Bewerbern um Aufnahme als Schüler am eidgen. Polytechnikum erfüllt werden müssen, und Vorkenntnisse, über welche sie eine Prüfung zu bestehen haben, 16/3/1859.

65 Schweizerischer Schulrat 1879, 23 f. See Oechsli 1905, 309; Keller-Schierlein 1977.

66 See Leemann and Speich 2005a. See also "Botschaft des Bundesrathes an die Bundesversammlung betreffend die Vermehrung der Mitglieder des eidg. Schulrathes und die Aufhebung des Vorkurses am eidg. Polytechnikum, vom 9. Juni 1881," Bundesblatt 3/1881, 350–366, tables annexed.

67 Oechsli 1905, 280 f.

68 NZZ, No. 25–30, 25–30/1/1959. See also Oechsli 1905, 277–279.

69 Oechsli 1905, 281.

70 Kappeler 1873, 7.

71 The new rules raised the minimum age of admission from 17 to 18 and required a better general preparation (EAR, Hs 9113:11, Regulativ für die Aufnahme von Schülern und Zuhörern an das eidgen. Polytechnikum von 1881). As a result, all existing contracts between the federal government and the secondary schools were dissolved and had to be renegotiated. Oechsli 1905, 338–340.

72 Barth 1919, 7. See also Vonlanthen, Lattmann and Egger 1978. During the same period, the Schweizerischer Gewerbeverband (Swiss Trade Association) pushed for national harmonization of vocational training and diplomas. Surdez 1998.

73 See Altermatt 1991c.

74 Gruner and Frei 1966, 34–50. In addition, the survey listed 66 "mature students."

75 In the twentieth century, the proportion of ETH graduates was clearly higher: in 1920, they represented 8 percent of the Federal Assembly 's academics, in 1944, 12.5 percent, and in 1968, 8 percent again. Gruner and Baechtold 1970, 14–16.

76 Dietler 1871, 4 f.

77 GEP-Bulletin, No. 4, January 1873, 4 f.

78 As representative of the extensive literature on the link between science and the economy in the Industrial Revolution, see Mokyr 2002; Mokyr 2003.

79 See Landes 2005; Fischer 1985; Radkau 1989; Buchheim 1994; Pierenkemper 1996; Kocka 2001; Wischermann and Nieberding 2004. On Switzerland, see Siegenthaler 1985a; Gruner and Wiedmer 1987.

80 See "Reglement für die eidgenössische polytechnische Schule, vom 31. Heumonat 1854," 6–8. See also Art. 2 in "Bundesgesetz betreffend die Errichtung einer eidgenössischen polytechnischen Schule, vom 7. Februar 1854."

81 Koselleck 1975. See also Peters 1996; Bauer 2004.
82 Radkau 1989, 155 f.; Schwinges 2001; Schalenberg 2002; Charle 2004, 55–59; Guagnini 2004, 500–504.
83 Minister of State Brefeld 1899 at the centenary of the Charlottenburg Technical University, cited in Rürup 1979, 20. See Jessen and Vogel 2002b.
84 Ben-David 1968, 58; Hobsbawm 1979, 42 f, and to some extent also Wehler 1995, 610–618, 1227 f.
85 Lundgreen 1973. See also Lundgreen 1975.
86 Fox and Guagnini 1993, 5. See Ahlström 1982; Dienel 1995, 339 f., König 1990; König 1998b; Shinn 2003; Wengenroth 2003b. See also Mokyr 2003; Wolf 2002.
87 See Weingart 2001, 87 ff.
88 See also the remarks on entering the middle class in this chapter, 87 ff.
89 On economic growth in Switzerland, see Siegenthaler 1985a; Beck 1983.
90 The opening of the Technikum in Winterthur probably also cost the polytechnic some pupils.
91 Osterhammel and Petersson 2003, 63. See Torp 2004.
92 Leemann and Speich 2005b. For Germany, see Titze 1987; Titze 1995; Titze 2004.
93 Leemann and Speich 2005b; Leemann and Speich 2005e. Figures for Germany in Lexis 1904, 44–46. Myllyntaus 2003 provides a good case study of Scandinavian students at the ETH.
94 See Siegenthaler 1996, 396; Leemann and Speich 2005a; Gesellschaft Ehemaliger Polytechniker 1869 ff. In 1894, half of the members of the GEP lived abroad. Gesellschaft Ehemaliger Polytechniker 1894, 93.
95 Jegher 1955, 7.
96 Dietler 1871, 5.
97 Meyer 1877. On the reform of 1881 see this chapter, below.
98 Schweizerischer Schulrat 1879, 2 f.
99 König, Siegrist, and Vetterli 1985, 359.
100 See below, Chapter 3.
101 ETH Jahresbericht 1897, 6.
102 Dietler 1871, 4.
103 Leemann and Speich 2005c. See Schweizerischer Schulrat 1879, In the 1890s, the number of graduates increased sharply. See below, Chapter 3, 130 ff.
104 This was reflected in the introduction of federal qualifying tests for medical professionals, foresters, and surveyors.
105 GEP-Bulletin, No. 4, January 1873, 5.
106 For pharmacists, see Büchi 1955; for surveyors, see Schmid 1987 and Speich 1999; and for foresters, see von Sury 1926.
107 See "Bericht über den Entwurf zu einem Reglemente für die eidgenössische polytechnische Schule, vom 21. Brachmonat 1854," Bundesblatt 3/1854, 143–227, quote 144.
108 Gagliardi, Nabholz, and Strohl 1938, 472 ff.
109 Oechsli 1905, 296. For chemistry, see Straumann 1995, 101–108.
110 Speich 2005b.
111 Gagliardi, Nabholz, and Strohl 1938, 483.
112 See Baumgarten 1997, especially 243–247.
113 Cited in Straumann 1995, 114. On mathematics, see Frei and Stammbach 1994, 33 ff.
114 Correspondence to Friedrich Autenheimer of 12/4/1866, cited in. Labhart 1984, 59.
115 Calame 1924; Blättler 1999. The "Ecole spéciale," founded in 1853 and integrated into the cantonal university in 1890, mattered little beyond the region. École d'Ingénieurs 1904.
116 Cited in Zweckbronner 1987, 108.
117 König 1999b, 16–28; Heymann 2005, 45–50.
118 EAR, SR1: Schulratsmissiven 1856, No. 6.
119 See Westermann 2005h.
120 Raths 1996, 55 f. On Reuleaux and Zeuner, see König 1999b, 32 ff.
121 SBZ, No. 2, 11/7/1903, 26.
122 König 1999b, 98.
123 Culmann 1875, Foreword, 6 f. On Culmann's influence, see Westermann 2005c; Maurer 1998; Maurer and Lehmann 2005.
124 Oechsli 1905, 238 f.
125 ETH Jahresbericht 1861, 3.
126 See Westermann 2005f.
127 Eidgenössische Polytechnische Schule 1889, 56.
128 Eidgenössische Polytechnische Schule 1889, 56.
129 Jegher 1955, 10.
130 Matschoss 1910, 90.
131 In 1908, regularly yearly tuition for the polytechnic amounted to 200 francs. In addition, one had to reckon with fees for lecturers and titular professors (6 francs per hour), usage fees for the library, laboratories, and workshops, as well as exam fees (25 francs each for the first and second prediploma exams, and 50 francs for the diploma exam).
132 See also the polytechnic's revised regulations of 1866 and 1881, and the detailed

information in Eidgenössische Technische Hochschule 1955, 222; Raths 1996, 71–74.
133 See Lenoir 1992; Lenoir 1997; Stichweh 1994; Weingart 2001, 87 ff.
134 Wild's successors were Otto Decher for topography and geodesy, Fridolin Becker for map drawing, and, from 1888, Kaspar Zwicky for rural engineering. Oechsli 1905, 341–351; Speich 1998, 72; Wild 1988, 48 ff.
135 EAR, SR1: Schulratsmissiven 1894, No. 24.
136 Enrollment in the mechanical engineering division increased from less than 100 at the beginning of the 1880s to 262 at the start of the winter semester 1893/94. Ten years later, it surpassed 500. Leemann and Speich 2005a.
137 Gugerli 1996, 212–225.
138 See Raths 1996, 95 ff.
139 See Hensel 1989; Puchta 2000; Heymann 2005, 58 ff.
140 Stodola 1897. For more on the congress, see Frei and Stammbach 1994, 1–3; Westermann 2005d.
141 Lexis 1904, Foreword; see also 14–19.
142 "Botschaft des Bundesrathes an die Bundesversammlung, betreffend die Erstellung eines Gebäudes für Physik und für die forstliche Versuchsstation der polytechnischen Schule in Zürich, nebst Lokalitäten für die meteorologische Centralanstalt, vom 5. Juni 1886," Bundesblatt 2/1886, 632–644, quote on 633 f. See Oechsli 1905, 344–346.
143 Loebner 1896. See also Dienel 1995, 337; Myllyntaus 2003.
144 Bluntschli, Lunge, and Lasius 1889, 16.
145 König 1999b, 58.
146 In 1903 Braunschweig became the last German technical university to open a mechanical engineering laboratory. Albrecht 1987, 326–333.
147 "Bericht des schweizerischen Schulrates betreffend das neue Maschinenlaboratorium für die mechanisch-technische Abteilung des eidgenössischen Polytechnikums, vom 2. November 1896," Bundesblatt 1/1897, 17–41. For a more detailed account, see Feuchte 2000, 89 ff.
148 Bundesblatt 1/1897, 22.
149 Feuchte 2000, 136 f.
150 Weyrauch 1922, 113–116. See also Zweckbronner 1991; Rohkrämer 1999, 64–70; Dienel 1992.
151 Grubenmann 1910, 3 f.
152 Grubenmann 1910, 8.
153 Vetter 1911, 11 f.
154 According to Bolley 1867, 20.
155 Schweizerischer Schulrat 1879, 45.
156 Kappeler 1873, 15.
157 Eidgenössische Polytechnische Schule 1889, 51 and 59. On the collections, see ETH Jahresbericht 1897, 17; Westermann 2005e.
158 Raths 1996, 56.
159 Zweckbronner 1991, 422 f.; Dienel 1993, 127 f.
160 Zielinski 1995; Oechsli 1905, 306 f.
161 Eidgenössische Polytechnische Schule 1889, 72. In 1897/98 the agricultural institutes were split off from the polytechnic, and put under the control of the then Federal Department of Trade, Industry, and Agriculture. Oechsli 1905, 356 f. For the history of these institutes, see Lehmann 2003.
162 See Zielinski 1995, 57–64; Burri 2005c.
163 Oechsli 1905, 352 f.; Amstutz 1955, 686.
164 Loebner 1896; Zielinski 1995, 66–71.
165 Empa 1980.
166 See Beniger 1986; Galison 2003.
167 Straumann 1995, 100 f.
168 Tanner 1996; Straumann 1995; Raths 1996; Bundesamt für Geistiges Eigentum 1988; Stettler 2004. A comprehensive economic history of nineteenth century Switzerland has yet to be written. See Siegenthaler 1985a; Humair 2004.
169 Raths 1996, 56–62; Gugerli 1996, 59–69.
170 Sulzer 1934.
171 Eichelberg and Quiby 1955, 419. On Stodola, see Feuchte 2000; Lang 2003; on Prášil see Wyssling 1929; on occupational differentiation in the machine industry, see Raths 1996, 90–93 and König, Siegrist, and Vetterli 1985, 328 ff.
172 Straumann 1995, 298.
173 Straumann 1995, 129 ff.
174 Straumann 1995, 127–129.
175 Straumann 1995, 134–137; Gugerli 1996, 168; Vischer and Schnitter 1991.
176 Bundesblatt 3/1881, 437.
177 On Naville, see Schmid and de Mestral 1960.
178 Lundgreen 2000a, 173. Lundgreen also provides information on the historical literature regarding the middle class. For an introduction to the history of the middle class, see Kocka 2001; Hettling and Hoffmann 2000; Lundgreen 2000b. On Switzerland, see Hettling 1999; Tanner 1995.
179 Siegrist 1988, 11.
180 Siegrist 1988, 12.

181 Minutes of the founding meeting of 24/4/1869, cited in Jegher 1955, 4.
182 Gesellschaft Ehemaliger Polytechniker 1869.
183 Jegher 1955, 8–10. See also Haldimann 1987.
184 Meyer 1877, 1.
185 Meyer 1877, 2.
186 Eidgenössische Polytechnische Schule 1889, 8.
187 Oechsli 1905, 297 and 346 f.; Zöller 1891, 188.
188 See Manegold 1970; Rohkrämer 1999, 56–71.
189 SBZ, No. 13, 31/3/1900, 142.
190 This difference in status is also the subject of an anecdote relating to Aurel Stodola. When, shortly after joining the polytechnic in 1892, Stodola greeted a professor at the university with "Dear Colleague," he was sternly rebuked. "You've got a lot of nerve addressing me as colleague – you! a teacher at the polytechnic!" Feuchte 2000, 62.
191 See this volume, Chapter 3.
192 Die Eisenbahn 12/2, 1880, 13 f.
193 Guggenbühl 1955, 134.
194 See this volume, Chapter 3, 116 ff.
195 Haldimann 1987, 205–211.
196 Oechsli 1905; 337–339.
197 Meyer 1877, 7 f. On multilingual instruction, see above, this chapter, 50 ff.
198 See this volume, Chapter 3.
199 "Bericht über den Entwurf zu einem Reglemente für die eidgenössische polytechnische Schule, vom 21. Brachmonat 1854," Bundesblatt 3/1854, 143–227, quotes from 150 and 157.
200 Kappeler 1873, 26. At the time, the 1866 regulation was in effect. The process of evaluation was revised several times.
201 Eidgenössische Polytechnische Schule 1889, 38 f.
202 Kappeler 1873, 26.
203 ETH Jahresbericht 1861, 5–7.
204 EAR, Hs 9113:2, Reglement für die eidgenössische polytechnische Schule, 31/7/1854, Art. 34–40. The disciplinary record was covered in the Annual Reports.
205 Diary entry dated 13/3/1856, cited in Gyr 1981, 153.
206 Oechsli 1905, 239–241; Erb 1937, 58–66.
207 "Bericht des schweizerischen Schulrathes an den Bundesrath über das neue, den 28. Februar 1866 in Kraft getretene Reglement für das eidg. Polytechnikum," Bundesblatt 2/1866, 776–799, quote from 792–794. EAR, Hs 9113:8, Reglement für die eidgenössische polytechnische Schule, 28/2/1866, Art. 31. On dueling, see Frevert 1991.
208 Correspondence from Deschwanden to Kern, dated 3/7/1856, cited in Gyr 1981, 142 f.
209 Cited in "Offizieller Bericht des Schweizerischen Schulrats an das Schweizerische Departement des Innern über die Vorfälle am eidgenössischen Polytechnikum," in: EAR, SR2: Schulratsprotokolle 1864, meeting of 29/7/1864, 53–58, quote 53.
210 See EAR, SR2: Schulratsprotokolle 1864, meeting of 29/7/1864, 53–58 and Polytechniker 1864. These two accounts make it possible to roughly reconstruct the events. That some of the details are contradictory is irrelevant for our purposes.
211 Bundesblatt, 2/1864, 470. "Bericht der ständeräthlichen Kommission für Begutachtung des Rekurses von sechs Zöglingen des Polytechnikums gegen ihre Wegweisung von der Anstalt, vom 24. September 1864," Bundesblatt 2/1864, 857–862. "Bericht und Antrag der Mehrheit der nationalräthlichen Kommission über das Rekursgesuch von sechs Polytechnikern vom 9. d. Mts. gegen den Beschluss des Bundesrathes vom 10. August d. J., betreffend Wegweisung derselben aus dem Polytechnikum, vom 27. September 1864," Bundesblatt 2/1864, 863–874, quote 873. "Bericht der Minderheit der nationalräthlichen Kommission für Begutachtung des Rekurses von sechs Zöglingen des Polytechnikums gegen ihre Wegweisung von der Anstalt, vom 29. September 1864," Bundesblatt, 2/1864, 875–881, quote 876–879.
212 Polytechniker 1864, 2.
213 Stichweh 1994, 338.
214 Verband der Studierenden an der ETH Zürich 1913, 7.
215 Kappeler 1873, 23; Eidgenössische Polytechnische Schule 1889, 29.
216 Schweizerischer Schulrat 1879, 48.
217 Zeitschrift für technische Hochschulen, No. 10, 15/3/1878, cited in Verband der Studierenden an der ETH Zürich 1913, 10 f.
218 Verband der Studierenden an der ETH Zürich 1913, 12–14.
219 ETH Jahresberichte; Verband der Studierenden an der ETH Zürich 1913, 13 ff.
220 Verband der Studierenden an der ETH Zürich 1913.

221 Zeitschrift für technische Hochschulen, No. 10, 15/3/1878, cited in Verband der Studierenden an der ETH Zürich 1913, 11.
222 Kappeler 1873, 39 f. For data on geographic origins see Leemann and Kupper 2005; Leemann and Speich 2005e.
223 For the example of chemistry, see Westermann 2005a; Straumann 1995, 230–243.
224 See Verband der Studierenden an der ETH Zürich 1913; Blattmann 1995; Spörndli 2003. Little is known about the relation between membership in student associations and career success. On federal politics, see Gruner and Frei 1966.
225 See Lengwiler 1995; Rychner and Däniker 1995; Jaun 1999, 367 ff.
226 Kölz 1992, 589. On the history of gender roles in Switzerland in the nineteenth century, see Mesmer 1988; Joris and Witzig 1992.
227 Cited in Wolf 1880, 19. Italics ours.
228 Women's education in Switzerland is underresearched. See Schweizerischer Verband der Akademikerinnen 1928; Gagliardi, Nabholz, and Strohl 1938, 618 ff.; Verein Feministische Wissenschaft Schweiz 1988; Mantovani Vögeli 1997; Eidgenössische Kommission für Frauenfragen 1998, Chapter 4. Data on Europe: Ringer 2004, 210 f.; on Germany: Huerkamp 1996; Mazón 2003; on the Technical University of Munich: Fuchs 1994.
229 Schweizerischer Verband der Akademikerinnen 1928, 52. See also Erb 1937, 69–73; Saxer 1999, 49–54. On Vögtlin, see Lange-Mehnert 1989.
230 Kappeler 1873, 40 f.
231 Verein Feministische Wissenschaft Schweiz 1988, 153 ff.; Schweizerischer Verband der Akademikerinnen 1928, 53 f.; Müller 2005. Precise numbers for the early days of women at universities are lacking. The ETH only began breaking down numbers by sex in 1917. See Leemann and Speich 2005f.
232 Rohkrämer 1999 64–68; Dienel 1992. Chemists adopted similar language. See Straumann 1995, especially 275–282.
233 Guggenbühl 1955, 98. See Schweizerischer Verband der Akademikerinnen 1928, 12 f. and 54. For statistical data, see Leemann and Speich 2005f.
234 Schweizerischer Verband der Akademikerinnen 1928, 54. On women pharmacists, see Zurbriggen 2000.
235 Hardmeier 1997; Jaun 1995; Kronbichler 1983, 12–38. See also Frevert 2000.
236 Jaun 1995, 118.
237 Lengwiler 1995. See also below, Chapter 3, 115 ff.
238 Straumann 1995, 269–272.
239 EAR, SR2: Schulratsverfügungen 1897, Verfügung des Präsidenten, 6/8/1897, 162 f.; EAR, SR2: Schulratsprotokolle 1898, meeting of 19/2/1898, 74.
240 Baum 1899. Cited in Straumann 1995, 272. In Germany, Marie Baum became a leading figure in the women's movement. See Moritz 2000.
241 Blattmann 1998.
242 For statistical data, see Speich 2005b. Hezner taught from 1910 to 1916. Grubenmann 1916. Flora Ruchat-Roncati was professor of architecture and design from 1985 to 2002.

Chapter 3

1 ETH Jahresbericht 1905, 12.
2 NZZ, No. 210 M, 31/7/1905. For the festivities at Berlin, see Schwarz 2000.
3 Oechsli 1905, 368.
4 Oechsli 1905; Zürcher Ingenieur- und Architektenverein 1905. The government subvention for the Festschrift was a princely 40,000 francs. NZZ, No. 181 S, 2/7/1905.
5 NZZ, No. 210 M, 31/7/1905. On federal celebrations, see Kreis 1991; Gugerli 1996, 27–35; Zimmer 2003, 163 ff.; on nationalism, Hobsbawm 1992.
6 NZZ, No. 209, 30/7/1905.
7 NZZ, No. 210 M, 31/7/1905.
8 NZZ, No. 210 M, 31/7/1905.
9 Schweizerische Elektrotechnische Zeitschrift 1905, 403. For details of the festivities, see also the repart in the SBZ, No. 6, 5/8/1905, 67–75.
10 ETH Jahresbericht 1903, 13.
11 Manegold 1970, 293–300.
12 For statistical details, see Leemann and Speich 2005a. See also above, Chapter 2, Chart 1, 41.
13 Cited in Gnehm 1904, 3. On the foreign question, see above, Chapter 2, 46 ff.
14 EAR, SR1: Schulratsmissiven 1898, No. 234, 253.
15 Gnehm 1904, 10.
16 SBZ, No. 16, 20/4/1900, 174 f. The SBZ reprinted the poem from the Munich art and literature magazine *Jugend* (No. 45, 1900), from which Jugendstil took its name.
17 "Nachklänge zur Jubiläumsfeier des

Polytechnikums," NZZ, No. 213 M, 3/8/1905.

18 In doubting the "real" significance of the *Promotionsrecht* for the history of the technical universities, Gundler dismisses the power of the symbolic over the "real." Gundler 1991, 15 f.

19 "Botschaft des Bundesrates an die Bundesversammlung, betreffend die definitive Auseinandersetzung der Eidgenossenschaft mit dem Kanton Zürich in Bezug auf die eidgenössische polytechnische Schule, vom 19. März 1906," Bundesblatt 2/1906, 240–265, here 240.

20 "Botschaft des Bundesrathes an die Bundesversammlung, betreffend den Bau eines Chemiegebäudes für das eidgenössische Polytechnikum in Zürich, vom 30. November 1883," Bundesblatt 4/1883, 783–796. See also above, Chapter 2, 75 ff.

21 ETH Jahresbericht 1897, 17.

22 EAR, SR1: Schulratsmissiven 1898, No. 234, 235–256.

23 "Nachtrag zur Botschaft des Bundesrates an die Bundesversammlung, betreffend die definitive Auseinandersetzung der Eidgenossenschaft mit dem Kanton Zürich in Bezug auf die eidg. polytechnische Schule (vom 19. März 1906), vom 27. Mai 1908," Bundesblatt 3/1908, 771–778. See Guggenbühl 1955, 137 f.; Gagliardi, Nabholz, and Strohl 1938, 761–767, 784 ff. The archives of the School Council as well as the federal archives contain comprehensive collections relating to negotiations.

24 Gnehm 1930, 33 f. In the final accounting, the federal government had to hand over 2,168,683 Swiss francs to the canton of Zurich for the "separation." Bundesblatt 2/1906, 258 f.

25 ETH Jahresbericht 1908, 14.

26 Gnehm 1930, 34.

27 Correspondence from Einstein to Maric dated 28/12/1901, cited in Renn and Hermann 1994, 160. Cf. Hobsbawm 1987; Galison 2003; Schwarzenbach 2005.

28 Schweizerische Elektrotechnische Zeitschrift 1905, 403c. Cf. Asendorf 1989; Hobsbawm 1987; von Bruch and Hübinger 1989; Lengwiler 1995; Messerli 1995, 217 ff.; Radkau 1998; Mölk 1999; Roelcke 1999. Inglin 1938 provides a stimulating literary treatment.

29 Cf. Wagner 1994; Nolte 1996; Hard and Jamison 1998b; Bauer 2004 77 ff.; on the new movements, Bachmann 1999; Rohkrämer 1999.

30 Cf. Gruner, Balthasar, and Hirter 1988; Gruner and Dommer 1988; Degen 1993; Fritzsche and Lemmenmeier 1994, 228 ff.; Koller 2003. On the simultaneous emergence of a new conservatism, see Jost 1992.

31 See König, Siegrist, and Vetterli 1985, 351–354. The same was true for Germany. See Sander 2004; Gispen 1989, 226 f.; König 1981a, 248 f.

32 SBZ, No. 20, 23/11/1907, 260.

33 SBZ, No. 23, 7/12/1907, 296 f.

34 SBZ, No. 24, 14/12/1907, 301 f.

35 SBZ, No. 25, 21/12/1907, 317–321.

36 SBZ, No. 25, 21/12/1907, 320.

37 SBZ, No. 25, 21/12/1907, 320. Two days before the meeting, the NZZ was already holding the GEP responsible for the delays. NZZ, No. 331 1M, 29/11/1907.

38 Cited in Manegold 1970, 74. For a detailed account, see Albrecht 1987, 292–298. The representative from Zurich had only observer status and was not entitled to vote.

39 The work of Manegold on this issue is essential reading: Manegold 1969; Manegold 1970; Manegold 1977. See also König 2000; Zweckbronner 1987, 193–202.

40 EAR, SR1: Schulratsmissiven 1900, No. 149. The initial effort in 1884 involved the natural sciences section (Division VI B) as well as chemistry. Cf. Guggenbühl 1955, 133 f.; Straumann 1995, 153–160.

41 Cited in EAR, SR1: Schulratsmissiven 1900, No. 313, 302 f.

42 EAR, SR1: Schulratsmissiven 1900, No. 313.

43 NZZ, No. 46 M, 15/2/1900; No. 47 M, 16/2/1900; No. 51 M, 20/2/1900; No. 54 M, 23/2/1900.

44 SBZ, No. 18, 4/5/1901, 197. See also Wurzer 1965, 47.

45 See, for instance, the satirical "Dr. ing.?" in SBZ, No. 11, 14/11/1901, 119 f.

46 EAR, SR1: Schulratsmissiven 1900, No. 313. Gerlich's presentation was printed in the SBZ, No. 13, 31/3/1900, 141 f. On gender roles and women students, see above, Chapter 2, 99 ff.

47 EAR, SR1: Schulratsmissiven 1900, No. 313.

48 EAR, SR1: Schulratsmissiven 1900, No. 149.

49 SBZ, No. 3, 20/7/1901, 33. Honorary doctorates went to Professors Fliegner, Franel, Prášil, Stodola, and Wyssling, as well as Professor Zschokke.

50 SBZ, No. 10, 7/9/1901, 107.

51 BAR, E 80, Bd. 86, Do. 649, Schreiben des Schulrats an das Departement des

Innern dated 27/5/1902. The petitions are attached.
52 NZZ, No. 168 A2, 19/6/1902.
53 The draft, mentioned as an enclosure in EAR, SR1: Schulratsmissiven 1902, No. 745, can be found neither in the federal archives nor those of the School Council.
54 EAR, SR1: Schulratsmissiven 1900, No. 312.
55 EAR, SR1: Schulratsmissiven 1902, No. 745.
56 EAR, SR2: Schulratsprotokolle 1901, meeting of 7/2/1901, 59; meeting of 20/7/1901, 121; meeting of 18/11/1901, 143. Gnehm had the support of his School Council colleagues Dietler and Haffter.
57 EAR, SR2: Schulratsprotokolle 1901, meeting of 4/5/1901, 86. Dietler did not attend this meeting.
58 Cited in Jegher 1955, 23. See also SBZ, No. 4, 28/7/1900, 37.
59 NZZ, No. 168 A2, 19/6/1902.
60 NZZ, No. 47 M, 16/2/1900.
61 NZZ, No. 190 M, 11/7/1903.
62 NZZ, No. 195 M, 16/7/1903. Further articles in the NZZ include No. 184, 5/7/1903; No. 203 M, 24/7/1903; No. 209 M, 30/7/1903; No. 214 M, 4/8/1903.
63 EAR, SR3: Schulratsakten 1903, No. 816, Sitzung des Schweizerischen Nationalrates vom 23/6/1903. The engineering school was burdened by the absence of several professors on sick leave. In autumn 1903, Otto Decher (topography and geodesy) died in office after a long illness. Health problems forced Karl Wilhelm Ritter (graphical statics, bridges and railways) to step down in 1905. Eduard Gerlich (engineering sciences) retired in 1903. Oechsli 1905, 351 f.
64 Jegher 1955, 21.
65 BAR, E 80, Vol. 88, Do. 664, Verband der Polytechniker, Schreiben an den Gesamtbundesrat, July 1903.
66 BAR, E 80, Bd. 88, Do. 664, Schreiben des Departements des Innern an den Schulratspräsidenten dated 3/11/1903.
67 ETH Jahresbericht 1903, 14.
68 Gnehm 1903, 5.
69 EAR, SR3: Schulratsakten 1904, No. ad 5.
70 EAR, SR3: Schulratsakten 1904, No. ad 5, Bericht der Minderheit, 23.
71 EAR, SR3: Schulratsakten 1904, No. ad 5, Bericht der Minderheit, 26.
72 EAR, SR1: Schulratsmissiven 1904, No. 123. The unnamed minority of the School Council declared themselves prepared to cooperate in the work of reorganization "despite their fundamentally different opinion." Ibid., 61.
73 EAR, SR3: Schulratsakten 1904, No. ad 5, Bericht der Gesamtkonferenz, 13.
74 EAR, SR1: Schulratsmissiven 1904, No. 123, 62.
75 EAR, SR1: Schulratsmissiven 1904, No. 123, 64. In addition, the reports of both the faculty conference and the School Council referred to the still pending issue of the doctorate.
76 EAR, SR2: Schulratsverfügungen 1905, Verfügung des Präsidenten dated 11/4/1905, 89 f.
77 NZZ, No. 210 M, 31/7/1905.
78 Labhart's assertion that Forrer was especially interested in expanding the polytechnic applies primarily to construction-related, rather than to organizational issues. Labhart 1973, 144.
79 See the documents in BAR, E 80, Bd. 94, Do. 706.
80 See SBZ, No. 13, 1/4/1905, 165.
81 Vice president Gustave Naville and Josef Düring.
82 BAR, E 80, Bd. 88, Do. 666, Schreiben der GEP an das Departement des Innern dated 7/6/1907, signed by Arnold Bertschinger, president, and Fritz Mousson, secretary. The handwritten note is in French and signed simply "R," which most likely stood for Federal Councillor Ruchet, who headed Home Affairs from 1900 to 1903, again from 1906 to 1910, and in 1912. On Ruchet see Altermatt 1991c, 285–289.
83 BAR, E 80, Bd. 88, Folder 666, Schreiben des Departements des Innern an den Schulrat dated 3/10/1907.
84 BAR, E 80, Bd. 88, Folder 666, Schreiben des Schulrats an das Departement des Innern dated 11/11/1907; EAR, SR2: Schulratsprotokolle 1907, meeting of 4/11/1907, 135.
85 Schweizerischer Schulrat 1908a. All the draft regulations can be found as attachments in EAR, SR2: Schulratsprotokolle 1908.
86 BAR, E 80, Bd. 88, Do. 666, Auszug aus dem Bundesratsprotokoll of 21/9/1908.
87 BAR, E 80, Bd. 88, Do. 666, Schreiben der GEP an das Departement des Innern dated 16/7/1908; Schreiben des Departement des Innern an die GEP dated 10/8/1908. See also EAR, SR2: Schulratsverfügungen 1908, Verfügung des Präsidenten, No. 238.
88 Schweizerischer Schulrat 1908a. EAR, Hs 9113:12, Reglement für die eidgenössische polytechnische Schule dated 21/9/1908. Cf. Guggenbühl 1955, 135.

89 ETH Jahresbericht 1908, 14.
90 See EAR, SR2: Schulratsverfügungen 1909 as well as EAR, SR2: Schulratsprotokolle 1909. Cf. BAR, E 80, Bd. 88, Do. 666; Verband der Studierenden an der ETH Zürich 1913, 32–35.
91 EAR, SR1: Schulratsmissiven 1909, No. 161. EAR, Hs 9113:12, Promotionsordnung für die Erlangung der Doktorwürde an der eidgenössischen polytechnischen Schule dated 31/3/1909.
92 Systematische Sammlung des Bundesrechts 414.133.1, Verordnung über das Doktorat an der Eidgenössischen Technischen Hochschule Zürich dated 16/12/2000 (as of 1/3/2005). For statistics on the doctorates granted at the ETH since 1909, see Leemann and Speich 2005d.
93 NZZ, No. 291 M1, 20/10/1909. In his speech, too, director Grubenmann referred to a new era.
94 BAR, E 80, Bd. 128, Do. 1401, Auszug aus dem Protokoll des Ständerates dated 6/12/1910, Traktandum 18/93 Schulfonds des Polytechnikums.
95 The School Council compiled a corresponding survey for the Department of Home Affairs. EAR, SR1: Schulratsmissiven 1911, No. 109, 4–8. On Germany, see Manegold 1969; Manegold 1970, 73 f.; on Austria, see Wurzer 1965, 39 f.
96 BAR, E 80, Bd. 128, Do. 1401, Auszug aus dem Protokoll des Ständerates of 6/12/1910, Traktandum 18/93 Schulfonds des Polytechnikums.
97 In a separate opinion for the attention of the School Council, the Gesellschaft der Ingenieure der Schweizerischen Bundesbahnen sided with the GEP.
98 BAR, E 80, Bd. 128, Do. 1401, Bericht des Departements des Innern an den Bundesrat dated 15/6/1911 betr. Eidgen. Polytechnische Schule; Namens-Aenderung. This folder contains all the documents mentioned. See also Bericht des Schulrats an das Departement des Innern, EAR, SR1: Schulratsmissiven 1911, No. 109.
99 EAR, SR2: Schulratsprotokolle 1911, meeting of 27/2/1911.
100 BAR, E 80, Bd. 128, Do. 1401, Bericht Departements des Innern an den Bundesrat dated 15/6/1911 betr. Eidgen. Polytechnische Schule; Namens-Aenderung.
101 Vetter 1911, 13.
102 The mathematician Richard Dedekind also received an honorary doctorate. Eidgenössische Technische Hochschule 1980, 581–592.
103 Cited in Jegher 1955, 23.
104 Haldimann 1987, 211 f.
105 NZZ, No. 47 M, 16/2/1900; No. 54 M, 23/2/1900. Cf. König, Siegrist, and Vetterli 1985, 326 f.; König 1988, 221 f.
106 *Technika* were established in 1874 in Winterthur and from 1890 to 1903 in Burgdorf, Biel, Fribourg, and Geneva. König, Siegrist, and Vetterli 1985, 312–328.
107 See König, Siegrist, and Vetterli 1985, 414–422. On the conflict between secondary school- and university-trained engineers, see ibid. 357–361. For the area of electrical engineering, see Gugerli 1996, 205–225.
108 SBZ, No. 25, 21/12/1907, 318.
109 EAR, SR2: Schulratsprotokolle 1908, meeting of 24/10/1908, 50.
110 König, Siegrist, and Vetterli 1985, 360. Cited in Rohn: STZ 1937, 427. On the ETH diploma, see also Kupper 2005.
111 Vetter 1911, 10. On the relationship between technologies of power and self-technologies, see Lemke, Krasmann, and Bröckling 2000.

Chapter 4

1 See, for example, the presidential address on ways of reducing fuel consumption, EAR, SR2: Schulratsverfügungen 1917, Verfügung des Präsidenten, 17/9/1917.
2 EAR, SR2: Schulratsprotokolle 1918, meeting of 9/3/1918, agenda item 26. See EAR, SR2: Schulratsprotokolle 1917, meeting of 5/5/1917, agenda item 51. In June 1917, so-called *Kriegsbeihülfen* (war allocations) were granted to all married, widowed, or divorced government officials and employees on the order of 375 francs. As long as the total remuneration did not exceed 6,000 francs, each employee was awarded per child under 16 an additional 25 francs. Unmarried persons received 225 francs. In August 1917, the School Council strongly argued for extending the subsidy to professors and "teaching assistants." EAR, SR2: Schulratsprotokolle 1917, meeting of 4/8/1917, agenda items 96 and 97.
3 Jost 1992, 132.
4 Wagner 1994; Nolte 1996.
5 James 2003, 80 ff, provides an instructive overview of the antiliberal and antidemocratic currents in Europe in the 1920s.

6 Gruner 1969, 86 f.; Wigger 1997; Ernst and Wigger 1993.
7 Unabhängige Expertenkommission Schweiz – Zweiter Weltkrieg 2002, 80.
8 Mattioli 1994; Mattioli 1995; Jost 1992; Ernst and Wigger 1993; Werner 2000.
9 Jost 1998, 63 ff.
10 von Salis 1968, 197. See also Imhof 1996.
11 See above, Chapter 1; Fueter 1928, 62.
12 Breuer 1993.
13 Dessauer 1958; Wagner 1998; Siegenthaler 1985b.
14 Only in the 1930s, and very sporadically, did the ETH experience politically motivated attacks. Even then, the criticism was aimed more at Arthur Rohn as School Council president than at the institution as such. For example, in 1935, the newspaper published by the corporatist movement criticized preferential treatment of wealthy students. Lorenz 1935. See also EAR, SR2: Schulratsprotokolle 1985, meeting of 30/3/1935, 46 ff.
15 Stichweh 1994. For the NZZ's criticism, see Guggenbühl 1955, 156.
16 Eugen Fierz-David: Sorgen der Eidg. Techn. Hochschule, in: NZZ, No. 1082, July 1925.
17 Fritz Haber: Wissenschaftspflege, in: Naturwissenschaften, 26 (1925), cited in Eugen Fierz-David: Sorgen der Eidg. Techn. Hochschule, in: NZZ, No. 1082, Juli 1925.
18 Schumpeter 1912.
19 Karl Scheurer Tagebücher 1914–1929, ed. H. Böschenstein, Bern 1971, 169. Cited in Brassel-Moser 1994, 194. Cf. on the following especially Brassel-Moser 1994, 225 ff.
20 Dürr 1928; Tanner 1998b, 246.
21 Werner 2000; Degen 1991.
22 Dürr 1928, 86.
23 Dürr 1928, 104.
24 Dürr 1928, 99.
25 Lang 1931, 99. Vgl. Glaus 1969, 49 ff.
26 Spengler 1918, 633.
27 Ermatinger 1930, 4.
28 Ermatinger 1927, 740.
29 Ermatinger 1927, 732 and 738.
30 For the "technology debate" see Dessauer 1927 and especially also Dessauer 1958.
31 On the debate, see, among others, Herf 1984; Willeke 1995; Hard and Jamison 1998b; Rohkrämer 1999; Fohler 2003; Emmerich and Wege 1995; Sieferle 1984. Also still excellent reading is Maier 1970. On the persistence of technocratic patterns in the twentieth century see also van Laak 2001a.
32 Hard and Jamison 1998a, 3.
33 Hard and Jamison 1998a, 9; Rohkrämer 1999, 256.
34 J.M. Musy: Staat und Arbeitgeber im sozialen Leben, Luzern 1928, 14 f., cited in Brassel-Moser 1994, 149. Brassel-Moser (144 ff.) also supplies a succinct overview of the rationalization debate in various political circles. For an in-depth analysis of technology-friendly modernism of the reactionary right, see Herf 1984. Even Oswald Spengler recognized the "cultural value" of technology. See Spengler 1931.
35 Breuer 1993; Peukert 1997, 111 ff. Unlike his opponent Robert Faesi, as a Germanist Ermatinger always made a point of being apolitical. The fact that he thus failed to serve the *Geistige Landesverteidigung* made his sympathetic attitude toward Germany particularly inflammatory. See Schütt 1996.
36 See, for example, Rathenau 1917; Rathenau 1918. On Rathenau, see Buddensieg, Hughes, and Kocka 1990.
37 Meyer 2004; Feder 1932. On Feder's role as a Nazi ideologist, see Ludwig 1974, 72.
38 Herf 1984, 221.
39 Stodola 1931, 7; Chase 1929. See also www.ethistory.ethz.ch/besichtigungen/touren/konjunkturkurven.
40 Stodola 1931, 10.
41 Stodola 1931, 23. On the political significance of Walther, see Menz 1976. On Laur see Baumann 1993.
42 Stodola 1931, 20. On the complex relations between technocracy, the self-image of engineers, and Nazism, see Lorenz and Meyer 2004.
43 Stodola 1931, 15 and 24.
44 Stodola 1931, 92.
45 Stodola 1931, 15.
46 This argument had already been made in the 1900 debate over the ETH's *Promotionsrecht*. See above, Chapter 3, 118 ff. For additional views, see Spengler 1922, 631 ff. On the technocratic movement in general in the 1920s, see Rohkrämer 1999, 246 ff. and in particular Willeke 1995; Willeke 1996.
47 On the technocratic movement in the United States, the retrospective view of a former member remains instructive: Elsner 1967.
48 Hardensett 1932.
49 Eichelberg 1932, 11.
50 Eichelberg 1932, 13.
51 Herf 1984, 221.
52 Böhler 1931, 25.

53 The ETH's involvement in the "historic" peace agreement of 1937 between workers and employers in the engineering industry is also treated by Dübi and Ilg 1945.
54 Böhler 1931, 26 and 42.
55 Jaspers 1931, 167.
56 Eichelberg 1959; Eichelberg 1965. See also Eichelberg 1960.
57 Wahlen 1956; Wahlen 1966 (1962). Traupel 1962; Traupel 1965. Other exponents of Swiss technocratic humanism are easy to find. The biographies of Federal Councillors Kobelt, Streuli, and Bonvin show the influence of technocrats in the Swiss political system of the latter half of the century.
58 Ostertag 1955, 602. De Sanctis also provided the motto for a meeting of the SIA in 1958 devoted to the "engineer as a human in the face of technology." Gruner 1958.
59 Ostertag 1955, 604.
60 Zoppi et al. 1948.
61 On the semantic field of normality and normativity see Link 1997. As of 1881, subjects could be freely chosen beginning with the third academic year. See above, Chapter 2, 90 f. On the Humboldt credo regarding the unity of research and teaching, see, inter alia, Schwinges 2001; Paletschek 2002.
62 Under agreement with the University of Zurich, the ETH's division of chemistry had already been supervising PhD students since the beginning of the 1880s.
63 Leemann and Speich 2005d.
64 Ruzicka, however, took on relatively few PhD students because he assigned rather difficult topics. In 1935, the administration asked him to ease the requirements. EAR, SR2: Schulratsprotokolle 1935, meeting of 17/5/1935, 98. On Ruzicka in general see Oberkofler 2001. On his leaving inorganic chemistry, which was thereafter taught by William Dupré Treadwell, an analytical chemist, see Ruzicka 1955, 108.
65 EAR, SR2: Schulratsprotokolle 1932, meeting of 17/12/1932, 156.
66 Gnehm 1930.
67 Gagliardi, Nabholz and Strohl 1938.
68 Gnehm 1930, 48.
69 Gnehm 1923, 4.
70 Gull 1930; Oechslin 2005.
71 On the 1924 regulations see Guggenbühl 1955, 143 ff.
72 Gnehm 1923, 8.
73 See EAR, SR2: Schulratsprotokolle 1920, meeting of 2/12/1920, agenda item 146. Contrary to the original design, the dome's concrete webbing was subsequently covered with a tile roof to increase general aesthetic appreciation of the building. See Oechslin 2005, 142.
74 Even the Federal Council's report of 1869, which made a plea for the new curriculum, took this fundamental objection very seriously. A postulate from 1882 once more confirmed the fear that training in agriculture was too theory-intensive. See above, Chapter 2, n. 59. On Fellenberg and the agricultural schools, see Guggisberg 1953.
75 "Botschaft des Bundesrathes an die h. Bundesversammlung betreffend Erweiterung der Forstschule des eidgenössischen Polytechnikums in eine Forst- und landwirthschaftliche Schule (vom 26. November 1869)," Bundesblatt 3/1869, 327–356, here 336.
76 See also the special arrangements for facilitating admission of students into the school of agriculture. See above, Chapter 2, n. 59. Schweizerischer Schulrat 1881; Schweizerischer Schulrat 1908b, Art. 5.
77 The Federal Council's dispatch of 1869 continues: "Men who, because they live and practice their profession among these people, are to a large extent suited, on the one hand, to be aware of the priorities and demands of these circles, and on the other to represent their views and needs in the proper way; men who, wherever they are, help to create an intelligent, rational local economy and are equally of great use in answering any question of an agricultural or economic nature at the cantonal or federal legislative and administrative level." Bundesblatt 3/1869, 336.
78 For relevant background with respect to the nineteenth century, see Mooser 1984, and for the twentieth century Baumann and Moser 1999.
79 Baumann 1995.
80 Laur 1971, 39 ff. Raphael takes this to be more scientific than social. Raphael 1996.
81 Pfister 1995, 49.
82 Laur considered his slim 85-page «gemeinverständliche Einführung in die Hauptprobleme der theoretischen Nationalökonomie» (Practical introduction to the main problems of theoretical economics) which found quite a wide readership, to be his magnum opus. Laur 1932.
83 Laur 1971, 45. Our emphasis. For the idea that the world was a "laboratory," see also Baumann 1993, 258.
84 The embedding of agronomy into existing

scientific practice also had an analog in the field experiments that were a fixture of geology and biology. See Westermann 2005f.

85 Laur 1971, 42. On the significance of Wiegner, see Hasler 1944, 171 f. Laur eulogized Wiegner as "sower who had sown the seed of refined engineering knowledge around the country. In so doing, he became a leader of farmers in the field of technological progress." Düggeli et al. 1936, 27. On the rise of the life sciences in Switzerland, see Stettler 2001.

86 Of course, compared with the rest of the industralized world, the applied social sciences developed hesitantly in Switzeralnd. See Zürcher 1995b.

87 Aly and Heim 1991; Heim 2000.

88 Bijker 1994 on the delta plan of 1953. For Dutch hydraulics in general, see Ven 1994.

89 For a general treatment, see Baumann and Moser 1999, 19 ff. On Bernhard, see also Winkler, Winkler and Lendi 1979 and Eisinger 2004, 82.

90 For Germany, see Heim 2003 and Kluge 2005. For Switzerland, the authoritative source remains Maurer 1985.

91 Baumann and Moser 1999, 84 f.

92 Tanner 1999, 383.

93 Hofmann 1943; Eisinger 2004, 48 ff.

94 Winkler, Winkler, and Lendi 1979. On Böhler see Böhler 1943; Böhler 1958; Böhler 1965. Dübi had already lodged a fundamental objection to economic planning. Dübi 1939. On the critique of "planification," see also Linder 1967.

95 Wahlen 1966 (1952); Holenstein 1998.

96 Leibundgut 1971.

97 For a general treatment, see Porter 1995.

98 On Lorenz see Zürcher 1995a and Tanner 2002, 150.

99 Eisinger 2004, 47. On the free economists see Schärrer 1983. Like much of the public, Max Frisch was sharply critical of Bernoulli's dismissal. Frisch 1974.

100 EAR, SR2: Schulratsprotokolle 1919, meeting of 18/10/1919, agenda item 101.

101 Raphael 1996.

102 EAR, SR2: Schulratsprotokolle 1919, meeting of 19/7/1919, agenda item 62; EAR, SR2: Schulratsprotokolle 1922, meeting of 25/11/1922, agenda item 130.

103 EAR, SR2: Schulratsprotokolle 1925, meeting of 28/11/1925, agenda item 140; EAR, SR2: Schulratsprotokolle 1930, meeting of 4/7/1930, agenda item 64; EAR, SR2: Schulratsprotokolle 1931, meeting of 20/2/1931, 33. The University of Zurich was also reluctant to provide sociopolitical expertise. See Saxer 2002.

104 Jaun 1986, 113.

105 EAR, SR2: Schulratsprotokolle 1929, meeting of 6/11/1929, agenda item 78.

106 EAR, SR2: Schulratsprotokolle 1929, meeting of 5–6/7/1929, agenda item 48.

107 Cited in Jaun 1986, 114.

108 Jaun 1986, 118.

109 EAR, SR2: Schulratsprotokolle 1931, meeting of 8/5/1931, 50. Vallière 1922.

110 Betriebswissenschaftliches Institut der ETH Zürich 1955, 333.

111 EAR, SR2: Schulratsprotokolle 1930, meeting of 25/4/1930, agenda item 33.

112 EAR, SR2: Schulratsprotokolle 1933, meeting of 23/9/1933, 170.

113 EAR, SR2: Schulratsprotokolle 1941, meeting of 9/4/1941, 69.

114 The complete list includes the Institute for Applied Acoustics (F. M. Osswald), the geotechnical testing station at the Institute for Mineralogy and Petrology (F. de Quervain), the Institute of Geophysics (F. Gassmann), an institute for earthworks research (E. Meyer-Peter, R. Haefeli and A. von Moos), the Institute of Statics (M. Ritter and F. Stüssi), the Institute of Photogrammetry (M. Zeller), an institute for aircraft statics and construction (E. Amstutz), the Institute for Aerodynamics (J. Ackeret, de Haller, and W. Pfenninger), the district heating power station at the ETH (B. Bauer), the Institute for Textile Engineering (E. Honegger), the Institute for Management Science (R. de Vallière), the economics department of the BWI (E. Böhler), the Institute for Photoelasticity (R. V. Baud and F. Tank), the Radiography Institute (E. Brandenberger), the high-voltage laboratory (K. Berger, K. Kuhlmann), the Institute for Electrical Engineering (J. Forrer), the Institute for High-Frequency Engineering (F. Tank), the Institute for Engineering Physics and the Center for Industrial Research (F. Fischer), the Institute for Microchemistry (M. Furter), the organic chemistry laboratory (L. Ruzicka), the high-pressure chemistry laboratory (A. Guyer), the service station for wastewater issues (E. Meyer-Peter and W. von Gonzenbach), the Institute for Milk Technology (M. Düggeli), the Institute for Special Botanics (E. Gäumann), the Institute for Plant Physiology (Jaccard and A. Frey Wyssling), the Institut for Animal Husbandry (A. Schmid), the Institute

for Applied Psychology (A. Carrard), the Unterhof and Rossberg-Kempttal Educational Farms (A. Volkart and O. Howald), the forestry teaching station and an agricultural machine-testing and training shop, as well as the yearly gymnastics and sports course (Jegher and Jegher 1938).

115 See, for example, vis-à-vis CIBA Ratmoko 2005, on Geigy Rosenbusch 1997, and on Sandoz Schaad 2001. On chemistry in general after 1914, see Simon 1997. For the history of the Basel chemical industry, the Geigy company remains a canonical example. Bürgin 1958.

116 Heiniger 1990, 12. For more on this idea, see Rohn 1934. On the example of the Gebrüder Sulzer company, see Oederlin 1965, 9 ff. We thank Florian Adank for the reference. On the general topic, see also Fleury and Joye 2002, 35 f.

117 Regarding Einstein's relativity theory, see Hampe 2005.

118 Spengler 1918, 636. Dingler 1926.

119 Stodola 1931 81.

120 On Weyl, see Frei and Stammbach 1994. See also Weyl's reflections on his time in Zurich in Weyl 1955.

121 Carnap 1928; Hilbert and Bernays 1934. Stodola also considered Heidegger's *Being and Time* to be an "abstract and tedious analysis." Stodola 1931, 92.

122 Grüttner 1997, 142.

123 A fulltext search of the string "Grundlagenforsch*" in the School Council minutes turns up a first hit in 1935, and the next one in 1939. Only beginning in 1942 do results appear for the string "Grundlagenforschung." Searching the full text of the *Bundesblatt* retrieves the first use of the term in the Federal Council's dispatch on the expansion of the ETH in 1945. See www.sr.ethbib.ethz.ch/digbib/home (22/7/2005).

124 At the ETH jubilee in 1930, this division of labor was more or less the main topic of discussion. For example, in his speech Federal Councillor Meyer first defined the ETH as a "school for the applied sciences," and then elaborated on the inaccuracy of this distinction. He concluded that the federal university, like the cantonal universities, was a cultural institution. Niggli et al. 1931, 23.

125 EAR, SR2: Schulratsprotokolle 1932, meeting of 31/10/1932, 121. and meeting of 18/3/1933, 43. On Tank see Druey in: Tank 1960. On Scherrer see Alder 1990.

126 EAR, SR2: Schulratsprotokolle 1937, meeting of 6/2/1937, 37, our emphasis.

127 EAR, SR2: Schulratsprotokolle 1937, meeting of 6/2/1937, 37.

128 Niggli 1945 (1929) and Niggli 1929. See also www.ethistory.ethz.ch/besichtigungen/touren/forschungspfade.

129 On the question of the unity of the sciences, see Niggli 1945 (1930).

130 Niggli 1945 (1929), 153.

131 Niggli 1947, 8 and 10.

132 Niggli 1947, 16. Alexander von Muralt also questioned the separation into pure and applied research post-1945. von Muralt 1955. The discursive dominance of basic research in Germany between 1945 and roughly 1970 was a reaction to Nazi science policy. Lengwiler 2005.

133 Cf. on the following Burri 2005f, and more generally Wehrli 1989. On Naville see Schmid and de Mestral 1960 and the entry in the *Historisches Lexikon der Schweiz;* on Alusuisse see Meier and Weisz 1942.

134 EAR, SR2: Schulratsprotokolle 1918, meeting of 9/3/1918, agenda item 39: "The president announced that the board of Aluminium Industrie A.-G. Neuhausen decided, at the suggestion of its president, Colonel Naville, to ask the General Assembly to give the E.T.H. a gift of 500,000 francs for scientific investigations. The president expressed his heartfelt thanks to Mr. Naville for his successful efforts." See also the Stiftungsurkunde: Eidgenössische Technische Hochschule 1918.

135 The federal funds came from liquidating an emergency institution of the war economy. See "Botschaft des Bundesrates an die Bundesversammlung betreffend die Zuwendung eines Beitrages an die Stiftung zur Förderung schweizerischer Volkswirtschaft durch wissenschaftliche Forschung an der Eidgenössichen Technischen Hochschule in Zürich," Bundesblatt 4/1919, 387–393. The Federal Council provisionally provided a grant of 1 million francs, but parliament halved it to 500,000 francs. Jegher 1955, 27.

136 Eidgenössische Stiftung zur Förderung schweizerischer Volkswirtschaft durch wissenschaftliche Forschung 1943, 37.

137 Eidgenössische Stiftung zur Förderung schweizerischer Volkswirtschaft durch wissenschaftliche Forschung 1943, 26.

138 Wehrli 1989, 237. Rohn 1937, 33. On the 1931 jubilee fund see national councillor Sulzer's speech on the occasion of present-

ing the fund in Niggli, Rohn, Meyer, Sulzer, Köhler, Naville and Eisenring 1931, 28–34. The centenary fund of 1955 was designed with a focus on applied research as a complement to the National Science Foundation of 1952. EAR, SR2: Schulratsprotokolle 1955, meeting of 8/7/1955, 304: "In formulating the purpose, it would be desirable to put applied engineering research in the foreground, so as to avoid having an aim that overlaps that of the National Science Foundation, which is known primarily for its support of basic research."

139 On the history of the *Versuchsanstalt für Wasserbau* see Meyer-Peter 1930 and, more recently, Vischer 2005. See also Burri 2005b.

140 EAR, SR2: Schulratsprotokolle 1933, Appendix, 23 ff.: Organisationsstatut des Betriebswissenschaftlichen Instituts.

141 Jaun 1986, 122.

142 EAR, SR2: Schulratsprotokolle 1938, meeting of 16/5/1938, 179.

143 EAR, SR2: Schulratsprotokolle 1935, Appendix, 10 ff. Bericht über die Konferenz zur Gründung einer Gesellschaft zur Förderung des Instituts für technische Physik der E.T.H. EAR, SR2: Schulratsprotokolle 1937: Gesellschaft zur Förderung der Forschung auf dem Gebiete der technischen Physik an der Eidgenössischen Technischen Hochschule, GTP, Statuten. See also Abteilung für industrielle Forschung 1977.

144 EAR, SR2: Schulratsprotokolle 1936, meeting of 15/2/1936, 1; Schüpfer 2003.

145 Figures for 1938–1940 based on EAR, SR2: Schulratsprotokolle 1940, meeting of 16/2/1940, 8. Figures for 1945–1953 based on the "Botschaft des Bundesrates an die Bundesversammlung über die Gewährung weiterer Beiträge an die Gesellschaft zur Förderung der Forschung an der Eidgenössischen Technischen Hochschule (vom 30. Juli 1954)," Bundesblatt 2/1954, 205–213. In 1945, the effectiveness of the society was evaluated, its scope of activity expanded, and its name changed to "Gesellschaft zur Förderung der wissenschaftlichen Forschung an der ETH" (GFF). EAR, SR2: Schulratsprotokolle 1945, Appendix, 135 ff. Gesellschaft zur Förderung der Forschung auf dem Gebiete der technischen Physik an der Eidg. Techn. Hochschule, Referat von Dr. F. Oederlin.

146 EAR, SR2: Schulratsprotokolle 1940, meeting of 16/2/1940, 8.

147 Oberkofler 2001, 148; Ruzicka 1955. On Ruzicka, see Prelog and Jeger 1980.

148 Oberkofler 2001, 106.

149 Ruzicka 1949.

150 Ruzicka in an evaluation regarding Goldberg's application for the habilitation thesis, dated 23/7/1940, cited in Oberkofler 2001, 221 f. The problem had already cropped up in the mid-1930s, with Tadeus Reichstein, whose position did not match his academic excellence. In 1936, Ruzicka successfully backed Reichstein's promotion to professor. EAR, SR2: Schulratsprotokolle 1936, meeting of 20/11/1936, 238.

151 EAR, SR2: Schulratsprotokolle 1954, meeting of 9/10/1954, 371–373; EAR, SR2: Schulratsprotokolle 1955, meeting of 5/2/1955, 76 ff.

152 EAR, SR2: Schulratsprotokolle 1954, meeting of 19/6/1954, 232.

153 EAR, SR2: Schulratsprotokolle 1967, meeting of 4/2/1967, 207. Westermann 2005g.

154 EAR, SR3: Schulratsakten 1968, No. 615.17, Dossier Pino, 3. Dokument, Zusammenarbeitsvertrag.

155 This allocation derives from Adam Smith's 2003 (1776) ideas about fundamental functions of the state. The question to what extent science and technology are a public good remains controversial. See, inter alia, Nelson 1989; Callon and Bowker 1994.

156 Shinn 2003, 143. On the German Kaiser Wilhelm Institutes, see Vierhaus and vom Brocke 1990. The Kaiser Wilhelm Institute for Coal Research was established explicitly for the purpose of applied research. Rasch 1989. On the history of the *Fraunhofergesellschaft* see Trischler and vom Bruch 1999. On the impact of science funding mechanisms in other industrialized countries as templates in the establishment of the Swiss National Science Foundation in 1952, see Fleury and Joye 2002, 88 ff.

157 On innovation in Switzerland, see Hotz-Hart, Mäder and Vock 1996 (1995), 327 ff.; Hotz-Hart, Reuter and Vock 2000, as well as Freiburghaus et al. 1991 and Balthasar 1998. See also Heiniger 1990 for an instructive overview. The OECD report for 1970 noted with surprise the almost complete absence of state support for applied research: OECD 1971, 15.

158 Schweizerischer Handels- und Industrie-Verein 1973.

159 AfZ, Vororts-Archiv XIII 200.1, correspondence from Homberger to Zipfel dated 23/11/1942.

160 On the metal and machinery sector, see Dübi's statement in EAR, SR2: Schulratsprotokolle 1942, meeting of 22/6/1942, 136. On the chemical industry, see Fleury and Joye 2002, 45.
161 EAR, SR2: Schulratsprotokolle 1961, meeting of 16/12/1961, 700.
162 On big science in general, see Price 1963. About physics, see Galison and Hevly 1992; Weinberg 1967.
163 Wildi 2003, 241.
164 Choisy 1965.
165 AfZ, Vororts-Archiv, XIII, 202.13, Sitzungsprotokoll der AG Forschungspolitik des Vororts, 2/11/1966.
166 AfZ, Vororts-Archiv, XIII, 202.13, Sitzungsprotokoll der AG Forschungspolitik des Vororts, 10/7/1966.
167 AfZ, Vororts-Archiv, XIII, 202.13, Sitzungsprotokoll der Schweizerischen Handelskammer, 13/9/1968.
168 Bundesblatt 2/1972, 419.
169 Straumann 2001.
170 Siegenthaler 1986, 498; Tanner 1998b, 248. On the business cycle, see Ritzmann-Blickenstorfer 1997. For the statistical data, see Siegenthaler 1996, Table F.19. See also Kunz and Morandi 1998 on the evolution of economic and sociopolitical ideas. For general background see David, Guex, and Perrenoud 1997 and especially Meier et al. 2002, 35–57.
171 The ETH had been similarly affected by the "Great Depression" of 1880. See above, Chapter 2.
172 Schärrer 1983, 245 ff; Grossmann 1934.
173 Grimm and Rothpletz 1934. The government grappled mightily with these issues in "Bericht des Bundesrates an die Bundesversammlung über das Volksbegehren zur Bekämpfung der wirtschaftlichen Krise und Not (vom 6. März 1935)," Bundesblatt 1/1935, 277–349. For Böhler's take, see Böhler 1932; Böhler and Keller 1935.
174 On the evolution of sociopolitical discourse in the 1930s, see Kunz and Morandi 1998. Hiltbrunner 2001 represents a first attempt at a documentary history of the Swiss Institute for Business Cycle Research.
175 "Bericht der Finanzdelegation der eidgenössischen Räte an die Finanzkommission des Nationalrates und des Ständerates über ihre Tätigkeit vom 1. Oktober 1932 bis zum 30. September 1933. (Vom 16. November 1933.)," Bundesblatt 2/1933, 771–793, here 791 f.
176 This is clearly evident in the "Botschaft des Bundesrates an die Bundesversammlung betreffend die ausserordentlichen und vorübergehenden Massnahmen zur Wiederherstellung des Budgetgleichgewichtes (vom 2. September 1933)," Bundesblatt 2/1933, 197–294. This conception of order also explains the stubborn refusal to devalue the Swiss franc up to 1936, thus scotching the export industry's chances at improving sales. Tanner 2000.
177 On the policy of intervention in the export sector, see Meier, Frech, Gees, and Kropf 2002, 82 ff. On the banking act, see Halbeisen 1998.
178 A good illustration is the "Botschaft des Bundesrates an die Bundesversammlung über eine Partialrevision der Wirtschaftsartikel der Bundesverfassung (vom 10. September 1937)," Bundesblatt 2/1937, 833–902.
179 For the tandem aims of fiscal discipline and social policy, see Perrenoud 2000, 120.
180 Hug 2002.
181 Bundesblatt 2/1939, 44. See also Fleury and Joye 2002, 20.
182 EAR, SR2: Schulratsprotokolle 1933, meeting of 18/3/1933, 86.
183 Rohn 1934, 136.
184 Extensive discussion of the dispute between Bosset and Rohn is to be found in EAR, SR2: Schulratsprotokolle 1935, meeting of 16/2/1935, 29 f. On 21/12/1935, Rohn apprised school councillors of the negotiations in the Council of States that past autumn. EAR, SR2: Schulratsprotokolle 1935, meeting of 21/12/1935, 245.
185 EAR, SR2: Schulratsprotokolle 1931, meeting of 2/9/1931. See also BAR, E 3001 A Akz. 2, Band 7, Ecole d'ingénieur à Lausanne – Zusammenarbeit mit der ETH (1931–1936).
186 See "Botschaft des Bundesrates an die Bundesversammlung über neue ausserordentliche Massnahmen zur Wiederherstellung des finanziellen Gleichgewichtes im Bundeshaushalt in den Jahren 1936 und 1937 (vom 22. November 1935)," Bundesblatt 2/1935, 757–904.
187 EAR, SR2: Schulratsprotokolle 1935, meeting of 21/12/1935, 240 f.
188 EAR, SR2: Schulratsprotokolle 1936, meeting of 18/09/1936, 145 f.
189 EAR, SR2: Schulratsprotokolle 1935, meeting of 16/02/1935, 29 f.
190 Baeschlin 1935, 2.

191 Rohn in EAR, SR2: Schulratsprotokolle 1936, meeting of 18/9/1936, 176 f. On the defense bonds, see Degen 2000.
192 Baeschlin 1935, 2.
193 "Der Eröffnungsakt der Hochschulwoche für Landesverteidigung in der ETH," NZZ, 12/5/1936; Criblez 1993, 33; Universität Zürich 1983, 57.
194 Etter 1936, 11 f. On the week's events at the ETH, see EAR, SR2: Präsidialverfügungen 1936, Verfügung No. 340, 2/5/1936.
195 Historians such as Hans Nabholz and Werner Näf distanced themselves from Meyer's ideological revisionism. Kreis 2000.
196 See "Botschaft des Bundesrates an die Bundesversammlung über die Organisation und die Aufgaben der schweizerischen Kulturwahrung und Kulturwerbung (vom 9. Dezember 1938)," Bundesblatt 2/1938, 985–1935, here 998.
197 Bundesblatt 2/1938, 999.
198 Glaus 1969, 49 ff.
199 EAR, SR2: Schulratsprotokolle 1938, meeting of 19/12/1938, 365.
200 On Brandenberger, see Glaus 1969, 233; Frischknecht et al. 1987, 736. See also EAR, SR2: Schulratsprotokolle 1939, meeting of 2/10/1939, 221; EAR, SR2: Schulratsprotokolle 1942, meeting of 22/6/1942, 160.
201 EAR, SR2: Schulratsprotokolle 1946, meeting of 2/2/1946, 71. Volksrecht, Vol. 49, No. 24, 29/1/1946. Stäger was dismissed by Fischer in 1947; his *venia legendi* was temporarily suspended. EAR, SR2: Schulratsprotokolle 1947, meeting of 7/2/1947, 28 and EAR, SR2: Schulratsprotokolle 1953, meeting of 6/2/1953, 25. On the "Eingabe der 200," see Frischknecht, Haffner, Haldimann, and Niggli 1987, 141 f.
202 On the concept of the *Geistige Landesverteidigung,* see Zimmer 1996; Criblez 1995, and especially Mooser 1997.
203 See, for example, Amrein 1997.
204 Unabhängige Expertenkommission Schweiz – Zweiter Weltkrieg 2001.
205 See "Botschaft des Bundesrates an die Bundesversammlung über die Organisation und die Aufgaben der schweizerischen Kulturwahrung und Kulturwerbung (vom 9. Dezember 1938)," Bundesblatt 2/1938, 985–1935, here 1021.
206 Burri 2005g; Angst and Cattani 1989; Gimmi 2002.
207 See "Botschaft des Bundesrates an die Bundesversammlung über die Organisation und die Aufgaben der schweizerischen Kulturwahrung und Kulturwerbung (vom 9. Dezember 1938)," Bundesblatt 2/1938, 985–1935, here 998. EAR, SR2: Schulratsprotokolle 1938, meeting of 16/5/1938, 185.
208 Schweizerische Landesausstellung in Zürich 1940–1941, 318.
209 Bundesblatt 2/1938, 993.
210 Beeli 2003; EAR, SR2: Schulratsprotokolle 1916, meeting of 26/2/1916, agenda item 34. As early as 1935, the education council of the canton of Zurich recommended that a lecture on "national education" be made part of the training of teachers in gymnastics and other sports. EAR, SR2: Schulratsprotokolle 1936, meeting of 26/9/1936, 189.
211 EAR, SR2: Schulratsprotokolle 1938, meeting of 17/6/1938, 221.
212 EAR, SR2: Schulratsprotokolle 1938, meeting of 5/11/1938, 323.
213 EAR, SR2: Schulratsprotokolle 1938, meeting of 19/12/1938, 407.
214 EAR, SR2: Schulratsprotokolle 1939, meeting of 17/2/1939, 52: "Before being admitted for the final diploma exam, each student must show that he has attended at least one Division XIIA lecture in Swiss history, Swiss civics, Swiss literature, or the Swiss economy." See also the meeting of 16/6/1939, 163. The civics requirement remained until 1971. ETH-Bulletin, Vol. 4, No. 34, June 1971, 4.
215 Bodmer 1979; Schütt 1996.
216 EAR, SR2: Schulratsprotokolle 1943, meeting of 25/6/1943, 204.
217 See also the importance that Etter ascribed to the radio in cultural communication. On this subject, see also Mäusli 1997; Reymond 2000.
218 Attenhofer 1989. On Schmid's life, see also Breitenmoser and Spillmann 1997.
219 Schmid 1998.
220 On the evolution of the *Geistige Landesverteidigung* from the 1930s to the 1950s: Imhof 1996; Tanner 1992. Note Jean Rudolf von Salis' aloofness regarding the *Geistige Landesverteidigung* during the Cold War. Perrig 1993, 180.
221 Grimm and Rothpletz 1934, 84 f. and 90 ff.
222 "Bericht der begutachtenden Kommission für Wirtschaftsgesetzgebung an das eidgenössische Volkswirtschaftsdepartement (vom 4. Juni 1937)," Bundesblatt 2/1937, 939. The same source later states: "A prerequisite for its realization is the coop-

eration of the producers in developing a research program as well as closer ties between universities and industry. The question also arises whether the new military subsidies might provide a means of funding critical research."

223 EAR, SR2: Schulratsprotokolle 1942, meeting of 22/6/1942, 131. Cf. on the following Fleury and Joye 2002, 32 ff. See also Burri 2005e.

224 Correspondence from Arthur Rohn to J. L. Cagianut dated 23/6/1941, cited in Fleury and Joye 2002, 38.

225 Within the ETH, Rohn spoke bluntly: "Matters that are not urgent or not political often go ignored in Bern, even when they have demonstrable value. Precisely for this reason, I am asking you to make liberal use of the category 'job creation and export promotion.' If we only seem to be concerned with research at the ETH – which would be assessed primarily as a purely scientific enterprise – our initiative will go down to defeat in the budget deliberations." Cited in Fleury and Joye 2002, 42.

226 "Über den Zusammenhang zwischen dem Problem der Arbeitsbeschaffung und Exportförderung mit der wissenschaftlichen Forschung. Bericht von Professor Saxer, Rektor der ETH (vom 22. November 1941)." See Fleury and Joye 2002, 45.

227 Fleury and Joye 2002, 54. The source of Basel's reluctance was the fear that it might "in future lose the benefits that had accrued to the university from industry up to that point." EAR, SR2: Schulratsprotokolle 1942, meeting of 11/7/1942, 211.

228 Fleury and Joye 2002, 56. EAR, SR2: Schulratsprotokolle 1942, meeting of 19/9/1942, 245.

229 EAR, SR2: Schulratsprotokolle 1942, meeting of 19/9/1942, 246. On the adoption of administrative rules regarding the allocation of funds, see the meeting of 18/12/1942, 355 ff.

230 EAR, SR2: Schulratsprotokolle 1943, meeting of 1/5/1943, 108 f.

231 EAR, SR2: Schulratsprotokolle 1943, meeting of 25/6/1943, 155 ff. See also EAR, SR2: Schulratsprotokolle 1944, meeting of 15/9/1944, 235.

232 EAR, SR2: Schulratsprotokolle 1944, meeting of 4/11/1944, 279 ff. Quotation on 282.

233 "Siebenter Bericht des Bundesrates an die Bundesversammlung über die auf Grund der ausserordentlichen Vollmachten ergriffenen Massnahmen (vom 3. November 1942)," Bundesblatt 2/1942, 740–766, here 752; Zipfel 1946, 12 ff.; Fleury and Joye 2002, 64 ff. Overall, 4 million francs from the initial job creation subsidy were reserved for research support. See the account in the Bundesblatt 1/1946, 773.

234 König 1999a, 155.

235 Fueter 1939. The book went through several printings.

236 Staub and Hinderberger 1943–1944.

237 Zipfel 1943a; Zipfel 1943b.

238 Technische Rundschau Vol. 35, No. 20, 6/5/1943; Atlantis Vol. 17, No. 9, 1945: Die Eidgenössische Technische Hochschule in Zürich. Ein Bericht.

239 Fueter 1946, 28.

240 The allocations were itemized in the "Botschaft des Bundesrates an die Bundesversammlung zum Entwurf eines Bundesbeschlusses über die Förderung der Forschung auf dem Gebiete der Atomenergie (vom 17. Juli 1946)," Bundesblatt 2/1946, 928–935. Around 8 million francs were earmarked for the establishment of a "experimental uranium facility" and for research and study of a fissile material available in Switzerland; 3 million for building a "Swiss institute for experimental research," and another 2 million for the construction of a "large atom smasher," at this institute. Finally, the "atomic energy commission" was awarded 1 million a year for the period 1947 to 1951 to further relevant research in Basel, Geneva, Lausanne, Neuchâtel, and Zurich.

241 Lachenal 1946; Rohn 1946.

242 "Botschaft des Bundesrates an die Bundesversammlung über den Ausbau der Eidgenössischen Technischen Hochschule (vom 17. Dezember 1945)," Bundesblatt 2/1945, 737–779, here 742.

243 "Botschaft des Bundesrates an die Bundesversammlung über die Gewährung eines jährlichen Beitrages an die Gesellschaft zur Förderung der Forschung an der Eidgenössischen Technischen Hochschule (vom 29. März 1946)," Bundesblatt 1/1946, 765–776, here 773 f.

244 Etter 1955; Altermatt 1991c.

245 Guggenbühl 1955. Guggenbühl whitewashes the developments of the first half of the twentieth century to such an extent that his work was of little use to the present volume.

246 Fueter 1946, 35.

247 "Botschaft des Bundesrates an die Bundesversammlung über die Gewährung

eines jährlichen Beitrages an die Gesellschaft zur Förderung der Forschung an der Eidgenössischen Technischen Hochschule (vom 29. März 1946)," Bundesblatt 1/1946, 765–776, here 774.

248 Hummler 1957, 6.

249 Vannevar Bush set the tone for the American discourse in 1945. In 1957, Robert Solow famously defined the importance of science and technology for economic development.

250 For the United States, see Killian 1977.

251 Poignant, Freeman, and Svennilson 1963.

252 Servan-Schreiber 1967. On the reaction in Germany, see Bähr 1995. Profound uncertainty was also aroused by the well-known phenomenon of brain drain. Chorafas 1968; Chorafas 1969a; Chorafas 1969b.

253 Gehmacher 1966.

254 The argumentative topos was based on conventional notions of relative economic backwardness, described in exemplary fashion in Gerschenkron 1962.

255 Horvath 1998; Kneschaurek 1963.

256 Labhardt 1964; Deppeler 1964.

257 Labhardt 1965.

258 See the "Bundesgesetz über die Hochschulförderung (vom 28. Juni 1968)," Bundesblatt 2/1968, 19–21.

259 These subsidies also spurred the building of an annex on the Hönggerberg. "Botschaft des Bundesrates an die Bundesversammlung über die bauliche Entwicklung der Eidgenössischen Technischen Hochschule und der mit ihr verbundenen Anstalten (vom 6. Februar 1959)," Bundesblatt 1/1959, 199–235. See also "Botschaft des Bundesrates an die Bundesversammlung über den weiteren Ausbau der Eidgenössischen Technischen Hochschule und der mit ihr verbundenen Anstalten (vom 9. Juli 1965)," Bundesblatt 2/1965, 889–999.

260 Hans Pallmann: Ergänzende und zusammenfassende Mitteilungen zur Botschaft No. 9289 des Bundesrates an die Bundesversammlung über den weiteren Ausbau der Eidgenössischen Technischen Hochschule (ETH) und der mit ihr verbundenen Anstalten (vom 9. 7. 1965), 27.

261 Hochstrasser 1967, 91. From 1969, Hochstrasser led the division of science and research at the Department of Home Affairs.

262 "Botschaft des Bundesrates an die Bundesversammlung betreffend Übernahme der Polytechnischen Schule der Universität Lausanne durch den Bund (vom 4. März 1968)," Bundesblatt 1/1968, 699–731.

263 On Jean Rudolf von Salis as the "voice of the nation," see, inter alia, Birrer 2003, 50 ff.

264 Maier 2002a, 8. As an example of mathematics in Germany, see Epple 2002b; Epple and Remmert 2000. See Leslie 1993 for the Cold War at MIT and Stanford.

265 Hug 1987; Hug 1998.

266 Hug 1998, 229.

267 For the nuclear research program, see Metzler 1997; Stüssi-Lauterburg 1995; Wildi 2003, 34 ff.; Kupper 2003a, 172.

268 Hug 1987, 188. Hug sources the data for 1948 to Edwards and La Roche 1950.

269 Heiniger 1990, 30.

270 Maier 2002a, 8.

271 In 1942 the KIAA awarded the ETH 10,000 francs to upgrade the Institute of Geophysics in order to carry out such studies. EAR, SR2: Schulratsprotokolle 1941, meeting of 8/11/1941, 297. See also meeting of 13/2/1942, 35 and meeting of 30/3/1942, 68.

272 Figures from Zipfel 1946, 16. See Fleury and Joye 2002, 75.

273 "Botschaft des Bundesrates an die Bundesversammlung über den Ausbau der Eidgenössischen Technischen Hochschule (vom 17. Dezember 1945)," Bundesblatt 2/1945, 737–779, here 742. As early as 1943 Rohn had judged the ETH fundworthy: "Based on your objectives, almost all the divisions and institutes of the ETH are in the business of job creation and export promotion," he maintained. Rohn 1943, 97.

274 Hug 1997, 65 and 69.

275 EAR, SR2: Schulratsprotokolle 1936, meeting of 22/5/1936, 70.

276 Grimm and Rothpletz 1934, 92.

277 Stenografisches Bulletin der Bundesversammlung (Nationalrat), 1936, Vol. 46, 731 ff. Gut's statement appears on 732.

278 EAR, SR2: Schulratsprotokolle 1937, meeting of 8/5/1937, 97. See also Burri 2005a.

279 Hug 1997, 66.

280 EAR, SR2: Schulratsprotokolle 1940, meeting of 13/7/1940, attachment, 6.

281 EAR, SR2: Schulratsprotokolle 1943, meeting of 12/3/1943, 44.

282 EAR, SR2: Schulratsprotokolle 1946, meeting of 21/6/1946, 268.

283 Muller 1988, 12.

284 An example is the International Association for Testing Materials, which was founded

in 1896 by ETH professor Tetmajer. Zielinski 1995.

285 Crawford, Shinn, and Sörlin 1993b, 25 f.

286 On national competitiveness in the context of the OECD, see Godin 2002a; Godin 2002b.

287 Crawford 1984; Jessen and Vogel 2002b.

288 Metzler 2002; Metzler 2000.

289 On changes in the proportion of foreign students, see Leemann and Speich 2005b and above, Chapter 2, Figure 1, 41.

290 Kury 2003; Arlettaz and Arlettaz 2004, 71 ff.

291 BAR, E 80, Bd. 88, Do. 665–667, correspondence from the parliamentary finance delegation to the Department of Home Affairs, dated 17/2/1908.

292 Schweizerischer Schulrat 1908a, 8. See also above, Chapter 2, 45 f.

293 Rohn 1923, 4.

294 EAR, SR2: Schulratsprotokolle 1924, meeting of 23/2/1924, agenda item 24.

295 Westermann 2005i. See also: EAR, SR2: Schulratsprotokolle 1945, meeting of 10/11/1945, 412 ff.

296 EAR, SR2: Schulratsprotokolle 1933, meeting of 24/6/1933, 93.

297 Unabhängige Expertenkommission Schweiz – Zweiter Weltkrieg 2001; Picard 1994.

298 EAR, SR2: Schulratsprotokolle 1933, meeting of 22/4/1933, 74. See also Kury 1998.

299 EAR, SR2: Schulratsprotokolle 1933, meeting of 23/9/1933, 165.

300 EAR, SR2: Schulratsprotokolle 1934, meeting of 3/2/1934, 18 ff.

301 Ist unsere Eidgen. Techn. Hochschule ebenfalls verjudet?, in: Die Front, No. 142, 17/8/1934; EAR, SR2: Schulratsprotokolle 1934, meeting of 21/9/1934, 142. The target of the attack was Moses Wolf Goldberg.

302 Picard 1994.

303 EAR, SR2: Schulratsprotokolle 1938, meeting of 26/9/1938, 291 ff

304 EAR, SR2: Schulratsprotokolle 1938, meeting of 7/7/1938, 287.

305 EAR, SR2: Schulratsprotokolle 1938, meeting of 26/9/1938, 293.

306 EAR, SR2: Schulratsprotokolle 1940, meeting of 30/3/1940, 73.

307 For example, an interest-free loan to Günter Baum, a Jewish civil engineering student, who was unable to withdraw money from Germany. EAR, SR2: Schulratsprotokolle 1940, meeting of 30/3/1940, 59.

308 EAR, SR2: Schulratsprotokolle 1940, meeting of 13/7/1940, 172.

309 Siegmund-Schultze 1998, 112.

310 EAR, SR2: Schulratsprotokolle 1944, meeting of 16/12/1944, 369.

311 EAR, SR2: Schulratsprotokolle 1945, meeting of 2/2/1945, 59. The project was a response to the intention of the Americans to attract 3,000 to 4,000 engineers from war-torn countries to the United States, where they would be trained as "poster students" for America. EAR, SR2: Schulratsprotokolle 1944, meeting of 23/6/1944, 196.

312 On the Swiss Donation, see Favez 1995; Schmitz 2004.

313 EAR, SR2: Schulratsprotokolle 1945, meeting of 15/9/1945, 299.

314 Speich 2005b.

315 EAR, SR2: Schulratsprotokolle 1932, meeting of 17/9/1932, 80.

316 Ist unsere Eidgen. Techn. Hochschule ebenfalls verjudet?, in: Die Front, No. 142, 17/8/1934.

317 EAR, SR2: Schulratsprotokolle 1935, meeting of 17/5/1935, 97 f.; EAR, SR2: Schulratsprotokolle 1946, meeting of 1/2/1946, 66.

318 Willstätter 1949, cited in Tank 1955. On Willstätter, see also Straumann and Wildmann 2001, 165 ff.

319 On the presence of Jews in science, see Volkov 1997 and (earlier) Volkov 1990, 146 ff., and Grüttner 2003, 69. The overrepresentation was especially marked in the economically insecure low ranks of faculty. It gave rise to an anti-Semitic, anti-intellectual stereotype.

320 Krohn 2002, 437 f.

321 Siegmund-Schultze 1998, 112; Picard 1994, 69. To give an idea of the significance of the number of university lecturers let go: In 1933, the ETH had a total of 136 faculty, including 69 full and 7 associate professors, 14 titulars, and 46 lecturers. Speich 2005b.

322 EAR, SR2: Schulratsprotokolle 1934, meeting of 22/12/1934, 205.

323 EAR, SR2: Schulratsprotokolle 1935, meeting of 16/2/1935, 14. Schlesinger then accepted a professorship at the Free University in Brussels. In January 1939 he emigrated to Britain, where he managed a manufacturing research laboratory until 1944. He died in 1949 at 75.

324 Cited in Siegmund-Schultze 1998, 112.

325 EAR, SR2: Schulratsprotokolle 1939, meeting of 2/10/1939, 203.

326 Hilbert and Bernays 1934.

327 Frei and Stammbach 1994, 60.
328 EAR, SR2: Schulratsprotokolle 1934, meeting of 3/11/1934, 163.
329 Frei and Stammbach 1994, 57; EAR, SR2: Schulratsprotokolle 1940, meeting of 13/7/1940, 172.
330 EAR, SR2: Schulratsprotokolle 1940, meeting of 20/6/1940, 132.
331 EAR, SR2: Schulratsprotokolle 1942, meeting of 22/6/1942, 151.
332 EAR, SR2: Schulratsprotokolle 1943, meeting of 25/6/1943, 238.
333 EAR, SR2: Schulratsprotokolle 1945, meeting of 10/11/1945, 387. On Pauli, see Enz, Glaus, and Oberkofler 1997; Enz 2005.
334 Schmid 1945, 14.
335 Ten years later Leibbrand was suspected of war crimes. When a murder case against him was opened in Germany, the School Council gave him leave until further notice. EAR, SR2: Schulratsprotokolle 1961, meeting of 30/9/1961, 624 ff.
336 EAR, SR2: Schulratsprotokolle 1950, meeting of 24/6/1950, 216.
337 EAR, SR2: Schulratsprotokolle 1950, meeting of 24/6/1950, 219.
338 EAR, SR2: Schulratsprotokolle 1950, meeting of 24/6/1950, 217.
339 Speich 2005b.
340 EAR, SR2: Schulratsprotokolle 1943, meeting of 1/5/1943, 133.
341 EAR, SR2: Schulratsprotokolle 1943, meeting of 25/6/1943, 224. In 1942, then aged 25, Eckmann accepted a post as lecturer at the engineering school in Lausanne. In 1948, he too was made professor at the ETH. Vgl. Historisches Lexikon der Schweiz.
342 Meier, Frech, Gees, and Kropf 2002, 291 ff. On in-house appointments, see Speich 2005a.
343 EAR, SR2: Schulratsprotokolle 1945, meeting of 15/9/1945, 299.
344 EAR, SR2: Schulratsprotokolle 1947, meeting of 21/6/1947, 239. See also www.ethistory.ethz.ch/besichtigungen/touren/politkarrieren.
345 EAR, SR2: Schulratsprotokolle 1945, meeting of 10/11/1945, 412 ff. On SFUSA in the 1920s, see Jaun 1986, 110.
346 Correspondence from Max Furter, dated 4/12/1945, cited in EAR, SR2: Schulratsprotokolle 1946, meeting of 1/2/1946, 17.
347 EAR, SR2: Schulratsprotokolle 1947, meeting of 20/6/1947, 245. Saxer pointed out with satisfaction that the father of the modern computer, John von Neumann, had once studied at the ETH Zurich. See also Heintz 1990; Furger and Heintz 1997; Furger and Heintz 1998.
348 EAR, SR2: Schulratsprotokolle 1948, meeting of 10/7/1948, 229; Speiser 2003. See also www.ethistory.ethz.ch/besichtigungen/touren/forschungspfade.
349 Peyer 1996, 115.
350 The ETH basically followed this German tradition. As early as the 1950s, however, Vladimir Prelog had instituted the American group model in the organic chemistry laboratory. Prelog and Jeger 1980. “In becoming director of the Laboratory I reached, according to Peter’s principle, the level of my incompetence and I tried hard for several years to step down. Surrounded and supported by a group of very able young colleagues, I finally succeeded in introducing a rotating chairmanship from which I was exempted,” wrote Prelog in an autobiographical sketch. www.nobelprize.org/chemistry/laureates/1975/prelog-autobio.html (23/6/2005). See also www.ethistory.ethz.ch/rueckblicke/departemente/dchab_chemie/entwicklung.
351 Steinlin 1962, 42.
352 On Ursprung and Wirth see the ETH Zurich’s electronic “Who Is Who” (26/11/2002). On Res Jost, see the Historisches Lexikon der Schweiz, and on Ralf Hütter www.nideco.ethz.ch/about/patronage_committee/huetter/index (23/6/2005).
353 Schweizerischer Wissenschaftsrat 1967, 13. In 1958, the future representative of the Federal Council for atomic energy, Urs Hochstrasser, was already active as science attaché for the Swiss diplomatic service in Washington and Ottawa, working to encourage the return of Swiss scientists to Europe.
354 Chorafas 1968; Chorafas 1969a; Chorafas 1969b; Bergier 1980, 64.
355 Wissenschaftspolitik. Mitteilungsblatt des schweizerischen Wissenschaftsrates Nov. 1968, Vol. 2, No. 3, “Rückgewinnung schweizerischer Wissenschaftler aus dem Ausland” (returning Swiss scientists from abroad). See also: AfZ, Vororts-Archiv, Ziffer XIII, Do. 202.11: Forschungsförderung (1969–1972).
356 EAR, SR2: Schulratsprotokolle 1949, meeting of 24/6/1949, 189. The reference to MIT is on 190.
357 EAR, SR2: Schulratsprotokolle 1951, meeting of 6/10/1951, 337 ff.

358 Strasser and Joye 2005; Krige 1997; Krige 2000.
359 Bundesblatt 2/1965, 978 f.
360 Bundesblatt 2/1965, 981.
361 Bundesblatt 2/1965, 986.
362 EAR, SR2: Schulratsprotokolle 1966, meeting of 12/6/1966, 278.
363 EAR, SR2: Schulratsprotokolle 1966, meeting of 8/7/1966, 560.
364 EAR, SR2: Schulratsprotokolle 1966, meeting of 8/7/1966, 564.
365 EAR, SR2: Schulratsprotokolle 1966, meeting of 10/12/1966, 773.
366 EAR, SR2: Schulratsprotokolle 1966, meeting of 10/12/1966, 773.
367 EAR, SR2: Schulratsprotokolle 1967, meeting of 4/2/1967, 6; Kupper 2003b.

Chapter 5

1 Schelsky, 1969, 9
2 Bell, 1967; Galbraith, 1967; Price 1965; Touraine 1969. See Gugerli, Kupper, and Speich 2005.
3 Gehmacher 1966; Poignant, Freeman, and Svennilson 1963.
4 Schelsky 1971 (1963).
5 EAR, SR2: Schulratsprotokolle 1968, meeting of 3/2/1968, agenda item 24. Also Rector Hans Leibundgut, who attended the meetings of the School Council as an observer, supported the proposal.
6 See Imhof, Kleger, and Romano 1999, 248–255.
7 Imboden 1967, 267.
8 Peyer 1983, 118; Kreis 1986, 142 and 177 ff. The surge of reforms in the 1960s (see Deppeler 1969a) only found its way into legislation in the 1990s. See the overview of Swiss higher-education law in Kottusch 1999.
9 In 1965, the office of vice president was introduced. In 1967, a deputy for the annex institutes was added to relieve the burden on the president. EAR, SR2: Schulratsprotokolle 1968, meeting of 28/9/1968, 655–660.
10 Huber 1969, 5.
11 Some 1,200 people heard Bonvin's speech. Studentischer Wochenkalender, No. 12, 27/1/1969. Because of the "extraordinary interest" elicited by Bloch's talk, the Schweizerische Hochschulzeitung printed it in its entirety. Bloch 1968. All the talks were published by Gerhard Huber as an anthology in 1969.
12 Ad in the Zürcher Student No. 5, November 1968.
13 Studentischer Wochenkalender, No. 4, 11/11/1968. For the number of women students, see Leemann and Speich 2005f.
14 See above Chapter 4, 144. See also Wengenroth 2003a.
15 Frisch 1957.
16 Bonvin 1969, 82 and 95.
17 Studentischer Wochenkalender, No. 12, 27/1/1969. See also the comments on Bonvin's appearance by the FSZ and the Liberale Studentenschaft Zürich (LSZ). EAR, VSETH-Archiv, ETH-Gesetz, 1–20 and 1.2.1, Folder 8 and Folder 17 FSZ and LSZ leaflets.
18 Bechtler titled his talk "Thoughts on training engineers to be leaders."
19 On Bonvin, see Andrey 1991. On Bechtler see the entry in Historisches Lexikon der Schweiz.
20 König 1998a, 12.
21 König 1998a, 13.
22 Huber 1969, 98.
23 Huber 1969, 111; Décosterd 1959. The Zurich *Hallenstadion* was the venue of a popular six-day bicycle race.
24 One of the major arguments for adopting the law heard in the campaign was that only a new law would enable the EPFL to ward off the threat of "paternalism" by the ETHZ. See EAR, SR2: Schulratsprotokolle 1969, meeting of 5/6/1969, 559.
25 Waiving a consultation process was unusual and earned the rebuke of the Zurich government. The law cleared the States' Council without debate, and engendered only a brief debate in the National Council before being passed with 141 yes votes. Amtliches Bulletin der Bundesversammlung, fall session 1968. Huber 2003.
26 On "Tschudi's tempo," see Linder 1991.
27 Gruner 1971, 360.
28 Kreis 1998, 21–38.
29 See the overview of Switzerland's science policy bodies in ETH-Bulletin, Vol. 5, No. 57, 31/8/1972. The conference of education ministers planned to establish a "concordat on the coordination of education." Tschudi 1970, 30 f.
30 Anton E. Schrafl: "Hindernisse einer schweizerischen Wissenschaftspolitik – ein Diskussionsbeitrag," in: NZZ, 3/4/1967, afternoon edition, 8. On the differentiation of science policy, see Benninghoff and Leresche 2003.

31 AfZ, Vororts-Archiv, XIII, 202.13, Protokoll der Arbeitsgruppe für Fragen der Forschungspolitik dated 6/9/1968. The working group was formed in 1966 at the initiative of the Swiss Chamber of Commerce.
32 AfZ, Vororts-Archiv, XIII, 202.11, invitation from Aebi dated 4/3/1969.
33 This movement corresponded to an international trend. OECD 1970, 158.
34 In 1968, the total number of students came to 5,865. The limit of 10,000 was exceeded only in 1986, when 10,347 students were enrolled. Jahresbericht ETH 1968 and 1986. On Pallman's planning horizon, see Hauri 1980, 525.
35 EAR, SR2: Schulratsprotokolle 1968, meeting of 4/5/1968, 278.
36 Schweizerischer Handels- und Industrie-Verein 1967. EAR, SR2: Schulratsprotokolle 1968, meeting of 3/2/1968, agenda item 41.4, 139. Kneschaurek's study appeared in 1971 as the fifth volume of his "Entwicklungsperspektiven der Schweizer Volkswirtschaft bis zum Jahr 2000." Kneschaurek 1971.
37 Böhler 1965, 279. On Böhler's fundamental critique of his contemporaries' mania for planning, see also the report by F. Kern in: Kneschaurek et al. 1973, 122.
38 EAR, SR2: Schulratsprotokolle 1968, meeting of 16/3/1968, Trakt. 65.
39 Stocker 1987, 78.
40 Input from the physics professors dated 9/2/1968, EAR, SR2: Schulratsprotokolle 1968, meeting of 16/3/1968, agenda item 65.
41 EAR, SR2: Schulratsprotokolle 1968, meeting of 30/9/1967, 616.
42 The debate launched by Eisenring led to the founding of the Federal Commission for Science and Research. EAR, SR2: Schulratsprotokolle 1968, meeting of 4/11/1967, 784.
43 The initial stage of the ETH Hönggerberg was considered the masterwork of architect Albert H. Steiner, who had long struggled to make his mark. See. Oechslin 2001; Stocker 1987. Steiner later described the period between 1968 and 1973 in which Hans Hauri took over the project, as a confused phase. Steiner 1984–1987, 26. Hauri, however, recalled the same time as a period of orderly planning. Hauri 1980, 525.
44 EAR, SR2: Schulratsprotokolle 1968, meeting of 7/12/1968, 876 f.
45 Schader 1969. Schader was a recognized expert in school construction. For example, he was responsible for the Freudenberg gymnasium in Zurich. As ETH professor, he was intensely involved with plans for the university. See, for example, Schader and Bamert 1968.
46 Circular from Hauri to all employees of the ETH dated 12 September 1969, cited in Schader 1969, 3.
47 On the founding of the coordinating group, see EAR, SR2: Schulratsprotokolle 1968, meeting of 18/2/1969, 22. On their work, see inter alia Koordinationsgruppe für Datenverareitung der ETH Zürich 1970.
48 Schader 1969, 18. In this matter, Schader also referred to Hempel 1967.
49 Telephone conversation between C. A. Zehnder and J. Schader of 14/10/1969, cited in Schader 1969, 8.
50 Helmut Schelsky referred to the industrial character of the modern university. Schelsky 1971 (1963), 145.
51 According to Rolf Deppeler in the foreword to the Basler Arbeitsgruppe für Bildungsforschung 1967. See also Deppeler 1968a, 43.
52 Hans Hauri recalled that during his tenure as president of the ETH Zurich, the academics had posed the greatest challenge because they rarely ever perceived their interests as "professionals," but rather as contradictory individuals. In any event, and in contrast to the student organizers, they did manage to make decisions, even if they were not all in agreement. "Sometimes they grumble a bit, but they resign themselves." ETH Bulletin, Vol. 6, No. 75, 15/10/1973, 10.
53 EAR, SR2: Schulratsprotokolle 1968, meeting of 18/1/1969, 22.
54 Verband der Studierenden an der ETH Zürich 1965. The publication grew out of a VSETH seminar in Dürrenäsch on the subject of technology and the educational mission of the ETH. Brunner et al. 1980, 483.
55 Meeting report by Peter Saladin in: Wissenschaftspolitik. Mitteilungsblatt des schweizerischen Wissenschaftsrates, Vol. 1, No. 3, November 1967, 24.
56 Plattner argued that the increasing importance of experts in the political process and of research and development for economic growth had led to a greater influence of science in politics, accompanied by a "politicization of science." This process had given rise to three areas of conflict: first, between academic freedom and the societal demand

that education be efficient; second, between research freedom and the need for industrial exploitation of scientific knowledge; and third, between value free rationality of science and moral political responsibility. Any curricular reform would have to take these tensions into account, and somehow to incorporate them into one overarching concept. A piecemeal solution "to the immediate shortcomings" would not suffice. Her talk would have greatly enhanced the School Council's lecture series held the following winter semester. But Burckhardt had not thought to invite a student as a speaker. Plattner 1968.

57 Orbis Scientiarum – Offizielles Organ der Schweizerischen Vereinigung Junger Wissenschafter, 1968, No. 5, 12 ff.

58 Peyer 1983, 126. The main speaker was supposed to have been Rudi Dutschke, but he was shot at shortly before the event. Wisler 1994, 230.

59 Schweizer Monatshefte, July 1968, 369, headlined "innenpolitische Rundschau." On riots, see Wisler 1994, 228 f.; Zweifel 1998

60 Schmidtke 2003.

61 Zürcher Student Vol. 46, No. 2, May 1968, 2: "Am Poly wird diskutiert!"

62 Zürcher Student Vol. 46, No. 3, June 1968, 7: "Der Poly-Student ist erwacht!" Bernhard Hoesli, who succeeded Hauri as division chair in the middle of 1968, initiated a study of the professional activities of graduates of the architecture division since 1945. Roth, Hoesli, and Kramel 1980, 95.

63 EAR, SR2: Schulratsprotokolle 1968, meeting of 15/6/1968, 542.

64 Hans Hauri: Studien an der ETH – Studentenaktivität und Studienplanreform an der Abteilung für Architektur, in: ETH-Bulletin, Vol. 2, No. 6, October 1968, 12 f.

65 Brunner, Deubelbeiss, Gaegauf, Haering, Ritter, Vorburger, and Werder 1980, 484.

66 Urs Maurer: VSETH, "anarchistisches Establishment"?, in: ETH-Bulletin,Vol. 2, No. 8, February 1969, 24.

67 Toni Lienhard: "Die armen Studenten, 'eigentlich haben sie ja recht.' Bericht vom Genfer Kolloquium über die moderne Universität," in: Zürcher Student Vol. 46, No. 5, November 1968, 9.

68 Urs Maurer: VSETH, "anarchistisches Establishment"?, in: ETH-Bulletin, Vol. 2, No. 8, February 1969, 24.

69 Denzler 1980. ETH-Bulletin, Vol. 2, No. 7, December 1968, 14. The following section draws on research by Martina Huber, whom we gratefully acknowledge. See Huber 2003.

70 ETH-Bulletin, Vol. 2, No. 7, December 1968, 9.

71 Out of a total participation of 63% (omitting students on leave during the winter semester 68/69 yields a participation rate of 71%), 2,296 students voted for the referendum, and 1,430 against. ETH-Bulletin, Vol. 2, No. 7, December 1968, 11. Different divisions voted differently. Large divisions such as civil, mechanical, and electrical engineering (II, III A, and III B), architecture (I), and physics and mathematics (IX) clearly voted for it, whereas the smaller divisions of chemistry (IV), pharmacy (V), forestry (VI), agricultural (VII), rural engineering and surveying (VIII), and natural sciences (X) mostly rejected it. ETH-Bulletin, Vol. 2, No. 8, February 1969, 4. At the EPUL, the referendum was clearly rejected, with 521 votes against and 192 votes for. The Lausanne students played a minor role in the subsequent campaign. Huber 2003, 13.

72 Wisler 1994, 228 f.

73 Further speakers were Jacob Taubes, Hans Peter Widmaier, Hans Heinz Holz, H. J. Hoffmann-Nowotny, Kurt Sontheimer, Wolfgang Lefèvre, and Rolf Deppeler. Gerhard Huber concluded with a lecture on "education issues under the banner of so-called idiocy coupled with expertise" 30 January 1969. Ad in the Zürcher Student, Vol. 46, No. 5, November 1968

74 Sozialarchiv, Flugblätter FSZ, leaflet dated 15/11/1968.

75 Quoted in Huber 2003, 12.

76 Huber 2003, 13.

77 Initially, these were the Forum Politicum, Gruppe 37, Team 67, Progressives Basel, Sektion der SP (unofficial), Zürcher Manifest, Junge Christlichsoziale, BSP, CNG, and the Seminar Hochschule für Demokratie. EAR, VSETH-Archiv, ETH-Gesetz, Folder 11, Protokoll Gründungsversammlung KRTH. Further groups were added later.

78 Gruner 1971, 380.

79 Urs Maurer: VSETH, "anarchistisches Establishment"?, in: ETH-Bulletin, Vol. 2, No. 8, February 1969, 24.

80 Studentischer Wochenkalender, No. 8, 9/12/1968.

81 ETH-Bulletin, Vol. 2, No. 8, February 1969, 9: Notice of the committee on the ETH

law for the submission of the referendum. Thereafter, the public handover of signatures became part of the standard practice of direct democracy in Switzerland.

82 Urs Maurer: VSETH, "anarchistisches Establishment"? in: ETH-Bulletin, Vol. 2, No. 8, February 1969, 24. At the same time, actions also took pace at the division level. Thus, in December 1968 the civil engineers held a "sit-in" on the student problems with professors Hans Grob and Pierre Dubas. See the appeals in the Studentische Wochenkalender, No. 007 [sic!], 2/12/1968. The akademische Ingenieurverein (AIV) and the students were by this time already systematically involved in divisional decision making. See "Mitsprache an der Abt. II" in the Studentischer Wochenkalender, No. 6, 25/11/1968.

83 Notice of the committee on the ETH law for the submission of the referendum. ETH-Bulletin, Vol. 2, No. 8 February 1969, 9.

84 EAR, SR2: Schulratsprotokolle 1969, meeting of 18/1/1969, 2. On the political position of Rudolf Farner's advertising agency, see also Frischknecht, Haffner, Haldimann, and Niggli 1987, 198 ff.

85 Bundesblatt 1/1969, 1314.

86 Sozialarchiv, Ar 201.35, Folder FSZ: Zur Situation, text by Thomas Held and Mathias Knauer, n.d. (probably June 1969). The Fortschrittliche Studentenschaft distanced itself further from the university and a little later merged into FASS (Fortschrittliche Arbeiter, Schüler und Studenten). Wisler 1994, 229.

87 Studentischer Wochenkalender, No. 14, 10/2/1969, FSZ event announcement.

88 Sozialarchiv, Ar 201.35, Dossier FSZ: Zur Situation, text by Thomas Held and Mathias Knauer, n.d. (probably June 1969).

89 VSETH communiqué dated 1 June 1969, cited in EAR, SR2: Schulratsprotokolle 1969, meeting of 5/6/1969, 551. According to the Bundesblatt 1/1969, 1314, participation amounted to 34%.

90 TH-Bulletin, Vol. 2, No. 8, February 1968, 6 f. In January 1969, School Council president Burckhardt commented: "I judge it as positive that the students have found a legitimate way to launch their sometimes imprecise ideas." EAR, SR2: Schulratsprotokolle 1969, meeting of 18/1/1969, 2.

91 The motion led to an intense debate among the VSETH executive committee over whether its transmission to the Federal Council would be reason to abandon the referendum campaign, since then the major student demands would have been met. ETH-Bulletin, Vol. 2, No. 7, December 1968, 11.

92 Année Politique 1968, 123.

93 Bundesblatt 1/1968, 715.

94 OECD 1970, 2. On the other hand, in autumn 1968 Rolf Deppeler commented vaguely that with the ETH law the government might have "missed an opportunity" to establish a milestone in higher-education legislation. Deppeler 1969b, 36.

95 Bonvin 1969, 92.

96 See NZZ, evening edition, 30/5/1969; Tages-Anzeiger, 30/5/1969.

97 The FSZ analyzed this "instrumentalization" as a strategy of the leaders to preserve the system. This analysis is true though its underlying conspiracy theory totally misses the point. On the one hand, the young left used the category of "bourgeois class conflict" to mask the internal heterogeneity of the political system, thereby overestimating the bargaining power of the liberals. On the other hand, their Manichaean world view masked the heterogeneity of student positions. The forces of the status quo were at work on all sides of the conflict.

98 NZZ, evening edition, 30/5/1969.

99 Fritsch 1969, 83.

100 Fritsch 1969, 82. On the debate over systems theory and social engineering, see Habermas and Luhmann 1971.

101 Drucker 1969, 358 f. and 434.

102 Herbert Schui: On the relationship between economic development and education and research policy, in: Bachmann et al. 1971, 15–19.

103 Sozialarchiv, Flugblätter FSZ, Signatur 335 356–2. "Diskussionsbeitrag der linken schweizerischen Studentengruppen zum ETH-Gesetz," probably written by Thomas Held and Mathias Knauer. See also Sauter 1971, 20–29.

104 The VSETH's demand had already been made in December 1968 in the case of rejection of the ETH law. The transitional arrangement would have to take into account "the general desire for a wide scope for experimental possibilities to gather practical experiences and to introduce new forms of community." Opinion of VSETH on Schmitt's motion and on the Federal Council's statement of 9/12/1968,

in: Studentischer Wochenkalender, No. 9, 16/12/1968.
105 Année Politique 1970, 152.
106 See e.g. Deppeler 1968a.
107 Federal judge and law professor Zwahlen was at this time president of the university conference. The expert committeee (also known as the Zwahlen committeee) was composed of two representatives of the School Council and one representative of each of the "professions" at the ETH Zurich and the ETH Lausanne. The EDI also appointed a number of party and association representatives. EAR, SR2: Schulratsprotokolle 1985, meeting of 5/7/1969, 713.
108 See AfZ, Vororts-Archiv, XIII, 204.9, circular from Tschudis dated 12/10/1970.
109 The model appeared in the ETH-Bulletin, Vol. 5, No. 40a, October 1971.
110 Burckhardt 1969.
111 Peyer 1983, 95–180, hier 135 f.
112 Bachmann, Blaser, Föhn, Frank, Janssen, and Raadsen 1971.
113 Roth, Hoesli, and Kramel 1980, 87–109, here 99.
114 Pierre Freimüller: "Ziegler, Holz, Rothschild, Janssen, Zinn, Schulte, Burckhardt, Gutmann, Manz. Oder: die Mitbestimmung wird umgangen. Oder: Zementierphase an den Hochschulen in Bern und Zürich." in: Studentischer Wochenkalender, special edition, "experimentierphase + r.i.p.," 22/6/1971.
115 Roth, Hoesli, and Kramel 1980, 101.
116 Roth, Hoesli, and Kramel 1980, 101.
117 Studentischer Wochenkalender, special edition, 22/6/1971.
118 Quoted in the decision of the conference of division heads dated 3/12/1971, threatening Pierre Freimüller with exclusion from the ETH. Announcement from Freimüller. Interview with Pierre Freimüller of 20/7/2004, www.ethistory.ethz.ch/materialien/interviews.
119 In 1972, even the federal court got into the act. See ETH-Bulletin, Vol. 6, No. 66, 9/2/1973 and No. 67, 23/3/1973.
120 Fritsch 1969, 83.
121 Ursprung 1986c.
122 Interview with Urs Maurer of 13/7/2004, www.ethistory.ethz.ch/materialien/interviews.
123 Rheinberger 1992, 25.
124 Année Politique 1969, 134 f. The idea of an "experimental phase" was widespread both at the ETH and at the level of the national higher-education policy, and was invoked as a matter of course.
125 "Botschaft des Bundesrates an die Bundesversammlung über die neuen Bildungs- und den Forschungsartikel der Bundesverfassung (Art. 27, 27^{bis} und 27^{quater}), vom 19. Januar 1972," Bundesblatt 1/1972, 375–444, here 396.
126 Fleck 1980 (1935), 114, quoted in Rheinberger 1992, 25.
127 The student representative in the School Council meeting of 24/2/1970 on the new core curriculum in the division of agriculture. EAR, SR2: Schulratsprotokolle 1970, 112.
128 Studentischer Wochenkalender, special edition, 22/6/1971.
129 EAR, SR2: Schulratsprotokolle 1978, 454.
130 EAR, SR2: Schulratsprotokolle 1978, 456.

Chapter 6

1 See Hans Bühlmann on the question of when "1968" ended at the ETH: "At the time the debate was very heated, the rector was Marmier and the president, Hauri. In 1973, they disappeared – you could almost say suddenly. Marmier died in office … and President Hauri submitted his resignation for reasons of health. And afterwards, the two were replaced by President Ursprung and Rector Zollinger, and somehow, from this point onward, it was kind of over, at least as I experience it; it had finished." Statement of Hans Bühlmann dated 27/7/2004, www.ethistory.ethz.ch/ debatten/studentenunruhen/frage1. For other interpretations, see the interview with Barbara Haering dated 3/8/2004, www.ethistory.ethz.ch/materialien/interviews.
2 On the concept of postmodernism, see Lyotard 1988; Jameson 1991, Harvey 1992, Nye 1997.
3 Habermas 1973, 9–19.
4 The problem of the "Massenuni" (university for the masses) preoccupied all the Western European universities. For the example of the Technical University of Munich see Wengenroth 1993, 261 f.
5 On 1968 as a crisis of higher education in Germany, see Schelsky 1969; Habermas 1969; Schelsky 1971 (1963); Lübbe 1972. On Switzerland, see Deppeler 1968a; Deppeler 1969b; Deppeler 1971.
6 Habermas 1973, 7.
7 Lübbe 1975, 55.

8 "Crises owe their objectivity to the fact that they issue from unresolved problems of control. Identity crises are connected with control problems," states Habermas 1973, 13; and Lübbe 1975, 36, states: "The essential point is that it is inappropriate to characterize the dominant problems of modern societies as growth problems, to pit the right to progress against traditional, self-legitimating forces. The real problem is how to deal with longstanding societal processes." For an approach that goes beyond this cybernetic crisis concept and considers social development as the result of individual action and social learning, see Siegenthaler 1993.

9 Ursprung himself addressed this phenomenon: "Strong individual opinions are contrary to today's Zeitgeist ... a Zeitgeist that attributes great weight to stakeholder consensus, a Zeitgeist that also is quick to brand individual opinion as an expression of personal greed for power. For this very reason, today we are trying – by means of the highly time-consuming method of consultation and the most varied forms of participation – to restore what a few nobel souls once managed to achieve [through the founding of the polytechnic], among them Alfred Escher." Ursprung 1986a, 240.

10 On the professionalization of public services at the ETH see www.ethistory.ethz.ch/besichtigungen/touren/dienstwege.

11 Bateson 2000 (1972), 505.

12 Lemke 2004, 86 f.

13 Ursprung 1986c, VI.

14 See, for example, Allenspach 1975; Hackh 1971; Hillert 1971; Marx 1972; Wyler 1976.

15 Schmidt 1974.

16 On the general historical development of the international currency system, see Eichengreen 2008. With reference to Switzerland, see Dam 1982 and Föllmi 1981. On the effect of the flotation on Switzerland, see Bernegger and Schelbert-Syfrig 1988.

17 Expertenkommission für die Vorbereitung einer Totalrevision der Bundesverfassung 1977; Kreis 1998; Kölz 2004, 906 f.

18 On the nuclear power controversy, see Kupper 2003a; for additional examples of the women's movement, Third World movement, New Left, as well as the "foreign infiltration" movement and separatism in the Jura, see König et al. 1998.

19 Germann 1998.

20 "The army must therefore dispose of a certain flexibility and be able to be deployed everywhere. A static defense planning in the sense that, even in peacetime, fortified fighting positions would be reinforced, is unacceptable. It would prevent us from honoring our obligation to neutrality. The same holds true for strewing the army about the entire territory (the so-called network defense)." Quoted from the "Botschaft des Bundesrates an die Bundesversammlung betreffend die Organisation des Heeres (Truppenordnung), 30. 6. 1960," Bundesblatt 2/1960, 826. On the réduit (redoubt) concept, see Lendi 1989.

21 See, for example, the "Botschaft des Bundesrates an die Bundesversammlung betreffend die Beschaffung von Panzerabwehrlenkwaffen, vom 19. Februar 1965," Bundesblatt 1/1965, 395–401, here 397.

22 "Botschaft des Bundesrates an die Bundesversammlung über die Beschaffung von Kampfflugzeugen (Mirage III S) and von weiterem Material für die Fliegertruppen, vom 25. 4. 1961," Bundesblatt 1/1961, 793–825, here 823. On the Mirage scandal, see Breitenmoser 2002, 78–83.

23 See "Bundesbeschluss über das Volksbegehren für die Schaffung eines Zivildienstes (Neufassung von Art. 18 BV)," Bundesblatt 1/1973, 89.

24 See "Bericht der Militärkommission vom 31. 1. 1979," Bundesblatt 2/1979, 241–252; Schmid 1973.

25 Gugerli 2002b; Bächi 2002.

26 In many parts of the PTT, the so-called postal payment system was treated as investment capital; see, for instance, PTT+Z, 24/7/1975, or Archiv PTT, Post-002 A 0003 1, "Geschäftspolitische Grundsätze im Bereich des Postzahlungsverkehrs," correspondence from the PTT Generaldirektion to the PTT-Verwaltungsrat, dated 17/9/1986.

27 Archiv PTT, Post-071 A 0001 1, final report of the APOCO-Kommisson of the PTT-Verwaltungsrat to the PTT-Verwaltungsrat, dated 4/1/1991, 15.

28 "Botschaft des Bundesrates an die Bundesversammlung zu einem Bundesgesetz über die Änderung des PTT-Organisationsgesetzes and des Postverkehrsgesetzes, vom 25. Februar 1976," Bundesblatt 1/1976, 909–919.

29 PTT 1973, 4.

30 Elsasser 2003; Hürlimann and Ischer 2004. In the 1980s, Hayek Engineering AG evaluated the SBB (national railways) and the ETH; see Parlamentarische Verwaltungskontrollstelle 1993.
31 "Botschaft des Bundesrates an die Bundesversammlung betreffend Übernahme der Polytechnischen Schule der Universität Lausanne durch den Bund, vom 4.3. 1968," Bundesblatt 1/1968, 699–713, here 715.
32 Gehmacher 1966, 9 and 37.
33 Steinbuch 1969, 72–78. See also Steinbuch 1961; Steinbuch 1963; Steinbuch 1968; Steinbuch 1971; Steinbuch 1972; Steinbuch and Keidel 1963.
34 AfZ, Vororts-Archiv, XIII, 204.9, Umfrage des Departements des Innern zum ETH-Gesetz (1970–1971). Opinion of the *Vorort* on the Department of the Interior's survey regarding new federal legislation for the Federal Institutes of Technology.
35 "Botschaft des Bundesrates an die Bundesversammlung über die neuen Bildungs- and den Forschungsartikel der Bundesverfassung (Art. 27, 27^{bis} and 27^{quater}), vom 19.1. 1972," Bundesblatt 1/1972, 375–444, here 395.
36 Schweizerischer Wissenschaftsrat 1973b, 218.
37 Gerecke 1956.
38 Schmid 1971, 21.
39 Lübbe 1972; Lübbe 1975; Lübbe 1992.
40 GEP-Bulletin, No. 89, May 1973, 2. See also 4: "We are living in a time of change that is throwing new problems at us with increasing rapidity. But it is also a time that, more than ever, requires the effort and opinion of every individual ... The executive committee has therefore decided to move on to a new kind of publication on a trial basis."
41 GEP-Bulletin, No. 89, May 1973, 2. After Zwahlen's death, the "Zwahlen commission" was presided over by H. Schultz. The commission was made up of representatives of the ETH Council, one representative of each "rank" from the ETH Zurich and ETH Lausanne, as well as from a range of political organizations. See also above, Chapter 5, 246 f.
42 ETH Jahresbericht 1973, 3.
43 EAR, SR2: Schulratsprotokolle 1977, Meeting of 30/9/1977, 474.
44 Both Baggenstos and the VSETH representative Georg Hodel complained on television that the school was ignoring the work of the Reform Commission. In Hodel's opinion, the solution to the problem was public relations. BAR, J 2.225 1996/68.67702, *Tagesschau* newscast of 4/7/1977.
45 On the joint commission, see the Verband der Studierenden an der ETH Zürich 1980, 21. Their requests for expansion of the ETH regulations of 1924 aimed, among other things, to establish "joint bodies," including a reform commission; see ETH-Bulletin, Vol. 4, No. 23, November 1970.
46 "ETH-Modell 1971, ausgearbeitet von der Reformkommission der ETH Zürich," published in the ETH-Bulletin, Vol. 5, No. 40a, October 1971, 7.
47 ETH Jahresbericht 1977, 7.
48 EAR, SR2: Schulratsprotokolle 1977, meeting of 30/9/1977, 471.
49 EAR, SR2: Schulratsprotokolle 1977, meeting of 30/9/1977, 478.
50 ETH Jahresbericht 1981, 10.
51 Defoe 2005 (1697), 30.
52 Defoe 2005 (1697), 30.
53 On Culmann's project concept and his "graphic statics," see above, Chapter 2, 72.
54 On science policy in the nineteenth and twentieth centuries and differentiation between science and politics, see Stichweh 1994, 156–173. On setting priorities in Swiss science policy, see Benninghoff and Leresche 2003; Latzel 1979; Wildi 2003.
55 Blumenberg 1993; Kaiser 1992; Raphael 1996.
56 See DIN 69900 Project network techniques, descriptions and concepts (1970) and DIN 69900 Project network techniques, network plan (1974), as well as DIN 69901 Project management systems, concepts (1979). See also Bech and Wolff 2003.
57 In the 1960s, general contractors specialized in higher education, like Karl Steiner AG, also began to experiment with project management. See Steiner 1967; Steiner 1966.
58 Klopotek 2004, 217. ETH-Modell 1971, ETH-Bulletin Vol. 5, No. 40a, October 1971, 1–2.
59 ETH-Modell 1971, ETH-Bulletin Vol. 5, No. 40a, October 1971, 9.
60 ETH-Modell 1971, ETH-Bulletin Vol. 5, No. 40a, October 1971, 28. Italics ours.
61 ETH-Modell 1971, ETH-Bulletin Vol. 5, No. 40a, October 1971, 28.
62 ETH-Modell 1971, ETH-Bulletin Vol. 5, No. 40a, October 1971, 30.
63 See Gugerli, Kupper, and Speich 2005.
64 Ursprung 1978b, 58.

65 Ursprung 1978b, 59.

66 "Botschaft des Bundesrates an die Bundesversammlung über die Wiederherstellung des Gleichgewichtes im Bundeshaushalt vom 3. April 1974," Bundesblatt 1/1974, 1309–1361, here 1327.

67 On the Research Commission, see also Gessler 2002.

68 "Die Forschungskommission erweist sich somit als reines Beratungsorgan der Schulleitung; wird ihre Zusammensetzung ohne Einräumung eines Vertretungsrechtes an die Stände geregelt, so steht dies nicht im Widerspruch zu Art. 12 UeR," EAR, SR2: Schulratsprotokolle 1974, meeting of 29/3/1974, 380.

69 EAR, SR2: Schulratsprotokolle 1974, meeting of 29/3/1974, 383.

70 EAR, SR2: Schulratsprotokolle 1974, meeting of 29/3/1974, 382 f.

71 EAR, SR2: Schulratsprotokolle 1974, meeting of 29/3/1974, 376.

72 Ursprung 1978a, 121.

73 The amount refers to the annual average for the years 1976–2001, exclusive of National Science Foundation monies; see Gessler 2002, 32.

74 In the mid-1980s, full professorships at the ETH were described as "kingdoms." See President Bühlmanns inaugural address, Bühlmann 1987: "The ETH is a republic of kingdoms." On the occasion of his promotion to president of the ETH Council, Ursprung said: "The ETHZ president is also hemmed in ... by participatory procedures (although the professors have not yet formed a 'republic of kings')." NZZ, No. 52, 4/3/1987. For the recollections of more contemporary witnesses on the subject, see www.ethistory.ethz.ch/debatten/unternehmen.

75 "In 1974, the responsibilities of the research commission were redefined. It consists of 15 to 18 members with successful research backgrounds and scientific interests, who were chosen by the ETH Executive Board irrespective of their research and teaching area, and will be chaired by a delegate of the rector for research." ETH Jahresbericht 1974, 16. On "credit as reward" and "credit as credibility," see Latour and Woolgar 1986.

76 EAR, SR2: Schulratsprotokolle 1978, meeting of 26/5/1978, 326.

77 Rohn 1923, 7.

78 ETH Jahresbericht 1974, 3.

79 An example is the reform of the division of rural engineering and surveying; see ETH Jahresbericht 1979, 12.

80 "Following a preparatory course, highly qualified graduates of advanced engineering colleges will now be able to transfer directly to an advanced class at the ETH following a preparatory course." ETH Jahresbericht 1974, 3. See also ETH Jahresbericht 1985, 19.

81 ETH Jahresbericht 1979, 13. See also President Ursprung: "As a step toward reform, I also note the ETH Council's decision that, in future, each candidate will be able to choose one subject from the humanities and social sciences. It is hoped that many students will avail themselves of this option." ETH Jahresbericht 1975, 2.

82 Link 1997.

83 ETH Jahresbericht 1985, 16.

84 ETH Jahresbericht 1985, 15–16.

85 "The courses should be undertaken in accordance with effective teaching methods; in particular, the students should participate actively and not purely passively ... It is desirable to combine educational elements and monitoring elements ... This kind of monitoring does not consist of many little tests scattered throughout the course, but rather in the fact that the educational elements themselves (e.g., group exercises) are used as a check." ETH-Modell 1971, ETH-Bulletin Vol. 5, No. 40a, October 1971, 42.

86 Lehrversuche an der ETH. Eindrücke von der Experimentierphase, NZZ, No. 97, 28/2/1971, 35.

87 Statement of Walter Schneider dated 20/7/2004, www.ethistory.ethz.ch/debatten/umweltnaturwissenschaften/frage3.

88 EAR, SR2: Schulratsprotokolle 1976, meeting of 20/5/1976, 346–349.

89 Bachmann et al. 1972.

90 ETH Jahresbericht 1979, 13. See also EAR, SR2: Schulratsprotokolle 1976, meeting of 20/5/1976, 346–349 and EAR, SR2: Schulratsprotokolle 1980, meeting of 2/7/1980, 484.

91 ETH Jahresbericht 1980, 11. See also EAR, SR2: Schulratsprotokolle 1978, meeting of 30/6/1978, 454–458.

92 ETH Jahresbericht 1976, 4.

93 Haering 1977.

94 Leemann and Speich 2005a.

95 Meadows 1972; Meadows 1974; Lenoir 1999; Lenoir and Alt 2002; Gugerli 1999b; Gugerli, Kupper, and Speich 2005; Kupper 2004.

96 Edwards 1996; Zopfi 2001.

97 "For when asceticism was carried out of monastic cells into everyday life, and began to dominate wordly morality, it did its part in building the tremendous cosmos of the modern economic order. This order is now bound to the technical and economic conditions of machine production which to-day determine the lives of all the individuals who are born into this mechanism, not only those directly concerned with economic acquisition, with irresistible force. Perhaps it will so determine them until the last ton of fossilized coal is burnt." Weber 1904–1906, 181. Schwarz and Kappel 1981; Nowotny 2002; Kupper 2006.

98 Nussbaum 1970, 13. On operations research in public administration the university of the 1970s, see Liebling 1974; Weinberg 1974. For further information, see Fortun and Schweber 1993; Johnson 1997; Kaijser and Tiberg 2000.

99 EAR, SR2: Schulratsprotokolle 1973, Meeting of 3/2/1973, 208.

100 ETH Jahresbericht 1975, 25.

101 ETH Jahresbericht 1975, 25.

102 Ugron and Lüthi 1974, 14.

103 Ugron and Lüthi 1974, 14.

104 Ugron and Lüthi 1974, 13.

105 The ETH's coordination group for data processing (KDV) conceived the system, and while the ETH Executive Board's IT Commission evaluated the various solutions, set priorities for realizing projects, and above all coordinated the "needs of the various administrative departments." Ugron and Lüthi 1974, 15. In 1969, under the direction of ETH professor C. A. Zehnder, it led to a workshop on using computers in the university administration. From the ETH side, R. Nussbaum, M. Rössler (Institute for Operations Research), as well as the rector's secretary A. von Arx took part. Koordinationsgruppe für Datenverareitung der ETH Zürich 1970.

106 Cogently explained in Ugron and Lüthi 1974, 57–59. On the evolution of the management concept at the university, see also Chapter 6, 378.

107 On the literature concerning Ugron and Lüthi, see, for example, Bleichner 1972; Kelly 1970; Kirsch 1974; Krieg 1971; Ulrich 1968.

108 Ugron and Lüthi 1974, 6 and 8.

109 Beginning in 1975, the equipment database GERDA was intended to gather all existing devices at the ETH into a uniform classification system, both in the interest of engineering and science, and of business information management. Equipment under 1,000 francs was not included. In 1994, GERDA was replaced by a new accounting system. ETH Jahresberichte 1979, 76 and 1994, 60.

110 Although the ETH used the government's human resources information system (PERIBU) for salaries, PERETH (designed in 1986 and implemented in 1988) was used to administer positions. Both systems complemented each other. PERETH superseded the old human resources system PISETH. ETH Jahresberichte 1987, 64 and 1988, 83.

111 In 1998, the introduction of PERETH was accompanied by that of the teaching information system LISETH. It was run by an administrative informatics committee that was charged specifically with troubleshooting interface issues between all the information systems. Together with accounting, LISETH and PERETH were to build a networked, integrated university information system that would provide critical information to the governing bodies at all levels of the ETH Zurich. ETH Jahresberichte 1986, 83 and 1987, 70.

112 The programmable teaching tool PLANETH was introduced at the ETH in 1975. It offered computer-supported instruction as a supplementary form of teaching and learning. The PLANETH system was interactive, that is, users received feedback on errors; in addition, the programmer could adjust the level of learning based on statistical surveys of needs. See Häberlin 1978.

113 In 1984, the ETH was connected to the European Academic and Research Network), which in turn was networked to ARPANET (Advanced Research Projects Agency Network) and BITNET ("Because It's Time Network") in the United States. A lively exchange of information and software followed, especially with Australia. ETH Jahresberichte 1984, 2 and 45; 1985, 2 and 36; on ARPANET see Salus 1995; Hauben 1999.

114 The communication system KOMETH was introduced in 1981. The broadband system linked any devices (computer, terminals) together and provided users with different services. In 1984, the last broadband facilities were installed in the ETH's main build-

ing. Overall, about 60 kilometers of coaxial cable were laid and around 4,000 offices, laboratories, and lecture halls connected. ETH Jahresberichte 1981, 80; 1982, 11 and 47; 1984, 2, 45, 50 and 57f.; 1987, 62 sowie 1988, 81.

115 In 1982, the integrated ETHICS system replaced the different loan and catalog systems that previously existed in parallel. ETHICS enabled decentralized catalog querying for all participating networked libraries. In 1984, the system was expanded to ETHICSplus, and computing power was increased. In 1985, online searching of titles became possible. See www.ethistory.ethz.ch/rueckblicke/verwaltung/biblio/innovationen. See also ETH Jahresberichte 1984, 2; 1985, 105; 1999, 20.

116 Statement of Heinrich Ursprung dated 16/7/2004, www.ethistory.ethz.ch/debatten/unternehmen/hayek.

117 Von Salis 1968, 269.

118 Von Salis 1968, 271.

119 On the universality of scientific practice, see Ben-David 1968; Merton 1973. On the topos of the universality of science, see Jessen and Vogel 2002a, 8; Stichweh 1991, 15–23, especially 17.

120 Von Salis 1968, 270. See also Schmid 1963. From 1952 to 1964, von Salis was president of the Swiss cultural foundation Pro Helvetia. For his biography, see von Salis 1975; Birrer 2003; Jost 2003.

121 The founding of the Science Council in 1965 was an indirect response of the government to the report of the expert commission under Labhardt's chairmanship. The establishment of the University Conference in 1969 was a direct result of the university support model inspired by the Labhardt Commission. See above, Chapter 4, 194, 196.

122 Labhardt 1965, 8.

123 In the first "overforeignization initiative" of James Schwarzenbach 1965 and overforeignization fears, see Kreis 1999.

124 On the presence of the ETH at international exhibitions of the nineteenth century, see above, Chapter 2, 45f.

125 On the many meanings of the nation as "imagined community" see, for instance, Anderson 2006; François, Siegrist, and Vogel 1995; Berding 1996; Hobsbawm 1992; Schulze and François 2001. On Switzerland, see Marchal and Mattioli 1992; Studer 1998a; Schweizerisches Landesmuseum 1998; Gugerli and Speich 2002. On internationalism as an expression of science policy, see Crawford 1992; Holbraad 2003; Max-Planck-Gesellschaft zur Förderung der Wissenschaften 1997.

126 In this connection, the successful recruiting, for example, of Werner Stumm, then professor at Harvard, as director of EAWAG. On the reshaping of the EAWAG from a service enterprise to a research facility with an "international focus," see the statement of Walter Schneider dated 20 July 2004, www.ethistory.ethz.ch/debatten/umweltnaturwissenschaften/frage2. On the concept of relative backwardness, see Gerschenkron 1962.

127 Schweizerischer Wissenschaftsrat 1973a, 56.

128 ETH Jahresbericht 1993, 26.

129 On the tension between international science organizations and denationalized industry, see Crawford, Shinn and Sörlin 1993a, especially Etzkowitz 1993. See also Etzkowitz and Leydesdorff 1997; Etzkowitz 2002.

130 Speich 2005b.

131 On the ETH's recruiting strategy since the late 1980s, see Eichenberger 2001.

132 On regionalization, see Leemann and Kupper 2005.

133 On Americanization in Germany, see Chorafas 1969b; Lüdtke, Marssolek, and Saldern 1996; Schildt 1996; Schröter 2004; on the Americanization of French universities, see Debouzy 1990. On MIT as a model for the ETH see Herbst, Hugentobler and Snover 2002.

134 For example: Hans Bühlmann, Hans M. Eppenberger, Klaus Hepp, Bernhard Hoesli, Ralf Hütter, Peter Läuchli, Philippe Matile, Urs Stammbach, Heinrich Ursprung, Niklaus Wirth.

135 EAR, SR2: Schulratsprotokolle 1967, meeting of 4/2/1967, 114.

136 Busch 1980, 358. Likewise, Anton Schuler in www.ethistory.ethz.ch/rueckblicke/departemente/dfowi.

137 Fleck 1980 (1935); Rose and Nowotny 1979; Lynch 1985; Latour and Woolgar 1986; Latour 1988; Lenoir 1992; Harwood 1993. On big science, see Price 1963; Galison and Hevly 1992. On German physics, see Metzler 2000. On the problem area of Nazism and science and technology development, see Meinel and Voswinckel 1994; Maier 2002b. On the Cold War, see Bud and Gummett 1999; Chomsky and

al. 1997; Edwards 1996; Leslie 1993; Levin 2000; Mindell 2002.

138 On coordination, see Elsasser 2003; on the TEE see Gugerli 2003; Mertens 1987; Zellweger 2003; on color television in the European Economic Area, see Kaiser 1993.

139 Persons employed in the second sector for 1965: 108,430, 1975: 92,845, and 1985: 53,892 and the third sector for 1965: 107,824, 1975: 113,177, and 1985: 143, 470. Siegenthaler 1996, 415. On the process of deindustrialization, see Altena 2002.

140 On the reorganization of communications between the ETH and the machine industry as an effect of globalization, see Fritz Widmer in www.ethistory.ethz.ch/rueckblicke/departemente/dmavt/problemlagen. See also the interview with Widmer dated 27/8/2004, www.ethistory.ethz.ch/materialien/interviews.

141 Report dated 27/1/1984, published in: Ursprung 1986b, 52.

142 EAR, SR2: Schulratsprotokolle 1985, meeting of 27/3/1985, 214 f.

143 Speiser 1985. On Speiser, see also Speiser 1992 and Helfer 1992.

144 EAR, SR2: Schulratsprotokolle 1985, meeting of 27/3/1985, 215. Along with Eduard Stiefel and Heinz Rutishauser, Speiser was considered a computer pioneer. He directed the IBM research center in Rüschlikon from 1956 to 1965. ETH Jahresbericht 2003, 87.

145 EAR, SR2: Schulratsprotokolle 1985, meeting of 27/3/1985, 215.

146 EAR, SR2: Schulratsprotokolle 1985, meeting of 27/3/1985, 215.

147 EAR, SR2: Schulratsprotokolle 1985, meeting of 27/3/1985, 216. ETH President Ursprung also made the connection between Japan and Swiss educational policy. See his report at a colloquium of the Swiss Academy of Engineering Sciences, titled “Die Schweiz in Konkurrenz mit Japan,” on 27/1/1984, published in: Ursprung 1986b.

148 EAR, SR2: Schulratsprotokolle 1985, meeting of 27/3/1985, 216.

149 Amtliches Bulletin der Bundesversammlung, Nationalrat. Wintersession 1983, 8. Meeting of 12/12/1983, 1755. See Bächi 2002; Gugerli 2002b.

150 The *Sonntags-Blick* of 11/11/1984 published a highly confidential report by the consultant Nicolas Hayek that had been generated at the request of the National Council and stated that Hayek had calculated a savings potential of 700 million francs. Hayek himself contested the numbers, which he put at 100 million maximum.

151 Bonhage 2007.

152 This preparatory work is evident, among other things, in the publications of the Integration Office: Integrationsbüro EDA/EVD 1992a; Integrationsbüro EDA/EVD 1992b; Integrationsbüro EDA/EVD 1992c; Integrationsbüro EDA/EVD 1992d. An early analysis of the failed accession to the European Economic Area can be found in Thürer 1993.

153 The McKinsey firm was given the contract. See Parlamentarische Verwaltungskontrollstelle 1993.

154 In 1967, Jean-Jacques Servan-Schreiber had already conjured up a “*défi américain*.” Servan-Schreiber 1967. Echoing Ambros Speiser, ETH President Heinrich Ursprung also spoke of a Japanese challenge. Ursprung 1986b. See also Ouchi 1982; Pascale and Athos 1982; Pascale and Athos 1985.

155 De Pury, Hauser and Schmid 1995, 45.

156 Haering Binder 1998, 222.

157 “In the institutional field, the autonomy of the university is the direct result of the overarching principle of academic freedom.” Cotti 1987, 6.

158 Mission statement of the ETH of 19 February 1996, Schulleitung 1996. In 1970, the ETH established an interdisciplinary postgraduate degree course for the problems of developing countries (INDEL). In 1980, after a pause of a year, the course content and organization were overhauled. The program currently offers postgraduate studies on developing countries (NADEL). ETH Jahresberichte 1977, 15; 1978, 7; 1979, 12; 1980, 11.

159 See in addition the individual recollections in www.ethistory.ethz.ch/rueckblicke/departemente.

160 See Peter Chen in www.ethistory.ethz.ch/rueckblicke/departemente/dchab_chemie/entwicklung.

161 Frei and Stammbach 1994; Urs Stammbach in www.ethistory.ethz.ch/rueckblicke/departemente/dmath.

162 For a contextualized history of mathematics, see Mehrtens 1990; Heintz 2000a; Heintz 2000b. See also Epple 2002a; Epple 2002b; Epple and Remmert 2000.

163 For mathematics, under the heading “Implementing the Strategy,” the multi-

year plan drawn up in 2004 specifies, "To strengthen the financial science section of the SEP Financial and Entrepreneurial Science, a second SEP professor in financial engineering will be established, who will also lead the RiskLab center of competence. ETH Rat 2002, 59.

164 On the satellite view of the earth, see Sachs 1992; Cosgrove 1994; Killian 1977; Roberts and Schein 1995; Slotten 2002. On the Landsat program, see Mack 1990.

165 On this revival of Alfred Wegener's 1915 theory of continental drift and the source of its refutation in the early twentieth century, see Oreskes 1999; Oreskes 2001; Hallam 1989.

166 Hans R. Thierstein in www.ethistory.ethz.ch/rueckblicke/departemente/derdw/forschung. See also European Science Foundation 1990; Freeman 1990; International Geodynamics Project Swiss Working Group 1979; Rybach and Bernoulli 1980; Rybach 1980.

167 EAR, SR2: Schulratsprotokolle 1973, meeting of 30/3/1973, 408 f. COST (European Coordination in the Field of Science and Technology and Coopération européenne dans le domaine de la recherche scientifique et technique) was established in 1971; Switzerland joined in 1972 (see Freiburghaus, Balthasar, Zimmermann, and Knöpfel 1991). In 1953, Switzerland signed the CERN (Centre européen de la recherche nucléaire) convention; see Heiniger 1990; Strasser 2002. On the history of CERN, see Krige 1996; Krige and Pestre 1992.

168 Année Politique 1988, 231.

169 Hütter 1990, 7. Switzerland has been a member of EUREKA (European Research Coordination Agency) since its founding in 1985; see Bundesamt für Bildung and Wissenschaft 2001.

170 ETH Jahresbericht 1990, 35.

171 See the commentary of economiesuisse, the corporate union encompassing the *Dachverband der Wirtschaftsverbände,* economiesuisse 2001, 7.

172 Magazin UNIZÜRICH 3/97; ETH-Bulletin 1997, No. 267, 74.

173 The ESA (European Space Agency) was founded in 1975. Switzerland was among the original members. Bundesamt für Bildung and Wissenschaft 2001, 14.

174 INDEL ("Interdisziplinäre Nachdiplomkurs für die Probleme der Entwicklungsländer"), 1970–1978, see ETH Jahresbericht 1978, 7.

175 ETH Jahresbericht 1988, 21.

176 ETH Jahresbericht 1995, 3.

177 See chart 14, 300. Data from the library catalog of ETH listed dissertations.

178 The Bologna Declaration of 19 June 1999. Joint Declaration of the European Ministers of Education; Projektleitung Bologna-Koordination 2001.

179 Albert Kündig in www.ethistory.ethz.ch/rueckblicke/departemente/ditet/lehre.

180 Informatikkommission and IT-Expertenkommission 2003; ETH Jahresbericht 2004, 1 f and 72; Programmleitung ETH World 2005.

181 ETH Jahresbericht 1982, 9 f.

182 ETH Jahresbericht 1980, 47. EMOS = ETH Multiprocessor Operating System, in service from 1975 to 1988. See Schai 1980 and ETH Jahresbericht 1989, 78.

183 Funds for construction of a computing center were approved by federal decree on 3/6/1964. EAR, SR2: Schulratsprotokolle 1969, meeting of 1/3/1969, 209. On the development of the computing center since 1980, see also Schai 1980.

184 ETH Jahresbericht 1976, 28; 1977, 36; 1980, 47; 1990, 99.

185 RZ-Bulletin, No. 30, 1977, 2.

186 ETH Jahresbericht 1978, 44.

187 See ETH Jahresbericht 1977, 37; 1979, 47.

188 RZ-Bulletin, No. 30, 1977, 3.

189 Frehse and Staub 2005, 2.

190 ETH Jahresbericht 1980, 47.

191 Peter Wegmann, cited in www.ethistory.ethz.ch/rueckblicke/verwaltung/informatikdienste/ida/unterricht.

192 Frehse and Staub 2005, 1. On electrical engineering, see Albert Kündig in www.ethistory.ethz.ch/rueckblicke/departemente/ditet/weitere_seiten/2.3_leistungsfaehige_Infrastruktur/index.

193 ETH Jahresbericht 1980, 47.

194 The then head of the RZ described the long search from 1970 to 1975 for a suitable operating system and the implementation of EMOS as a "painful process." Schai 1980, 563.

195 ETH Jahresbericht 1980, 47. At the end of the 1950s, the Federal School Council established the first computer committee. In the 1980s that split into several subcommittees and working groups, and in 1992 became the so-called informatics committee. See EAR, SR2: Schulratsprotokolle 1959, meeting of 2/5/1959, 223–228; ETH Jahresbericht 1987, 83; 1989, 81 f; 1992, 26. On its disbandment, see the interview with

Ralf Hütter on 30/7/2004, www.ethistory.ethz.ch/materialien/interviews.

196 For example, the ETH's informatics concept of 1993: "The utility of this informatics concept will be reviewed periodically. In this way, substantial changes in demand and in technology can quickly be taken into account." Arbeitsgruppe Informatikkonzept ETH Zürich: Informatikkonzept der ETH Zürich für die Jahre ab 1994, 7, in www.ethistory.ethz.ch/rueckblicke/verwaltung/informatikdienste. See also the ETH's ICT concept 2003–2007 in www.ethistory.ethz.ch/rueckblicke/verwaltung/informatikdienste.

197 On change management at MIT, see Williams 2002. See also Rosovsky 1990.

198 See the report of the witnesses to the founding of the degree course, in www.ethistory.ethz.ch/debatten/informatik. See also Speiser 1987 and Zehnder 2003. On the history of the ETH Department of Informatics, see also Andreas Nef and Tobias Wildi in www.ethistory.ethz.ch/rueckblicke/departemente/dinfk.

199 On hackers since the 1950s, see Pias 2002.

200 "Botschaft über Sondermassnahmen zugunsten der Ausbildung and Weiterbildung sowie der Forschung in der Informatik and den Ingenieurwissenschaften, 2.12. 1985," Bundesblatt 1/1986, 321–383, here 321.

201 Bundesblatt 1/1986, 336.

202 Bundesblatt 1/1986, 336.

203 See ETH Jahresbericht 1991, 25. On the founding of the CSCS in Manno see Jahresbericht 1990, 25 and 99. See also Andreas Nef and Tobias Wildi in www.ethistory.ethz.ch/rueckblicke/departemente/dinfk/weitere_seiten/cscs/index_DE.

204 ETH Jahresbericht 1981, 80. On PLANETH (since 1975), see ETH Jahresbericht 1978, 4 and 11. On the history of the Ethernet, see von Burg 2001.

205 ETH Jahresbericht 1984, 45.

206 See also Vester 1974; Vester 1980.

207 Address of GEP president Schudel at the celebration of the 125th anniversary of the ETH in the Kongresshaus in Zurich, 28/11/1980, see GEP-Bulletin, No. 122, March 1981, 3.

208 ETH Jahresbericht 1984, 50.

209 ETH Jahresbericht 1984, 50.

210 ETH Jahresbericht 1984, 93.

211 ETH Jahresbericht 1984, 50. On the scientific and historical significance of computer-supported visualization technologies, see Gugerli 1999b; Gugerli 2002a.

212 ETH Jahresbericht 1984, 51.

213 ETH Jahresbericht 1992, 64. On SWITCH, see Stiftung Switch 1988; Stiftung Switch 1989; Stiftung Switch 1998.

214 ETH Jahresbericht 1986, 92. See also Dudler 2003.

215 ETH Jahresbericht 1986, 92.

216 ETH Jahresbericht 1986, 93.

217 ETH Jahresbericht 1986, 106.

218 ETH Jahresbericht 1987, 72. On Lilith, see Braegger, Diener and Dudler 1984; Furger 1993; Hoppe 1983; Knudsen 1983; Koch 1983; Ohran 1984; Ostler 1983; Ostler 1985; Pomberger and Blaschek 1985; Rebsamen et al. 1982; Wirth 1981. On Ceres, see Eberle 1987; Heeb 1988; Heeb and Noack 1991.

219 Hartmut Frehse in www.ethistory.ethz.ch/rueckblicke/verwaltung/informatikdienste/wiss_rechnen/avantgarde.

220 In 1994, the "user support" at computing services covered everything from "design and installation of a www server: to "offering interactive, networked information"; "establishing a hotline (telephone and e-mail); and conducting 303 courses with nearly 1,700 participants as well as providing "comprehensive support for computer problems and IT projects." ETH Jahresbericht 1994, 64 f.

221 On "backwardness" and the "technology push," see Hayek Engineering AG 1985; see also the statements of Niklaus Wirth dated 21/6/2004, www.ethistory.ethz.ch/debatten/informatik/frage1 and and an interview with Carl August Zehnder dated 6/7/2004, www.ethistory.ethz.ch/materialien/interviews. On the Hayek report, see below, 316 ff.

222 Kübler 1992, 88.

223 Schaufelberger 1992, 10.

224 On IDA see Schaufelberger 1988; Domeisen 1992. On the use of desktop computers in teaching, see also Domeisen 1989; Domeisen 1990; Domeisen 1991; Keller 1989; Projektzentrum IDA 1988; Ventura and Schaufelberger 1988; Ventura 1988; Ventura 1989.

225 "In 1994, at a meeting of IT Services, students raised the topic of the World Wide Web, and suggested it might be a more modern form of disseminating information." See www.ethistory.ethz.ch/rueckblicke/verwaltung/informatikdienste/www/internet2www.

226 "Caliban is able to handle both hierarchies and networks," wrote H. Frei, M. Bärtschi and J.-F. Jauslin in April 1985. Frei, Bärtschi, and Jauslin 1985, 10. See also Jauslin 1984.
227 Berners-Lee 1989/90, 4.
228 First International Conference on the World-Wide Web, held 25–27 May 1994 at CERN in Geneva; see the conference homepage at www94.web.cern.ch/WWW94.
229 www.ethistory.ethz.ch/rueckblicke/verwaltung/informatikdienste/www/internet-2www.
230 www.ethlife.ethz.ch since 2000; see also Programmleitung ETH World 2005, 6. For the viewing statistics for ETH websites and homepages, see www.ethistory.ethz.ch/rueckblicke/verwaltung/informatikdienste/weitere_seiten/www_access_stat/index/popupfriendly. On the highly controversial introduction of SAP at MIT, see Williams 2002.
231 On the so-called IT building blocks, see Programmleitung ETH World 2005, 7.
232 Broggi and Wittmann, 1.
233 Schmitt 1999a.
234 Programmleitung ETH World 2005, 1.
235 Since the start of the project in autumn 2001, over 10,000 students and employees have purchased notebooks from the ETH, see Programmleitung ETH World 2005, 12.
236 See Williams 2002.
237 https://myeth.ethz.ch. On WebCMS and MyETH, see Programmleitung ETH World 2005.
238 On the role conflicts, duplicate roles, script errors, and corrective stage directions that are bound to occur between consultants and clients, see Femers 2002.
239 On the emergence of management consulting, see Kipping 2002.
240 On the "mindset" of the management consultant, and its various manifestations from a management science perspective, see Greiner 2005; for a sociological take, see Bohler and Kellner 2004. Who consults for management consultants is difficult to calculate. See Schwan and Seipel 2002 and Kuchenbecker 2004.
241 Hablützel et al. 1995; Schneider 1995.
242 Parlamentarische Verwaltungskontrollstelle 1993.
243 Agar 2003. On Thatcherism, see Evans 1999; Evans 1997; Gilmour 1992. On New Public Management in Switzerland, see Hablützel, Haldemann, Schedler and Schwaar 1995; Schedler 1995; Federli 2003.
244 On the concept of governmentality, see Foucault, Sennelart, and Arnold Ira Davidson 2007; Foucault and Sennelart 2008, and Burchell et al. 1991. For the German attitude, see Lemke 1997; Bröckling, Krasmann, and Lemke 2000; Pieper 2003; Opitz 2004.
245 The revised ETH law of 21/3/2003 came into effect on 1/1/2004.
246 Walliser Bote, 31/7/1985; Zuger Tagblatt, 31/7/1985.
247 See Stabstelle Presse and Information ETHZ 1985.
248 Correspondence from Nicolas G. Hayek to Maurice Cosandey, president of the ETH Council, 11/7/1985, in: Hayek Engineering AG 1985.
249 See Schweizerischer Handels- and Industrie-Verein 1985, especially Speiser 1985. See also above, Chapter 6, 291 (Speiser's report).
250 "Hayek fordert mehr Stellen and Geld für die ETH," Tages-Anzeiger, 26/7/1985.
251 "Botschaft über die Rechnungen and den Geschäftsbericht der Schweizerischen Bundesbahnen für das Jahr 1982 vom 4. Mai 1983," Bundesblatt 2/1983, 321–335, here 333. See also Bartu and Hayek 2005.
252 Interview with Nicolas G. Hayek dated 21/6/2004, www.ethistory.ethz.ch/materialien/interviews.
253 Hochschulpolitik mit dem Japan-Schock?, NZZ, 30/7/1985. Hayek also pointed out this unusual approach to the ETH Council: "In such optimization studies, our company recommends streamlining and savings measures, and normally requests no additional positions and no more money." EAR, SR2: Schulratsprotokolle 1985, meeting of 19/7/1985, 698.
254 Statement of Heinrich Ursprung dated 16/7/2004, www.ethistory.ethz.ch/debatten/unternehmen/eth_beraten.
255 Statement of Heinrich Ursprung dated 16/7/2004, www.ethistory.ethz.ch/debatten/unternehmen/eth_beraten.
256 Statement of Ralf Hütter dated 30/7/2004, www.ethistory.ethz.ch/debatten/unternehmen/eth_beraten. In 1988, Ralf Hütter was named the first vice president for research and corporate relations. See ETH Jahresbericht 1988, 31.
257 "In recent years, the main topic of conversation at every ETH event has been the hiring freeze." Tages-Anzeiger, 26/7/1985.

258 Tages-Anzeiger, 26/7/1985.
259 EAR, SR2: Schulratsprotokolle 1985, meeting of 19/7/1985, 702.
260 EAR, SR2: Schulratsprotokolle 1985, meeting of 19/7/1985, 699.
261 NZZ, 30/7/1985. On Sputnik shock, see Clowse 1981; Divine 1993; Killian 1977; Plane 1999; Speich 2005c; Zill 2002.
262 Additional critiques of the Hayek report are to be found in the following newspapers: Luzerner Neueste Nachrichten, 26/7/1985; Basler Volksblatt, 26/7/1985; Werdenberger und Obertoggenburger, 26/7/1985; Oltener Tagblatt, 27/7/1985.
263 "ETH Council asks for 700 new positions," NZZ, 26/7/1985.
264 On the creation and composition of projects, see EAR, SR2: Schulratsprotokolle 1985, meeting of 11/9/1985, 784–798.
265 Häusermann & Co. AG 1986a.
266 Häusermann & Co. AG 1986c, ETH main library copy, 948860:1q, insert title page verso.
267 Häusermann & Co. AG 1986c, ETH main library copy, 948860:1q, insert preceding the table of contents.
268 Häusermann & Co. AG 1986c, ETH main library copy, 948860:1q, insert preceding the table of contents.
269 Häusermann & Co. AG 1986c, ETH main library copy, 948860:1q, 0.11.
270 Häusermann & Co. AG 1986c, ETH main library copy, 948860:1q, insert 1.02 verso.
271 Häusermann & Co. AG 1986d, 4.
272 Interview with Jürg Lindecker dated 26/8/2004, www.ethistory.ethz.ch/materialien/interviews. The ETH's painstaking, months-long promotion procedure is an oft-cited example of analytical decision making. See Häusermann & Co. AG 1986b, 8.08.
273 Opinion of the Professorial Conference of Unit III B dated 11/9/1986 on the ETH's new management structure, in: Häusermann & Co. AG 1986d.
274 EAR, SR2: Schulratsprotokolle 1987, meeting of 25/2/1987, 214.
275 EAR, SR2: Schulratsprotokolle 1987, meeting of 25/2/1987, 214.
276 EAR, SR2: Schulratsprotokolle 1987, meeting of 25/2/1987, 215.
277 EAR, SR2: Schulratsprotokolle 1987, meeting of 25/2/1987, 216.
278 The "structures" were assumed to be those of the ETH Executive Board. EAR, SR2: Schulratsprotokolle 1985, meeting of 25/2/1987, 214 ff.
279 EAR, SR2: Schulratsprotokolle 1987, meeting of 25/2/1987, 217 f.
280 EAR, SR2: Schulratsprotokolle 1987, meeting of 25/2/1987, 219.
281 Statements of Hans Bühlmann dated 27/7/2004, www.ethistory.ethz.ch/debatten/unternehmen/neue_ordnung.
282 Statements of Ralf Hütter dated 30/7/2004, www.ethistory.ethz.ch/debatten/unternehmen/neue_ordnung.
283 EAR, SR2: Schulratsprotokolle 1988, meeting of 14/9/1988, 771–774.
284 EAR, SR2: Schulratsprotokolle 1988, meeting of 14/9/1988, 771 f.
285 See also Gugerli 2005.
286 Bundeskanzlei 1996, 1, 3, and 9.
287 On the discusson of the matrix structure in private industry during the 1970s and 1980s, see Leumann 1978; Reber 1988; Schneider 1974; Stierli 1986; Weigmann 1975; Zimmermann 1987.
288 On change management applied to teaching at the university, see Hirsch 2001; Duke 2002; Welte 2005.
289 The working group included Meinrad Eberle, Olaf Kübler, Peter Marti, and Ulrich Suter. This group, too, had the input of a management consultant. On creative chaos as a management tool of the late 1980s, see Peters 1988.
290 Chandler 1977.
291 On managing academic units, see Bolton 2000.
292 On university management in general, see Albach and Mertens 2003 and Welte 2005; on change management, see Williams 2002; on governance in education and science and on the economics of university, see Fisch 2005 and Backes-Gellner and Brinkmann 2003. On governance and effective leadership, see Gayle, Tewarie and White 2003; Kyrer 2002.
293 Some discerned a managerial revolution in the area of higher education as early as the 1960s; Rourke and Brooks 1966. See also Gray and Fleischer 1998 and Duke 2002.
294 ETH Jahresbericht 1974, 26. On more flexible allocation of resources, see above, Chapter 6, 273.
295 ETH Jahresbericht 1977, 38; 1978, 47.
296 Hayek Engineering AG 1985, 59, 109, 114, 117.
297 Bühlmann 1987. See also GEP-Bulletin, No. 149, December 1987, 2.
298 Interview with Ralf Hütter dated 30/7/2004, www.ethistory.ethz.ch/materialien/interviews.

299 ETH Jahresbericht 1991, 74.
300 ETH Jahresbericht 1990, 96 f.
301 ETH Jahresbericht 1992, 9. See also ETH Jahresbericht 1994, 10, on the topic of data management in the rectorate.
302 On upgrading the ETH Executive Board's IT, see above, Chapter 6, 278 f.
303 On financial management, see ETH Jahresbericht 1993, 39.
304 On the growing importance of industrial employees in the age of scientific management, see König, Siegrist and Vetterli 1985 and Jaun 1986.
305 See Eichenberger 2001.
306 ETH Jahresbericht 1999 ("Fernsehmann Probala kommt"). ETH Jahresbericht 2000 ("Neue Schwerpunkte in der Kommunikation").
307 ETH Jahresbericht 1999 ("Fernsehmann Probala kommt"). ETH Jahresbericht 2000 ("Neue Schwerpunkte in der Kommunikation").
308 European Foundation for Quality Management 1991.
309 ETH Jahresbericht 1995 ("Ganzheitlich optimieren").
310 ETH Jahresbericht 1996 ("Aktion Q – Qualitätsmanagement in den Dienstleistungsbereichen").
311 ETH Jahresbericht 1996 ("Veränderung von innen").
312 ETH Jahresbericht 1997 ("Die Verwaltung – Fundament im Wandel"). On total quality management, see Bröckling 2000.
313 Hanft 2000; Robins 2002; Gayle, Tewarie, and White 2003; Kyrer 2002; Backes-Gellner and Brinkmann 2003; Welte 2005.
314 Bröckling 2000, 133.
315 ETH Jahresbericht 1997.
316 Interview with Olaf Kübler dated 15/7/2004, www.ethistory.ethz.ch/materialien/interviews.
317 ETH Jahresbericht 1997.
318 Schelsky 1969, 135.
319 On the concept of university autonomy, see Deppeler 1968a; Deppeler 1968b; Deppeler 1969a; vom Bruch, Fichte, and Helmholtz 1993; Berka 2002; Brinckmann 1998 and Kimmich and Thumfart 2004. On budgetary independence at the ETH, see Schmitt 1999b.
320 Schelsky 1971 (1963).
321 Weingart 2001.
322 Buschor 1993; Buschor and Schedler 1994; Schmitt 1999b; Pelizzari 2001.
323 ETH Domain, Strategic Plannung 2000–2003, 24/9/1997, 13.
324 EAR, SR2: Schulratsprotokolle 1984, meeting of 9/5/1984, 243.
325 Cotti 1987, 6.
326 NOVE 1996–1999, NOVE DUE 1997–2000, and NOVE TRE 1998–2000. Schmitt 1999b, 55.
327 The law on the Swiss Federal Institutes of Technology (ETH Law) of 4/10/1991 went into effect on 1/2/1993 and was revised on 21/3/2003. EAR, SR 414.110. See also Böhm et al. 1988; Eidgenössische Technische Hochschule Zürich 1992.
328 Brinckmann 1998.
329 Bullinger 1999; Ciborra 2000; Dobiéy and Wargin 2001; Haug 2001; Schneider 1995.
330 Schmitt 1999b, 61.
331 ETH Jahresbericht 1999 ("Betriebswirtschaftliche Instrumente eingeführt"). Schmitt 1999b, 63. A cost model for educational institutions was duscussed at the Swiss Conference of Cantonal Ministers of Education (EDK) in 1998. Institut für Finanzwirtschaft and Finanzrecht HSG 1998. See also Ciborra 2000 and Williams 2002.
332 EAR, SR2: Schulratsprotokolle 1978, meeting of 30/6/1978, 560.
333 Lenoir 1992, 209–225. See also Kohler 1982.
334 Foucault 1981, 59.
335 Rheinberger 1995.
336 ETH Jahresbericht 1986, 20.
337 ETH Jahresbericht 1989, 30.
338 Schweizerischer Wissenschaftsrat 1973a, 31.
339 See, for example, Leibundgut 1971; Fornallaz 1975.
340 Fornallaz 1975, 315.
341 ETH Jahresbericht 1988, 33. Baumeler 2005 provides an ethnography of a polyproject.
342 ETH Jahresbericht 1988, 33.
343 ETH Jahresbericht 2000, 9.
344 On SEPs see ETH Jahresbericht 2001, 14 f.; ETH Zürich 2002; ETH Rat 2002, 99–104.
345 In the ETH's annual reports, the terms "integration" and "interdisciplinary" appear frequently, as do a number of carefully differentiated notions of anti-integration. The 1980s saw increased use of the term "multidisciplinary," which ceded ground in the 1990s to "transdisciplinary." For an exploration of the use of the three concepts, see also Keller and Ledergerber 1997, 52 f.
346 On the electrical engineering master's in "Man, Technology, Environment," see ETH Jahresbericht 1973, 5 and 1974, 9 f. On the Department of Humanities,

Social, and Political Sciences, and on the Collegium Helveticum, see Weiss, Wächter and Nowotny 2001. See also Daniel Kauz, Verena Rothenbühler, and Hans Werner Tobler in www.ethistory.ethz.ch/rueckblicke/departemente/dgess. On the cross-disciplinary doctorate, see ETH Jahresbericht 2000, 21.

347 ETH Jahresbericht 1979, 12 f. On the history of the natural sciences division between 1950 and 1980, see Frey-Wyssling 1980.

348 Statement of Theodor Koller dated 15/7/2004, www.ethistory.ethz.ch/debatten/umweltnaturwissenschaften/frage3.

349 Interview with Walter Schneider dated 20/7/2004, www.ethistory.ethz.ch/movies/schneider_MSTR.

350 ETH Jahresbericht 1979, 13.

351 ETH Jahresbericht 1979, 13.

352 Leisinger 2005.

353 Statement of Theodor Koller dated 15/7/2004, www.ethistory.ethz.ch/debatten/umweltnaturwissenschaften/frage1.

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355 Statement of Dieter Imboden dated 18/6/2004, www.ethistory.ethz.ch/debatten/umweltnaturwissenschaften/frage3. “It was like Chernobyl.” Statement of Walter Schneider dated 20/7/2004, www.ethistory.ethz.ch/debatten/umweltnaturwissenschaften/frage3.

356 See Tanner 1988. The popular topic of forest dieback is very rarely mentioned in interviews with contemporary witnesses, owing to the desire of environmental scientists to distinguish themselves from foresters. The foresters had no political or institutional clout vis-à-vis the state of the forests, and the university treated them as obsolete. On forestry science, see Anton Schuler, in www.ethistory.ethz.ch/rueckblicke/departemente/dfowi. On forest dieback in Switzerland, see Dejung 1996.

357 Interview with Theodor Koller dated 15/7/2004, www.ethistory.ethz.ch/movies/koller_MSTR.

358 See www.ethistory.ethz.ch/debatten/umweltnaturwissenschaften/frage1.

359 www.globalsustainability.org (30/8/2005). On the AGS, see Baud 2001.

360 www.ags.ethz.ch/de/projects/portfolio.cfm (30/8/2005).

361 Abir-Am 1997. On the *disunity of science,* see Galison and Stump 1996.

362 Rheinberger 1995, 2.

363 Schweizerischer Wissenschaftsrat 1973a, 31.

364 Abir-Am 1997, 495.

365 EAR, SR2: Schulratsprotokolle 1963, meeting of 13/7/1963, 447. See www.ethistory.ethz.ch/besichtigungen/touren/vitrinen/forschungspfade/vitrine61.

366 EAR, Hs 1244:89, correspondence from Robert Schwyzer to Heinrich Ursprung: Gedanken zur Zukunft des Institutes für Molekularbiologie der ETHZ (Thoughts on the future of the Institute for Molecular Biology at the ETHZ) (1982–1987). Report of the head of the Institute for Molecular Biology and Biophysics to the president of the ETHZ, dated 20/10/1981. See also Schwyzer’s inaugural address of 11/6/1966, published In the NZZ, No. 3112, 17/7/1996, 5.

367 Crick 1970, 613.

368 On the development of microbiology at the ETH, see Leisinger 2005, here 12–14. On hydrobiology in the context of the sewage system construction boom of the 1960s and 1970s, see Gugerli 2000. On biotechnology in agricultural and food sciences at the ETH, see Amrhein and Potrykus 1996. On the political economy of biotechnology, see Barben 1998.

369 EAR, SR2: Schulratsprotokolle 1994, meeting of 30/3/1994, 291–317.

370 Nikolaus Amrhein in www.ethistory.ethz.ch/rueckblicke/departemente/dbiol.

371 Abir-Am 1997, 515.

372 EAR, SR2: Schulratsprotokolle 1994, meeting of 30/3/1994, 295.

373 EAR, SR2: Schulratsprotokolle 1994, meeting of 30/3/1994, 302.

374 On the gene-protection initiative see “Botschaft über die Volksinitiative zum Schutz von Leben and Umwelt vor Genmanipulation (Gen-Schutz-Initiative), 6. 6. 1995,” Bundesblatt 3/1995, 1333–1369. See also Latour 1998.

375 Galison 1999.

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377 Feyerabend 1975; Hoyningen-Huene 1997; Farrell 2003.

378 For a philosophical critique of the new complexity, see Habermas 1985. Scientific research has also recognized the need for rethinking. See Nowotny, Scott, and Gibbons 2001. On science’s fraught relationship with hybrids, see Latour 1993.

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ABBREVIATIONS

AfiF	Abteilung für industrielle Forschung (center for industrial research)
AGS	Alliance for Global Sustainability
AIAG	Allminium-Industrie-AG (alusuisse)
ASVZ	Akademischer Sportverband Zürich (student sport association)
BBC	Brown Boveri Co.
BGB	Bauern- und Gewerbebund (farmers', trade, and citzens' party)
BWI	Betriebswissenschaftliches Institut (scientific management institute)
CERN	Centre européen de la recherche nucléaire (european organization for nuclear research)
CMOS	Complementary Metal-Oxide-Semiconductor
CMS	Content Management System
COST	Coopération européenne dans le domaine de la recherche scientifique et technique (european coordination in the field of science and technology)
CSCS	Centro Svizzero de Calcolo Scientifico (swiss national supercomputing center)
DEC	Digital Equipment Corporation
DESY	Deutsches Elektronen Synchrotron (german electron synchrotron)
EARN	European Academic and Research Network
EAWAG	Eidgenössische Anstalt für Wasserversorgung, Abwasserreinigung und Gewässerschutz (aquatic research institute)
EDI	Eidgenössisches Departement des Innern (department of home affairs)
EFTA	European Free Trade Association
EIR	Eidgenössisches Institut für Reaktorforschung (federal institute for reactor research)
ELSBETH	Elektronisches Administrationssystem für den Lehr- und Studienbereich der ETH Zürich (electronic administration system for teaching and study at the ETH Zurich)
EMD	Eidgenössisches Militärdepartement (department of defense)
EMPA	Eidgenössische Materialprüfungsanstalt (federal materials testing institute)
EPFL	Ecole Polytechnique Fédérale de Lausanne (federal institute of technology at Lausanne)
EPUL	Ecole Polytechnique Universitaire de Lausanne (federal institute of technology at Lausanne)
ESA	European Space Agency
ETH	Eidgenössische Technische Hochschule (Swiss Federal Institute of Technology)
ETHZ	Eidgenössische Technische Hochschule Zürich (Swiss Federal Institute of Technology Zurich)
ETHICS ETH	Library Information Control System
EU	European Union
EUREKA	European Research Coordination Agency
EWR	Europäischer Wirtschaftsraum (European Economic Area)
FAO	Food and Agriculture Organisation
FDP	Freisinnig demokratische Partei (radical free democratic party)
FSZ	Fortschrittliche Studentenschaft Zürich (progressive student union)
GEP	Gesellschaft Ehemaliger Polytechniker (alumni association)
GERDA	Gerätedatenbank (equipment database)
GFF	Gesellschaft zur Förderung der Forschung (society for the promotion of research)
GTP	Gesellschaft zur Förderung des Instituts für technische Physik der ETH (auch: Gesellschaft für Technische Physik) (society for the advancement of the institute for applied physics at the ETH (also called: society for engineering physics)
HSG	Handelshochschule Sankt Gallen (business school St. Gallen)

IBM	International Business Machines
ICT	Information and Communication Technologies
IDA	Informatik dient allen (computers for everyone)
INDEL	Interdisziplinärer Nachdiplomkurs für die Probleme der Entwicklungsländer (interdisciplinary postgraduate degree course for the problems of developing countries)
KIAA	Kriegs-, Industrie- und Arbeitsamt (wartime industry and employment office)
KOF	Konjunkturforschungsstelle (swiss institute for business cycle research)
KOMETH	Kommunikationssystem der ETH (communication system at the ETH)
KTA	Kriegstechnische Abteilung des Militärdepartements (war technology division at the department of defense)
KTI	Kommission zur Förderung der technischen Innovationen (commission for the promotion of scientific research)
LAN	Local Area Network
LESIT	Leistungselektronik, Systemtechnik, Informationstechnologie (power electronics, systems engineering, and information technology)
LISETH	Lehrinformationssystem der ETH (teaching information system)
MIT	Massachusetts Institute of Technology
NSDAP	Nationalsozialistische Deutsche Arbeiterpartei (national socialist german workers' party)
NVSH	Nationale Vereinigung Schweizer Hochschuldozenten (national association of swiss university lecturers)
NZZ	Neue Zürcher Zeitung
OECD	Organisation for Economic Cooperation and Development
OEEC	Organisation for European Economic Cooperation
PERETH	Personalinformationssystem der ETH (human resources information system)
PLANETH	Programmierbare Lehranlage der ETH (desktop-computer-based, audiovisual, interactive teaching system)
POST	Projektorientiertes Studium (project-oriented program of study)
PTT	Post-, Telefon- und Telegrafenverwaltung (post, telegram, and telegraph authority)
RZ	Rechenzentrum (computing center)
SA	Sturmabteilung (paramilitary organization of the NSDAP)
SAD	Schweizerischer Aufklärungsdienst (swiss intelligence service)
SAP	Systemanalyse und Programmentwicklung (system analysis und program development)
SBB	Schweizerische Bundesbahnen (swiss federal railways)
SDS	Sozialistischer Deutscher Stundentenbund (socialist german student union)
SEP	Strategische Erfolgsposition (strategic success factor)
SFUSA	Swiss Friends of the United States of America
SHIV	Schweizerischer Handels- und Industrieverein (swiss trade and industry association)
SIA	Schweizerischer Ingenieur- und Architektenverein (society of swiss engineers and architects)
SIN	Schweizerisches Institut für Nukleartechnik (swiss institute for nuclear research)
SNF	Schweizerischer Nationalfond (swiss national science foundation)
SP	Sozialistische Partei (social democratic party)
STV	Schweizerischer Technikerverband (society of swiss technicians)
SVIL	Schweizerische Vereinigung für Innenkolonisation und industrielle Landwirtschaft (swiss association for domestic land use and industrial agriculture)
SWITCH	Swiss Education and Research Network
TEE	Trans Europe Express

UNESCO	United Nations Education, Scientific, and Cultural Organization
UNO	United Nations Organisation
VAW	Versuchsanstalt für Wasserbau (laboratory of hydraulics, hydrology and glaciology)
VAX	Virtual Address eXtension
VDI	Verein Deutscher Ingenieure (society of german engineers)
VPP	Verteiltes Printen und Plotten (versatile printing and plotting)
VSETH	Verband der Studierenden an der ETH (ETH students' association)
VSS	Verband der Schweizerischen Studentenschaft (federation of swiss students)
WSL	Forschungsanstalt für Wald, Schnee und Landschaft (swiss federal institute for forest, snow and landscape research)
WWW	World Wide Web
ZIR	Zentrum für interaktives Rechnen (center for interactive computing)

INDEX OF NAMES