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Natural and Technical Sciences at Universities or Higher Education Institutions from the 16th to the 20th Century

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1.

In the historical development of European universities, the emergence of new study disciplines or reformed studies (some of which had existed at universities ever since general studies began in the 13th century) within higher-education and university study programmes in late 18th century is linked to the emergence of the scientific and technological revolution in the 16th and 17th century. To start with, let us take a brief look at the origin and development of this civilization phenomenon, which in one way or another had a decisive role in introducing new or revised study content in modern universities.

When we consider some of its features, we may speak of a scientific and technological revolution in the 16th and 17th century rather than just shifts in the development of scientific disciplines. Contemporaries in these centuries were convinced that a new age had dawned and the leading scientists of the time believed that medieval science exhibited some fundamental flaws. All of them shared a contempt for the strict scholasticism of the past centuries. Along with the schools' representatives, the schools themselves became objects of contempt.

Universities suffered criticism as well. At least from the moment when Paracelsus, as he took his chair at the Brussels University, burned the works of Avicenna and Galen in public, or the moment when Giordano Bruno poured venom against the Oxonian "fools", universities were spared in nothing: they neglect research and merely foster sciences as slavish imitators of classical literary authorities.

Opinions on to how to explain the scientific revolution vary. Most historians believe that universities played an extremely small role in it. Some even believe that the scientific revolution took place entirely outside universities. At any rate, universities cannot be considered the motivators of the scientific revolution.

However, the number of those opposed to these views has recently increased. There is no doubt that most of the more than one hundred European universities did not engage in scientific research at the time, while those that did were hardly research universities. And why should they be? "Universities were expected to instruct boys, not to work as research institutions."

However, the statutes and official curricula often present an entirely false image. At some universities, where the study process was *de jure* dominated by Aristotle, Ptolemy, Galen and their commentators, a new science was evolving *de facto* through extraordinary lectures, in private groups and in teacher-student seminars. Historians who shifted their attention from the regulations and study catalogues to the more personal, largely handwritten sources (student notes and letters, bibliographies, library catalogues and written lecture plans) are coming to new conclusions about a significantly greater interest in scientific activity as well as significantly more scientific activity itself.

Recent studies have shown that universities in the Early Modern Era were far from being monolithic institutions, closed to all that was not concocted from desiccated classical natural science and medicine glossed with scholastic commentary. On the contrary, academic science was very much alive, as supported by the abundant evidence of present-day studies on individual institutions and the life paths of professors and students. In the 16th century, universities in Italy, Germany and Switzerland thus started teaching botany and natural sciences in a highly efficient way. There was a similar trend in Spain, where universities showed a lively interest in the flora and fauna discovered in the New World. Even at the Parisian medical faculty, noted for its conservative stance, dissertations from the first half of the 16th century show a surprisingly high degree of receptiveness to new ideas. Studies from recent years indicate that North Italy and the Netherlands, especially the Universities of Padua and Leiden, were leaders in the development of new sciences. Several sources indicate that science held a firm place in universities.

The concept of the scientific revolution is anything but clear and unambiguous. The term was most likely introduced in literature a good half century ago by Alexander Koyre. But its substance, scope and time frame have never been precisely defined; moreover, views differ to such a degree that we may conclude that, while the scientific revolution remains "an important heuristic aid (...) and the subject of many textbooks and lectures as a poorly explained concept"; "it is getting harder and harder to believe in the existence of a single coherent and distinct scientific revolution."

The answer to the question of what universities contributed to the scientific revolution of course depends on our understanding of the concept. It is defined as a long-lasting revolution spanning several centuries and reaching far back into the Middle Ages: "The scientific revolution, which is usually associated with the 16th and 17th century, may be traced to the preceding periods." And although its pace visibly gathered speed after the late 16th century, "the origins of modern natural science reach as far back as the 13th century. »However, placing the beginnings of the scientific revolution in the late Middle Ages attributes a major role in its emergence to the universities; the existence of late medieval science was throughout the result of the great rise of science and philosophy, which was closely linked to the institution of *studium generale* and the study of Aristotle's writings in Paris, Oxford, Bologna, Padua and other universities. The 17th century was a scene of violent natural scientific and philosophical disputes, which may often be interpreted as struggles between the old and the new and which – much more than in the 16th century – ended in the victory of the new.

Furthermore, several natural science disciplines saw dramatic changes in terms of underlying theory and in specifics. Around 1600, the geostatic and geocentric system still dominated astronomy. But around 1700, the international scientific elite adopted the heliocentric theory. Around 1600, the principles of Aristotle's physics on finitude, locomotion and the four elements were popularly accepted, often in a revised and improved form. Around 1700, no scientist of standing supported them. Theories on matter no longer rested on the traditional four elements and properties. Instead, concepts such as "particles and short-range forces" were used, leading to new elements of motion and dynamics principles. The old distinction between the sciences of earthly and celestial bodies was challenged by Galileo's discoveries and abolished by Newton's law of universal gravitation. In methodology, the development of scientific instruments such as the telescope and the microscope lead to great progress in observation. This opened up new worlds at both the macro and micro levels, both in theory and in observation, and lead to the general development of research instrumentation, which was to have a central role in modern natural science. At the same time, the experiment lead down new pathways in research and strengthened science in its pursuit of the objective truth. Furthermore, advances in mathematics, especially the analytical geometry of Descartes and the infinitesimal calculus of Newton and Leibniz gave natural science – individual areas of knowledge that had so far been studied non-scientifically – the advantage of precise calculations.

Of course these changes were not just a revolution of thought – pious hopes for a large-scale reform – but permanent and very promising factual developments. In themselves, the discoveries of Kepler or Descartes, Galileo or Boyle brought as much confusion as they did solutions. But as a whole, their research resulted in the revision of fundamental hypotheses until – mostly thanks to Newton – it lead to a far-reaching, coherent synthesis that was fascinating in scope and potential and able to solve everyday problems as well as spark further research.

Changes were seen in the concepts and practical activities of individual scientific disciplines: kinetics, hydraulics, pneumatics, optics, etc. Faith in physics led to the introduction of mechanical models in new fields such as Borelli's physiology. The status of natural philosophy improved to the point of establishing itself as the apex of true science, as indicated by the enthusiasm with which the 18th century embraced Newton's views on aesthetics, psychology, social philosophy, moral philosophy and state philosophy. Radical intellectuals of the Enlightenment understood the successes in science as an end to metaphysics and theology. Changes in science meant a new perspective on man in the universe and a justification of his supremacy over nature, as well as the leading role of science in society.

Neither the representations of Marxist historians, who recognized the scientific revolution as the essential element of the transition from the feudal to the bourgeois social order, nor the views of other historians, who link the Reformation, Protestantism, and lately especially the press to the phenomenon of the scientific and technological revolution, make no reference to the universities as important or even significant institutions in the process.

In certain respects though, the scientific revolution was the product of the universities. First of all we should of course point out that most of the intellectuals who vitally contributed to the revolution, had received a university education. Thus in England around 1665, two thirds of the 115 members of the Royal Society had completed university studies, largely in Cambridge and Oxford, and were also entered into the Dictionary of National Biography for their achievements, which contradicts the so far established belief that "the great researchers of the 19th century were autodidacts in their discipline". It is also true however that many major researchers of the 18th and 19th centuries never attended universities, some came from poor families; the representatives of technical and experimental sciences in particular, as well as physics, worked their way from craft workshops and factories. A considerable share of 16th and 17th century researchers were university professors, some of them moving from university to university, e.g. Tycho Brache, Copernicus, Kepler and Descartes – while others, even better known, worked as tenured professors at certain universities, e.g. Albinus and Boerhave in Leiden, Aldrovandi in Bologna, Aselli and Cardano in Pavia, Barrow in Cambridge, Bartholin in Copenhagen, Bernoulli in Basel, Borelli in Messina, Bradley in Oxford, Camerarius in Tübingen, Celsius in Uppsala and others. Such a large proportion of university professors involved in major research work was probably never matched until the early 20th century.

While the claim that universities were responsible for the scientific revolution is absurd, conclusions that "the history of the scientific revolution happened completely outside universities" make even less sense.

Of course it also involved members of various academies, research institutions under the ruler's patronage, various court astronomers, court astrologers and court physicians, but we may still say that in the Early Modern Era, universities were the life thread of every scientific career.

Universities offered the essential tools for scientific research work that might else be unavailable to individual researchers or only accessible with difficulty. In the Early Modern Era, universities created important libraries and in the 16th century, most Italian universities possessed botanical gardens and natural science collections, which eventually became the key guide for plant and fossil identification. Also, the invention of the telescope improved the facilities of university observatories, though they could never compete with the equipment of private and royal observatories. Dissection tools for medical studies and the gradually evolving laboratory for chemical experiments facilitated practical exercise and collective research efforts.

Universities thus played an important role in the scientific revolution as a forum for the transfer and dissemination of scientific thought and the stimulation of scientific interests. Without universities, it would be hard for science to reach the level of quality that made fundamental changes possible. This is not to say that universities were ideal places for promoting science. To shift our view from scientists to the scientific though, the interactivity between universities and the scientific revolution becomes even more apparent. The scientific fields that saw the greatest changes and experienced the most exciting development in the 16th and 17th centuries were at the centre of the universities' interest. The scientific revolution from Copernicus to Newton involved a radical revision of astronomy and cosmology, a changed theory of matter, the transition from Aristotelian elements to corpuscular philosophy and mechanics, new theories of motion, new laws of mechanics and kinetics, the idea of gravity, the triumph of the

infinite universe subjected to natural laws and last but not least, the triumph of the quantitative and particularly the mathematical method in natural science, which was summed up in Newton's Mathematical Principles from 1687. All the above disciplines – astronomy, physics, mathematics and, in its general form, natural philosophy – were, since the introduction of scholastic general studies (*studium generale*) in the 13th century, an integral part of university studies with a trivium and quadrivium, the three philosophies of the arts and the texts of Aristotle, Euclid, Ptolemy, Alhazen and their commentators.

Former generations of historians built on the fact that scholastic science soon ossified. More recent research into the physics and metaphysics that was taught in late medieval times and the Renaissance, have radically changed this view. Various universities, especially late medieval Oxford and renaissance Padua, engaged in very lively discussions on the problems of the theory of inertia and motion. In the 16th century, Aristotle's philosophy was fundamentally revised when the Greek essays of Aristotle and Plato, and the Stoic and other classical philosophical schools were accessed under humanistic influences through Arabian commentaries.

Equally important is the conclusion of recent studies that mathematics made strong progress in Renaissance times. 16th century Italian universities established several new mathematics chairs and a similar trend was seen elsewhere in Europe. Mathematics was particularly strong in Jesuit colleges. Its development was not surprising; the basic harmonies of the cosmos could only be explained to a civilization founded on Platonism and Pythagoreanism.

Of course, the 15th, 16th and 17th century universities taught essentially Aristotelian natural philosophy. The entire structure of metaphysics, ethics and theology was based on its solidity and unity. But within this Aristotelianism, there was enough space for doubts, questioning, discussion and correction. The findings of the scientific revolution disproved a series of Aristotle's basic assumptions, but this was the work of scientists that did not accept Aristotle as an absolute authority, instead studying him with a critical mind. This put them a situation where they were able to use Aristotle's arguments against Aristotle himself, and the study of mathematics offered excellent instruments to replace the largely qualitative research of nature with a more quantitative approach. The celebrated scientific revolution could only reject Aristotle since he was studied at universities in the first place.

The scientific revolution of the 17th century was definitely less successful in those research areas that were hardly taught at universities or not at all. In chemistry, navigation, agriculture, mining and other practical disciplines, successful scientific research was conducted outside and with no involvement from the universities, but these areas did not see any totally new scientific development or any breakthroughs in terms of revolutionary new theories.

In the late 17th century, chemistry for instance was taught only rarely. It was mostly practiced by alchemists and used in apothecaries. In the 16th and 17th centuries, there was a definite increase in academic interest in chemical processes, stimulated by Paracelsus' medical art of separation, for example. But hardly any science historian would dare make the claim that chemistry experienced profound changes in those times that might be crucial for its further development. A similar fate was encountered by other scientific efforts outside the universities. Scientific disciplines of the Earth, geography and navigation promoted the discovery and exploration of new continents and valuable new insights. But compared with the exact sciences, they experienced no revolutionary changes in these centuries. Consequently, geology did not emerge as a scientific discipline in the modern sense until the late 18th century. In a similar way, research into the physical properties of bodies, heat, magnetism and electricity was widespread, often carried out within the frame of almost occult sciences (as in the case of magnetism), but since this took place outside universities, they lacked the theoretical coherence and discipline necessary for a thorough conceptual revision.

We may say that the universities and their scientific tradition at the very least provided a basis for the scientific revolution, which however advanced so successfully and dynamically that it soon moved beyond the domain of universities.

But the fact that universities were overshadowed by academies in the Enlightenment period, does not mean that they closed their doors to new sciences. In Germany, most universities were too small and too tightly entangled in the theological controversies of the Reformation and Counter-Reformation to focus on scientific research. But this bleak picture was not universal; in the 17th and 18th centuries, larger universities regularly updated the curricula of the faculties of philosophy, where natural philosophy was taught, in the light of new findings, though only gradually and cautiously.

Step by step and part by part, the new science found its way into the curricula. In Leiden, in French colleges (*college de plein exercise*) and Italian faculties, for example, Galileo's laws of freefall were accepted with more or less reluctance The first experimental lectures in physics in Europe were held in 1672 in the Nuremberg Altdorf university; in Padua, Poleni (1683-1761) introduced the experiment into his lectures; and in Cambridge, the original synthesis of simplified Newtonianism was introduced in the early 18th century by way of a replacement for traditional scholastic metaphysics. We should also point out there was a scientific discipline, namely medicine, whose instruction and progress had been the domain of universities from the very beginning and without interruption. The supporting medical disciplines of botany, pharmacy and chemistry owe their development into independent university study disciplines to the exceptional success of medicine.

Therefore it would be inaccurate to speak of a general aversion on the part of universities to new sciences, even those not covered by universities before the reforms that were introduced after the French Revolution. It is undeniable that universities shared the credit for scientific progress with other institutions: academies, scholarly establishments and specialized research centres such as observatories, which probably met the needs of science better than universities in the 18th century.

2.

At the turn of the 18th century, the education of technicians and engineers was associated with occupational and basic scientific skills. But on the whole, technology was not the subject of higher education studies. Post-secondary schools that taught applied sciences were scarce; their main focus was educating government officials for military and

civil duties. At the end of the 19th century, the old nucleus of military and administrative schools dissolved into a multitude of new-founded higher education schools designed to train professionals for the industry rather than candidates for public offices. The development of training for engineers varied by country, both in terms of the number of higher education schools and in terms of quality. But at the end of the First World War, university-level study courses and diplomas for engineers existed in all the industrial regions of Europe. In fact, this segment of higher education was seen to make huge leaps forward.

The spread of technical higher education was not a one-way process. An essential feature of its development was the mass of forerunners that gave rise to such schools. Most of them stemmed from a colourful range of professional schools outside the university system and they were very slow to rise to the top of the education hierarchy.

The rise of technical colleges, in both quality and quantity, generally caused friction in the tertiary education sector. In all European countries, it provoked a resistance to changes in the firmly entrenched system of post-secondary education.

The academic level of the new schools varied from country to country, particularly in terms of the prior education required. These schools, which at first started with elementary instruction, were trying to raise the standard of the curricula and began to apply stricter criteria for candidate admission. In this respect, schools for training military officers and higher officials were among the top-level educational institutions and represented the basic cornerstone of the development of university-level technical education. And yet none of the officials' or officers' schools was ever part of the university system.

Almost everywhere, the first technical schools were founded to meet the army's needs. Apart from the military academies, special schools for military architecture and the artillery were established to train officers for the technical tasks of fort construction and maintenance and the manufacture, storage and use of munitions. Such schools were best organised in France. In 1748, the war ministry opened a military school (from 1775, royal) [École (École Royale)]. Its students, mostly of aristocratic and military parentage, entered at the age of 16 with an entrance exam and studied for two and later three years, studying mathematics, natural philosophy, machine diagrams, fortification studies, architecture and, towards the end of the century, also chemistry. With its fine scientists and teachers, as well as the scientific work of its students, the school enjoyed great academic prestige. Charles Bassut (1730 – 1814) and Gaspard Monge (1746 – 1818) are two famous names associated with the school in the 18th century. By around 1800, most European countries had schools for the technical training of officers, although some of them were short-lived in light of the turbulent times. However, the Napoleonic Wars highlighted the importance of new techniques and the effectiveness of French military schools in warfare and encouraged other countries to pay greater attention to technical training for military staff. In 1816, the Prussian war ministry established the "United Artillery and Engineering School" in Berlin and an artillery and engineering military school was formed in Swedish Marieberg in 1818. In Russia, Spain, Belgium and the Italian states, the likewise available schools for military architecture and artillery were reorganized in 1820. Of course the scope of technical studies at these schools was limited and was first and foremost connected to purely military subjects and exercises. But as only a few schools in the first few decades of the 19th century could provide technical qualifications, military schools had an important role in producing a new generation of technical experts. Engineers that were trained for the army were in fact often employed to plan and carry out the construction of public buildings. In Sweden, the civilian engineering profession was supervised by military engineers.

In a similar way, mining academies, which were mostly established in late 18th century, had nothing in common with universities. Since natural resources were state-owned in most countries, these schools had the task of training a small number of government officials to manage and supervise work in mines. One of the oldest and best known mining academies was established in 1763 in the middle of a rich Austrian mining region in Schemnitz, today's Slovakian Banska Štiavnica. Two years later, Prince Xavier of Saxony (1730 – 1806) founded a similar institution in Freiberg and in 1770 and the Prussian government established a mining academy in Berlin. Studies at all these schools lasted for three years and included geometry, hydraulics, mining technology, chemistry with practical laboratory work and also visits to mines. In the 19th century, the Freiburg mining academy was the most renowned and it was also attended by foreigners and trained mining engineers for different neighbouring countries, particularly Poland and Scandinavia. Still, its number of students was small – with about 40 students a year at around 1770, Schemnitz represented the best-attended mining school.

The establishment of the predecessor of the Polytechnic (École Polytechnique) in France at the end of the 18th century created an entirely new situation. The changed character of the school, designed by Monge and then adopted by Napoleon, embodied an elite school that would train staff for the highest positions in the state and military administration. In fact, a complete reorganisation of training of staff for the highest posts in the state administration took place. The Polytechnic represented a milestone in the system of technical higher education, the apex of the education pyramid and it was much more prestigious than Napoleon's French University (Université de France).

The Polytechnic was subject to the war ministry and, from 1804 onward, when Emperor Napoleon I reformed the school, its students were subject to military discipline. To enter the school, a special national exam was required, the *concourse*, with mathematics as the main subject. At the Polytechnic, students undertook two-year studies in mathematics, mechanics and geometry, while technical subjects hardly existed.

The French model was imitated with little success by Spain and Russia. In Italy, the French system of technical higher education met with genuine admiration, but with genuine resistance in their universities, which totally dominated the higher education system. However, by the second half of the 18th century, some universities, especially Turin, Pavia, Padua and Rome, offered courses providing vital technical knowledge for activities in public services or the private business sector, which were organised within philosophy studies. After Italy united, engineering schools were integrated into its university study system. They admitted students that had completed the second year of studies in mathematics or physics and their professors were members of mathematical & natural science faculties. In light of the cross-institutional setting and also the strong influence of the French engineering schools, the instruction centred on theory. Until 1900,

there was almost no practical training. In Prussia, developments took a different turn. Here, a civil engineering academy was established in 1799 as part of the general reform of the post-secondary education system, which was completed in 1810 with the establishment of a university in Berlin. The reform was characterized by the neo-humanist educational ideal and the reformers realized the importance of scientific and technical education as the driving force behind economic progress and also realised the scientific merits of the French engineering schools. Both elements were connected by establishing less academically oriented professional colleges. The educational goal of the Berlin civil engineering academy resembled the French schools to a great extent: the training of government officials to carry out and supervise important national construction projects, chiefly roads and water canals. However, the aim was a purely technical profession and not careers that might lead to the highest offices. We should add that the style and level of education at the civil engineering academy was widely different from the style and level of education at the universities. Scientific education was reserved for universities, while education at the academy was professional and vocationally restricted. Lastly, the civil engineering academy did not come close to approaching a university system and had a decidedly second-class status.

The Polytechnic in Paris also served as a model for the advocates of establishing technical colleges in the Austrian monarchy, but the Austrian government took a different path, which also differed from the Prussian path. First, the authorities granted a university-independent higher education status to the "polytechnic provincial institute", which was established in 1806 in Prague by the Czech estates, and to the "Imperial Royal Polytechnic Institute« established in Vienna in 1815. Scientific disciplines were at the centre of their curricula as an irreplaceable foundation of engineering education. Emphasis was also placed on vocationally oriented technical subjects. Students also received instruction in subjects important for industry, particularly technical chemistry and mechanical technology. This is what distinguished the polytechnic institutes in Prague and Berlin from the French model. Their students were not only trained for public offices but also for work in the private industry.

The French system was least influential in Great Britain. Its intense industrial progress went hand in hand with the development of transport routes, canals, roads, bridges, ports and port installations and (after 1820) the railway network; but control over these developments was largely in private hands. In accordance with its general policy of laissez-faire, the government did not concern itself with the qualification and education of the engineers who carried out such work. Although hardly any schools for engineers existed before 1850, their education was governed by strict rules that were firmly established within the engineering system.

Experience and practical know-how were by far the most important qualifications in the career of engineers, both in independent trades and in industrial companies. The professional values and rules were embodied in the "Institute of Civil Engineers", established in 1771, which started bringing together the engineering elite. A similar attitude to professional qualifications was embraced by the "Institute of Mechanical Engineers", established in 1847. Membership in both associations required a certain level of experience and professional success on the part of the candidates; scientific education and academic study carried no weight. This of course does not mean that the associations underrated the acquisition and improvement of technical knowledge. They supported research, organised conferences and promoted self-study and the exchange of experience between members. But there was a lack of effort to substitute experience with post-secondary education. This line of development allowed little space for establishing engineering schools.

All the above mentioned schools for public offices at least offered studies in subjects such as chemistry and applied mechanics, which were also useful in craft and industrial practice. Occasionally, graduates from these schools found their way into the industry. But almost no European government was willing to take the education of technical experts for industry into their own hands. In this regard, the industry was not exerting adequate pressure on the authorities; in the first decades of the 19th century, only few factory owners promoted the education of engineers that would be oriented towards industry. There were exceptions in the chemical industry, where some factory owners – not just in Germany – started hiring university graduates at around 1840. Academics trained in analytical methods and laboratory techniques were especially suitable for the supervision of testing and control procedures. Some universities provided such experts; the university in Giessen, where Justus von Liebig started his study and research laboratory in 1825, was particularly successful. But these were exceptions. Prior to 1850, links between academic science and industrial practice were weak. The gap between theory and practice increased in all other fields aside form chemistry, e.g. in the mechanical industry, the textile industry and in machine manufacture, although university scientists and professors were now and then consulted on certain issues.

At the time, the French *grand schools* (grandes écoles), a term that was understood to encompass the polytechnic school and schools of applied sciences, represented the undisputed model of technical higher education across Europe. In Switzerland, a polytechnic was established in Zurich in 1855 on the model of the polytechnic schools of the Austrian-German tradition with six vocational courses. They admitted students at the age of 10 with a satisfactory knowledge of mathematics, algebra, descriptive geometry and physics. The curriculum was very demanding, especially in the first three levels; besides theoretical lectures in basic sciences, it included the technical application of practical work. Due to the large number of subjects and their quality, the school soon earned renown that reached beyond the borders and in 1862, it counted 225 students and just as many other non-full-time attendees.

Between 1850 and 1880, the number of students at German technical colleges increased as well. The redesign and expansion of engineering education and the increasingly strong role of the university chemistry institutes in the development of the chemical industry was followed with admiration and concern from outside Germany. In the second half of the 19th century, the German economy visibly boomed, especially with the expansion of the metal, mechanical and chemical industries. The educational policy in the German states, especially in the technical area, was assessed by contemporaries as the expression of a will for progress and as the crucial factor of the industrial boom. In countries that perceived this boom as a threat and in countries that admired it, the demands for technical higher education directed towards

authorities and factory owners in the last decades of the 19th century were underlined by pointing at Germany's success. This included Great Britain, which had seen no changes in this area in the previous decades. From 1840 onwards, chairs for technical sciences were established with royal support at the University of Glasgow and the Queen's University of Ireland in Belfast, while two new institutions were also founded in England in Durham and London: the Royal Institute of Chemistry in 1845 and the Royal School of Mines in 1851. Under the influence of the development in Germany and in the universities in Durham, Glasgow, London and Belfast, engineering science chairs were established at the universities that emerged in the second half of the century in the major cities of Northern England. Their status was not comparable to the old universities in Oxford and Cambridge; most were not recognized as universities until the 20th century. At first, they were not authorized to confer degrees; they prepared their students for university degrees awarded by the University of London. In the following two decades, more than ten such chairs were formed in other British cities. A chair for engineering sciences was even established at Cambridge in 1894 and at Oxford in 1907.

France was another country where initiatives in the area of post-secondary education fell behind Germany's development. This is not to say, of course, that there were no attempts to spread technical expertise. Town councils had supported training in applied sciences since the beginning of the century. Local academies and private associations took part in these efforts; a prominent example was the Industrial Society of Mulhouse (Société Industrielle de Muhlhouse) established in 1826, which was the hub of the spiritual life of the regional industrial elite and, along with the town authorities, the initiator of craft schools that taught drawing, weaving, spinning and trading. Although these local and private endeavours were valuable for the regional economy, their overall significance should not be overrated, either in France or in Italy and Spain.

In the last quarter of the 19th century, the technical sciences made great progress in theoretical and experimental developments. In various fields, from studies in the physical properties of raw materials to the drafting of steam engines, a balance was achieved between rigorous methods of analysis, systematic experiments and the frequently contrary needs of practical application. The new generation of teachers in technical higher education produced textbooks combining basic theoretical proficiency in their discipline with experience from practical technology. The new textbooks were more demanding than their predecessors as regards theoretical bases, but also more alive to the special interests and tasks of practical engineers. In the new curricula, the theoretical aims were much better worked-out and adapted to the triumphs of the electric power industry in the past years. Changes in the curricula also reflected the importance that laboratory lessons acquired after 1880. Of course laboratory work had existed earlier, but it was only attended by professors and didn't include students. Chemistry was the only field where, around 1850, laboratory practice was something quite common. Laboratories for machine manufacture became standard around 1870 in American schools. In Europe, they were first introduced by Carl von Linde (1842-1934) in 1876 at the Technical College of Munich and by Alexander Blackie William Kennedy (1847-1928) at the University College London. Laboratories for machine manufacture, materials research, technical chemistry and, after 1885, electrotechnology represented the fundamental elements of a modern, developed technical college. The Technical Colleges of Berlin and Zurich were particularly well-equipped.

The academisation of the curricula and the extension of study to laboratories were basic elements in the endeavours to achieve recognition of the academic status of technical colleges. Technical college teachers especially demanded equality with universities, underlining curriculum improvements and the social importance of technical progress. Though technical colleges gradually approached the universities in terms of reputation, their study reports and diplomas did not function as proof of qualification for scientific work; notably, they did not enable an academic career. In England in 1890, the great efforts of engineers' professional associations finally led to the introduction of the academic title of baccalaureate in engineering sciences, which was formally a university degree, but the existing academic elite only accepted it with difficulty and contempt. The situation was even more complicated in France, where the value of a diploma or academic degree depended on the prestige of the awarding institution. The problem of academic equality was especially evident for engineering schools that were attached to university faculties, since equality with the home university represented the first step towards the independence of engineering science faculties. Even in Italy, where engineering schools were reorganised in 1860 to give them a status similar to faculties, efforts for their independence grew stronger at the end of the century.

While the process of winning independence and academic recognition for engineering schools varied greatly in content and time across the European countries, it was met by violent resistance everywhere before 1880 from university professors - not just the professors of arts faculties but also professors of exact sciences. Even in France, where the Polytechnic School was at the very top of the education system, the engineering schools did not enjoy the reputation their representatives expected. Its graduates (polytechnicians) who excelled in studies of abstract and theoretical subjects, particularly mathematics, were quite closed to the idea of developing industrially oriented education - no less than the graduates of humanities. In Germany, which was renowned for its technical colleges all across Europe, the traditional elites showed no special sympathy for the engineering sciences. Moreover, the resistance of the universities to academic equality with the technical colleges was not broken until 1899 with the personal intervention of the emperor, who was in general very committed to the promotion of scientific research and the promotion of technical education. Despite the reluctance of the universities, engineering schools reached a status equal or at least comparable to universities by the turn of the century in most European countries. But scientific research work could only become properly established at technical colleges when they gained the right to award doctoral degrees (in Germany in 1900, in Austria in 1901 and in Switzerland in 1908) as a result of independent research work and, hence, suitable research opportunities at these schools. In Great Britain, the doctoral title for natural sciences was introduced in 1878 and the doctoral title for engineering sciences was introduced for the first time in 1912 at the University of London. In France, scientific research work in engineering was institutionally recognized in 1923 by introducing a doctoral title, which however was not awarded by engineering colleges but by universities, on the basis of further two-year training in university laboratories.

However, we should point out that, at the turn of the century, European countries did not show any particular concern for the scientific research work of natural science and engineering faculties. Their laboratories for study and research work were instead largely equipped by city authorities and private sponsors. Even the renowned National Physical and Technical Institute (Physikalisch-Technische Redichanstalt) in Berlin, famed as the model of a modern institution entirely dedicated to scientific research work, was established in 1887 at the private initiative and with the private capital of Werner von Siemens (1816-1892). In order to promote basic research work, the German central government did, however, establish the Emperor Wilhelm Society in 1911 (*Kaiser-Wilhelm-Gesellschaft*), the forerunner of the 1946 Max Planck Society for the Advancement of Science (*Max-Planck-Gesellschaft zur Förderung der Wisenschaft*). In Great Britain, pressure from physicists without public funding led to the establishment of the National Physical Laboratory in 1902, the Committee for Scientific and Industrial Research was formed in 1915 and the Technical Directorate (*Direction Technique*) in 1915, which was reorganised into an independent institution for the promotion of scientific research in 1919 and into the National Office for Scientific and Industrial Research (*Office National des Recherches Scientifiques et Industrielles)* in 1922. In Italy, the National Committee for Technical Research was established after the First World War, replaced in 1923 by the National Council for Research.

3.

In Slovenia, the first traces of post-secondary studies of natural science and technology may be found in the study process of the Jesuits in the 17th and particularly the 18th century. Like elsewhere, as a teaching order, the Jesuits in Ljubljana, Klagenfurt and partly in Maribor raised the entire educational programme of lower and higher studies (*studia inferiora, studia superiora*) to an entirely new level with their study rules, the *Ratio studiorum.* This was a level of significantly higher quality; they built an educational system that was fascinating for those times and highly superior to the previous school structures, introducing new emphases into teaching activities. Despite their efforts, however, they failed to raise their higher studies to an academic, university level. With the Jesuit school system, the Catholic reform enabled the Slovenian people to join the European currents of thought and culture on an equal footing.

The Jesuit colleges in Ljubljana and Klagenfurt belong among the Austrian Jesuit province colleges, where Jesuits were actually willing to allow more space for natural science subjects (as pressed by the state) in their higher studies, e.g. experimental physics, mechanics and agronomy. Thus in mid-18th century Ljubljana, three important professors lectured in natural sciences as non-compulsory subjects: Franz Kasaver Wulfen (1728-1805), Gabriel Gruber (1740-1806) and Jožef Mafei (1742-1807). Nor should we overlook some other renowned Ljubljana Jesuit professors: Bernhard Ferdinand Eberg, Janez Pogrietschnigg, Kristjan Riegerj, Gregor Schöttel, Janez Schöttel, Jožef Kaufmann and Inocenc Taufferer. But the crucial watershed in the treatment of natural science subjects in the Ljubljana Jesuit schools was the purchase of instruments for experimental physics lessons in 1754 at the time of professor Bernard Ferdinand Eberg (1718 - 1773), who by order of Empress Maria Theresa, introduced experimental lessons in mathematical and physics subjects in Ljubljana. The Viennese Jesuit Kristjan Rieger, one of the greatest military theorists of the age, was the last rector of the Ljubljana Jesuit schools for fifteen and a half months, before the order was dissolved in 1773. His example and vast erudition was a beneficial influence on the young students, among which Jurij Vega stood out even then. Rieger's famous textbook on military architecture encompassed all the existing military sciences, not just fortifications. This remarkable volume was used for centuries after its printing and the progress of the Habsburg artillery due to Kristjan Rieger soon had to be acknowledged even by the Prussian King Frederick the Great himself. It is also noteworthy that in the middle of the 18th century, a surprising number of military technical and mathematical experts also worked at the Jesuit college in Maribor, for example the weapons researcher Ernst Apfaltrer from Carniola, as well as the mathematicians Peter Haloy from Belgium and Janez Kaschutnigg from Carinthia. The beginnings of post-secondary education in geodesy in Slovenia are likewise linked to Jesuit education, although the head office of the mercury mine in Idrija ran a cave surveying, land surveying and drawing school. In 1766, the Jesuits in Ljubljana established, a chair for mechanics and drawing within their higher studies with support from the Carniolan Agricultural Society and started training masons and carpenters. Apart from Jožef Kaufmann, the most distinguished professor at the chair was Gabriel Gruber, who also taught geometry, hydraulics, land surveying and land survey drawing. Gruber's lessons at the Jesuit higher studies in Ljubljana were the beginning of post--secondary studies in theoretical engineering geodesy, which was complemented by practical work in measurement and mapping at the Craft School. Gruber also taught civil construction and mapping to Jurij Vega.

By pressing for a tertiary education model, which had already been outlined based on the Bavarian model at the time of Joseph II (1780 -1790), much better opportunities to receive academic education were created in Austria at the end of the 18th and the beginning of the 19th century. Due to the double level of this branch of education – lyceum and "erudite" (university) studies – the small philosophy & theology lyceum schools in the provinces, which were regarded with distrust by the enlightened reformers in the second half of the 18th century, took on an entirely new significance, especially in the non-German parts of the monarchy. Unlike proper universities focused on scientific work, lyceums were primarily dedicated to instruction for professional practice, since their main aim was to educate priests (who were expected to be knowledgeable in divinity as well as agriculture), surgeons, estate managers and teachers. In this regard, lyceums fell into two groups: those that could award doctorates in philosophy and theology (downgraded universities) and lyceums that arose as some sort of atrophied gymnasiums in place of the former Jesuit studies and became scientific educational institutions in provincial centres, though without the right to confer doctoral titles. The Imperial Royal Lyceum of Ljubljana *(Archiducale Lyceum Labacense, Caesareo Regii Lyceum Labacense, K.K. Lyzäum zu Laibach, K.K. Lyzeum zu Laibach)*, which was formally established in 1791, was among the Austrian lyceums without the right to award academic titles and, as semi-university institutions, served as a kind of connecting link between gymnasiums and

proper universities. It comprised three branches of study – philosophy, medicine & surgery and theology – and also offered a number of elective subjects ranging from agriculture to history, pedagogy, botany and philosophy to modern languages. What undoubtedly marked out the philosophical studies at the Ljubljana lyceum as special was its mechanical (craft & industry) school. "After the Austrian occupation, the territory of the Illyrian provinces remained subject to abolished guild rights, which opened free access to craft trades and made professional education even more necessary to increase the competence of emerging professionals and improve the quality of craft services."

In February 1815, the school started Sunday elective studies in the rudiments of geometry, mechanics and other physical and chemical phenomena. They were taught by the lyceum professor Janez Kersnik, who encouraged the philosophy study directors to present a proposal to the Court Study Commission in Vienna through the governorate to accredit the mechanical school as a craft and industry school. The request was approved in January 1818 and Janez Kersnik then taught arithmetic, geometry, mechanics and chemistry at the Sunday course for two hours a week in the lyceum's philosophy lecture hall as a permanently appointed employee under the supervision of the philosophy study directors. Although the course was elective, the school was always well attended.

The most important subject within the professional studies of the time was drawing (the art of draughtsmanship). As soon as Austria reassumed power, a drawing school was established at the philosophical studies of the lyceum in Ljubljana, which involved a special course for lyceum and gymnasium students on Tuesdays and Thursdays (when they were free and had no classes) and for craft students on Sundays and holidays. To wit, priority in obtaining a master craftsman's licence was given to assistants who had attended drawing lessons and, by order of the Ljubljana governorate of 1814, only graduates of philosophical studies who mastered drawing could enter for traineeship at the building directorate. Drawing skills also benefited those students of the Ljubljana lyceum philosophical studies who opted for the various technical disciplines or studies at the polytechnic institute in Vienna. Drawing was mostly taught by primary school drawing masters.

French rule over the east coast of the Adriatic Sea in Napoleon's time in the early 19th century (1809-1814) was an extremely important though short-lived period also in the history of the education system. Besides the reorganisation of primary and secondary education, the most important bonus of the French school reform was the establishment of a university in Ljubljana. The underlying motivation was to stop future generations of the academic profession going to study in Austria. With the 1810/11 academic year, the so-called "central schools" (écoles centrales) were launched in Ljubljana with five study courses: for medical doctors, surgeons, engineers, architects, lawyers and theologians. The first year was the same for everybody and consisted of lectures in oratory, metaphysics and physics – these philosophical studies were preliminary to proper discipline-based studies. At the beginning of the first year, the central schools had a total of 300 students and half the number at the end of the year. Neither of the faculties for pharmacy and land surveying had any students at all. It seems the young people of the time were not drawn to the disciplines. Nor could the faculty for engineers and architects boast of a huge rush on study, with five students in the first year and nine in the first- and second-year studies in philosophy. Franc Hladnik taught natural history (mineralogy) in German, S. Gunz mathematics (pure mathematics and practical geometry in Latin and H. Maine drawing and architecture in French. The subjects of these studies (as well as the land surveying course) were too practical for the current venerable universities to included them in their scientific programme, so they had to be taught at independent professional schools. The average age of freshmen was 18-19 years, which was roughly a year above the current European average. Predominantly, the students of engineering and architecture were the sons of craftsmen. Studies at the faculty for engineers and architects were planned as a four-year course. Central schools could award academic titles. After the first year, the studies saw some changes. The central schools became a single academy and the study courses were rearranged, abandoning engineering and architecture. Of course, no one ever completed studies at the French university in Ljubljana apart from the theologians, since it only survived for three years. On their return in 1814, the Austrians restored the education system to its previous state.

By placing the subjects of the land surveying, engineering and architecture faculty on a level with the most distinguished studies of the time – theology and law – and under a single leadership and administration for all studies, the central school embraced the spirit of progressive views on the mission of university studies, which, however, did not catch on in Europe until later.

We should also note for this period that professional education was conducted in the frame of the senior years of primary schools and was best developed in Idrija. In 1811-1812, the mathematical department of the Idrija school had two classes with five teachers for arithmetic with logarithms, algebra and equations, geometry with trigonometry, drawing (machine drawing and cave map drawing), architecture and a remedial French language course. Both classes had four hours of lessons a day, except on Thursdays which was a day off. This mining school for qualified workers and employees of the Idrija mine was attended by graduates of the four-year primary school in Idrija.

A considerably lower level was offered by the Craft School in Ljubljana (*école d' arts et métiers*). Besides literacy, the admission requirements for candidates were proficiency in the province language and the rudiments of mathematics. Three skilled craftsmen – a builder/architect, a joiner and a locksmith – taught theoretical and practical lessons for three hours a day, each in his own class, whereas drawing and religious education were attended at the Ljubljana primary school. The Craft School was ran by Valentin Vodnik and supervised by the rector of the central school Jožef Balant (Walland). However, the school was discontinued after its first year. The only professional schooling to stand the test in the following decades of the first half of the 19th century was the one that had been introduced earlier (at the Ljubljana primary school) and where it developed owing to local incentives (in Idrija).

From the middle of the 19th century onwards, in keeping with the new structure of Austrian secondary education, Slovenia embraced the "realka", a new type of secondary school that, unlike the classical gymnasium, emphasized instruction in tangibles – i.e. natural science subjects. The first lower realka school was established in Ljubljana in 1851/52 and was followed by realkas in Gorizia (1860), Trieste and Maribor (1870) and Idrija (1901). The realka in Ljubljana evolved

into a higher realka in the 1860s and was decidedly pro-German in character; both its teachers and students were Germans living in Carniola, but they also educated Slovenians, including the writer Ivan Cankar, Rihard Jakopič, Maks Fabiani, Srečko Kosovel and many others.

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Technical University Course in Ljubljana

With the slow economic development of the Slovenian provinces in the Austro-Hungarian Monarchy, there was no perceptible demand for the education of local technical experts. The modest industry was controlled by foreign, largely German capital that mostly employed Germans, while public services were mostly provided by Czech experts. In the decade-long struggles of the Slovenians for their own university before World War I, technical studies were never mentioned. However, in the new confederation with Serbs and Croats, the previously backward Slovenian nation found itself ahead of others in technology, which prompted the idea of university-level technical studies in Ljubljana, organized within a university or an independent college. The initiative was taken up by the society of engineers and its active individual members. These included Milan Šuklje, a professor at the Craft School, who after the overthrow of the monarchy immediately proposed setting up technical courses at his school; engineer Dr. Miroslav Kasal, who at the founding meeting of the University Commission, suggested that a faculty of technical sciences should also be established at the Ljubljana university based on the American model; engineer Pavlin, who attended the first meeting of the University Commission on behalf of the society of engineers; engineers Šuklje, Rataj, Tavčar and Štembov, who alternately attended its meetings during its ten-month operation, and others.

After two months of efforts by the University Commission, especially focused on organising temporary chairs in Zagreb with Slovenian as the teaching language, firm demands were also made by Slovenian technologists in late January 1919. Their memorandum, submitted to the Commission, urged that the industrially stronger western parts of the new state should also obtain university technical studies, since the technical faculties in Belgrade and Zagreb alone could not meet the need for technical human resources. They proposed civil, mechanical and electrical engineering departments comprising 8- to 10-semester studies and a geodesy department with 6-semester studies. Other departments would be added later as necessary (chemistry, mining & smelting and architecture). The memorandum advocated that the technical lectures should be started as soon as possible in the form of courses at the Craft School in order to make the eventual establishment of a faculty of technical sciences easier.

In early February, Dr. Karel Verstovšek, the commissioner for education and religious affairs at the Provincial Government, sent the central authorities in Belgrade a request for the establishment of a university and divinity school, as well as an elaborated request for the establishment of a technical college in Ljubljana. Soon enough, in March, Ljubljana received news that the council of ministers in Belgrade had announced that the university would be established in autumn 1919, including a faculty of technical sciences. This surprising news triggered intensified preparations for the upcoming establishment of the university. These were led by special subcommittees of the University Commission, who were charged with designing plans for the respective faculties. The subcommittee for the faculty of technical sciences consisted of: Prof. Dr. Plemelj and the engineers Rataj and Šuklje on behalf of the University Commission; engineers Prelovšek, Remec and Strgar from the society of engineers in Ljubljana and engineer Seilecky on behalf of the society of land surveyors.

The subcommittee preparing the faculty of technical sciences was among the first committees to complete its work, which was summarized in a report and presented on 15 March 1919 at the next meeting of the University Commission. Within it, the previously planned technical college was replaced by a faculty of technical sciences attached to the university in Ljubljana. In their report, the members of the subcommittee for the faculty of technical sciences stressed that *in order to successfully vie with other nations in the technical field, it is crucial to educate local officials for national and municipal technical services and teachers for technical schools*. At first at least, until enough local experts were available in all the disciplines, there would have to be reciprocity with Czech institutions, so it was suggested that the first two study years should follow the curriculum of the Czech technical colleges, which was equivalent to those of the Austrian institutions. It was also decided that the final curriculum of the faculty of technical sciences should be drawn up by its board of professors in collaboration with the society of engineers and submitted to the government by no later than 1 June 1920. The opening of a university in Ljubljana was anticipated by many Slovenian students who could no longer study at foreign universities, and some were also expected from other parts of Yugoslavia. The subcommittee for the faculty of technical sciences therefore suggested starting with the lessons early – on 1 May 1919 – with the first extraordinary semester for civil, mechanical and electrical engineers, miners and land surveyors ending on 15 July. The second extraordinary first-year course would run from 15 August to 31 October, and the first second-year course could begin on 15 November, which would launch regular studies for both first and second-year students. The proposal also called on the government to promptly open three chairs, specifically for *mathematics, mineralography and chemistry, as well as seven part-time assistant professorships with teaching orders, two for mechanics and one for descriptive geometry, geodesy, technical and construction drawing, mechanical drawing and legal subjects, respectively*.

When the establishment of the Ljubljana university was temporarily put off, the society of engineers still campaigned for the earliest possible kick-off for the technical studies in Ljubljana and, with a special resolution of 15 April 1919, demanded that, if the planned opening of the faculty of technical sciences was no longer possible, a temporary technical university course should start immediately.

At a meeting of the Provincial Government of 26 April, the proposal was accepted, the planned courses confirmed and, on 7 May 1919, the Official Gazette of the Provincial Government for Slovenia published the *Decree on the Establishment of a Temporary Technical University Course for the Civil, Mechanical and Electrical Engineering, Mining and Land Surveying Disciplines*. By 10 May, fifty students had applied for study and the University Commission nominated the first professor candidates. The teaching staff for the technical courses, partly nominated by consensus and partly by a majority vote, included: Rihard Zupančič for mathematics I, engineer Jaroslav Foerster for descriptive geometry (lectures), the higher gymnasium headmaster Prof. Jože Mazi for descriptive geometry (practical work), who was given the assistants eng. Ladislav Bevc and technician Milan Fakin, engineer Dr. Milan Vidmar for mechanics I, Prof. Dr. Maks Samec for general chemistry, Prof. Dr. Pavel Grošelj for mineralogy, the engineer of architecture Ivan Vurnik for technical drawing, engineer M. Mihor for mechanical drawing, engineer Dr. Miroslav Kasal for situation drawing, engineer Leo Novak for basic geodesy and eng. Ladislav Bevc again as an assistant for practical work in geodesy.

The Provincial Government executed the appointments on 19 May. At the same time, engineer Milan Šuklje was appointed president of the board of trustees of the provisional technical university course. Other trustees were representatives of the individual departments: Ivan Vurnik for the civil engineering department, Rihard Zupančič for the mechanical & electrical engineering department, Maks Samec for the mining department and Leo Novak for the geodesy department. On the same day, there was a ceremonial opening of the courses, which was attended by the president of the Provincial Government Janko Brejc, the commissioner for education and religious affairs Dr. Karel Verstovšek, the vice-mayor Triller, the members of the University Commission and society of engineers and the entire teachers' assembly. The ceremonial keynote speeches were followed by inaugural lectures by Dr. Milan Vidmar, *The Engineer – the Philosopher and the Machine – Colossus*, and Dr. Rihard Zupančič, *On Mathematics in Technical Science*.

On 3 July 1919, the Provincial Government for Slovenia established two technical university funds to raise voluntary contributions in order to support the education of technical experts. The technical university fund for Slovenia was to provide aid for students who studied at national or foreign technical colleges, particularly in the mining and smelting disciplines, for graduation candidates to enable further study or practical training abroad and for foreign study institutions for the education of candidates for technical assistant professorships at Slovenian faculties. The second fund was intended for the equipment of technical institutes in Ljubljana. The funds were managed by an administrative committee.

Classes at the Technical University Course ran without a break from May to November. The first-semester weekly schedule comprised 32 hours of lectures and 32 hours of practical work. In the second semester, there were 36 hours of lectures and 38 hours of practical work weekly. In this time, the complete first-year syllabus of technical colleges was covered. The course was organised in two departments: electrical & mechanical engineering and civil engineering, its programme designed in way that allowed students to continue their studies at the departments of architecture and mining as well. There is no list of the students' names on the course or their exact number in the preserved archival material, only a reference that second-semester lectures were attended by 116 students. An examination of the personal documents of students enrolled at the technical course in Ljubljana in 1919 has shown that 83 of the students attending the technical university course advanced to the second year.

The establishment of the Technical University Course and the beginning of university lectures in Ljubljana was highly significant for the Slovenians. Its practical significance, since the launch of the technical courses enabled previously inaccessible further studies for many a Slovenian student, was significantly exceeded by its moral significance, since, as Polec summed up Majaron's thought, this was seen by everyone as the modest beginning of *Almae matris labacensis*.

The Establishment of the Faculty of Technical Sciences and the Struggle to Preserve It

In the summer months of 1919, when lectures were in progress at the technical university course, the university idea matured owing to the efforts of the University Commission and support from the Slovenian MPs.

On 23 July 1919, the Regent Alexander signed an act on establishing the University of Ljubljana with five faculties: arts, law, theology, medicine and technical sciences. Its first full professors were appointed on 31 August. At the Faculty of Technical Sciences, these included: the professor of the Viennese technical college Dr. Rihard Zupančič for mathematics, the mining councillor of the geological institute in Vienna Dr. Karel Hinterlechner for mineralogy and petrography, the professor of a Viennese "realschule" secondary school Dr. Maks Samec for chemistry and the assistant professor of the Vienna technical college engineer Dr. Milan Vidmar for electrical engineering.

The appointed full professors formed faculty councils and, after the University Commission was dissolved, they led the preparations for the earliest possible launch of lectures in the function of faculty registrars. Their main tasks included: obtaining temporary premises and teaching staff for the first generations of students and providing a legal framework for faculty operation. The registrars eagerly set out to organize the faculty, their difficult task made even harder by constant threats to the faculty's existence.

The development of the barely established Ljubljana university was threatened by attacks on individual faculties or departments, at one time even putting the existence of the university as a whole at risk. Tendencies to abolish or curtail the university would arise at budget discussions throughout the first and in the beginning of the second decade of the university's operation, forcing the university officials, supported by Slovenian cultural institutions and national representatives, to engage in constant painful justification of the need for a non-curtailed university in Ljubljana to the decision-makers. It was the faculties of medicine and technical sciences that were most often in danger. The issue of keeping these two faculties was first raised as early as in the beginning of the 1921/22 academic year when the state budget for 1922/23 was being drawn up, when news of plans for their abolishment came from Belgrade. In defence of their faculty, its staff

published a Memorandum Against Abolishment, which emphasized that the credit for the establishment of a Slovenian faculty of technical sciences largely went to the Slovenian industry, banks and Slovenian engineers and that its abolishment would be *a slap in the face of the Slovenian nation, like it was used to before the liberation*. The protest achieved its aim and the academic year started, but continued in a state of uncertainty; at the end of the summer semester, the ministry in Belgrade was again thinking about reorganising technical studies in the state and, for this purpose, called a consultation on 16 June 1922, where delegates from all three technical faculties in the state discussed which three departments to keep in Belgrade, Zagreb and Ljubljana, *since financial and local reasons did not allow all three universities to have complete faculties of technical sciences*. In 1925, professor Hinterlechner offered arguments in his brochure *The Issue of Yugoslav Universities (with special regard to the Ljubljana university),* which proved what a small burden the university in Ljubljana was to the state, and the University Council drew up a memorandum with the slogan *The Nation to its University* to appeal for stronger support for the Ljubljana university from university professors, banks and industrial companies. As a new financial act was being passed in Belgrade, news was again received of the intended abolishment of faculties. The student council of the Ljubljana university organised a three-day strike on 24 December 1927 to protest the abolishment of the medical and technical faculties and a large protest gathering at the Union building. The strike ended with a meeting of the Ljubljana university students on 26 November in the University Assembly Hall and a lecture by professor Milan Vidmar entitled *The Faculty of Technical Sciences of the University of Ljubljana* in Union's hall. On 25 November, the University Council adopted a resolution for the Ljubljana university and sent it to all the Slovenian ministers and MPs. It met with a favourable response from the politicians. In late 1927, the printed memorandum *The Importance of the University of Ljubljana for Slovenians and the State of SCS* was also published, stating the reasons for the existence of the individual faculties. It defended the Ljubljana Faculty of Technical Sciences by saying that *it could develop where there are favourable conditions, which is in Ljubljana. The highly developed secondary schools produce thoroughly and seriously prepared students. Besides, Slovenia is sufficiently industrialized to attract students from other faculties as well. Our professors have already written several books and scientific treatises.* On 3 October 1929, the preparation of a new university act was reported by the rector to the university administration, entailing the consolidation of the institutes at the Ljubljana Faculty of Technical Sciences. A deputation from the Ljubljana university interceded with the king and the act passed on 20 June 1930 preserved all the faculties. The 1932 financial bill was going to give the education minister authority to abolish the faculties of medicine, theology, technical sciences and law. This would leave only the Faculty of Arts in Ljubljana and, in the technical field, the department of mining sciences. This provision was also later crossed out from the financial act. On 5 January 1933, the *Slovenec* newspaper wrote that the minister was again considering the reorganisation of the universities, this time by detaching all three technical faculties from their home universities. The news was responded to by professor Vidmar on 12 January with a demand that technical studies should remain an integral part of the university on the following grounds*: Technical science has matured. It is now equal to the historical sciences.... Over the decades, the education of engineers in technical secondary schools and independent colleges has been an all-round failure. All the best engineers have been produced, with few exceptions, by the classical gymnasium*. In his view, an independent technical college would increase costs, since this would require twice as many professorships. The current dean Král and professor Zupančič likewise spoke up against the detachment in *Slovenec*.

Faculty Development

Despite the threats to its existence, inadequate premises, scarce funds and hence insufficient staffing, all of which hampered its development, the Ljubljana Faculty of Technical Sciences ran successfully thanks to the efforts of the teaching staff and support from Slovenian industry.

In the 1919/1920 academic year, when the university technical course was accredited for all the departments expect for chemistry (which had only started work that same year and only offered the first two semesters), four complete semesters began. Due to staffing problems, the third and fourth year could not yet be organised in some cases and some of the students from the first generations had to continue their studies abroad or break off studies for a year. They mostly went to Brno and Prague, while some also went to Vienna, where the same study programme was available. German universities had not yet recognized the Ljubljana technical faculty, which meant that studies had to be stated from scratch.

The registrars strove to complete the teaching staff. In the first academic year, additional lecturers included associate professor Alojz Král (technical mathematics) and assistant professor Ivan Vurnik (building construction) and part-time professors: Ivan Arh *(agriculture*), Josip Mazi *(descriptive geometry)*, Leo Novak *(basic geodesy),* Rado Kregar *(land survey drawing),* Alfonz Gspan *(cadastral technique),* Ciril Pirc *(spherical astronomy),* Valentin Kušar *(physics),* Marij Rebek *(chemistry),* Josip Zidanšek *(agriculture),* Milan Škerlj *(the basic principles of applicable civil law for technical students)*, Edvard Pajnič *(laws and decrees for land surveyors),* Ivan Škarja *(administrative law),* Albin Kandare *(bookkeeping),* Otmar Krajec *(hygiene),* Mavricij Rus *(first aid),* Stano Premelč *(mechanical technology)*. In the first academic year, the Faculty of Technical Sciences had a total of four full professors, one associate professor, one assistant professor and 14 part-time teachers. In the second academic year, the third study year opened at the civil engineering, architecture and mining departments and the second study year at the chemistry department. In the 1921/22 academic year, a staff of 11 full professors, 3 associate professors, two assistant professors and 29 part-time teachers allowed four-year studies at the architecture, mining and chemistry departments, while only three years were available at the civil and electrical engineering departments. Further appointments of professors in the 1922/23 academic year were not effected, so the extent of the studies remained the same as in the previous year. A complete eight-semester course in all five departments of the Faculty of Technical Sciences became available with the 1923/24 academic year.

The subjects for which no permanent professors could be obtained were covered by outsourced recognized experts, who were appointed by the education ministry as part-time lecturers at the proposal of the

teaching assembly, but they were hard to acquire. The lack of secondary technical schools and a weakly developed industry meant that Slovenian experts were scarce and besides, experts from the industry were several times better paid than university teachers. The shortage of staff led to the resolution that, if no home experts were available, a faculty may employ foreigners. The newly founded Ljubljana university took advantage of the emigration wave of Russian academics, who fled the South Siberian town of Omsk, which was facing a civil war and sought refuge at foreign universities in 1919. Some of them passed through Belgrade to Ljubljana and were crucial in facilitating the steady operation of the new university in an extent that Slovenia could never manage with its capacities alone. The already established and recognized experts contributed a lot of knowledge and, above all, experience in university work, also launching studies in some sciences and trends that were quite new for that time and territory. Within the Ljubljana university, these Russian emigrants were most numerous at the Faculty of Technical Sciences: Dimitrij Vladimirovič Frost, Vasilij Vasiljevič Nikitin, Fjodor Fjodorovič Grudinski, Aleksander Nikolajevič Mitinski, Dimitrij Šahnazarov, Vladimir Aleksandrovič Itin, Vasilij Isajevič, Ignacij Nikolajevič von Majdel and Aleksej Kopylov.

The faculties of Ljubljana also helped each other solve their staffing problems. The Faculty of Technical Sciences cooperated with the Faculty of Arts above all, since some disciplines were taught at both; at the technical faculty to train engineers for industry and at the faculty of arts to provide education for research and teaching occupations.

Until after the war, chemistry at the Faculty of Arts had no full-time teachers; instead, chemistry students attended lectures at the Faculty of Technical Sciences, where special practical work was also organised for them, and Maks Samec lectured part-time at the Faculty of Arts from the summer semester of 1927 onward. In the mid-thirties, lectures were also given there by Klemen Rihard and Marij Rebek. The students of the Faculty of Arts also heard lectures in mineralogy and petrography at the Faculty of Technical Sciences from the first academic year onwards, and in 1923-1929, Karl Hinterlechner also did part-time lecturing at the Faculty of Arts. Faculty of Arts students heard lectures in physics at the Faculty of Technical Sciences by Valentin Kušar. Another part-time teacher at the Faculty of Arts was Rihard Zupančič, whereas the mathematician Josip Plemelj, a full-time professor of the Faculty of Arts, also lectured in mathematics at the Faculty of Technical Sciences throughout his service. Other professors from the Faculty of Arts that taught at the Faculty of Technical Sciences were Franc Jesenko (raw materials and technical microscopy) and Marijan Salopek (geology). Evgen Kansky, a full professor at the Faculty of Medicine, taught food chemistry to technical students.

In the first few years, the study subjects were organised in groups of related subjects: mathematical subjects, natural science subjects, mechanical and electrical engineering, civil engineering and architecture, and the group "other" included first aid, hygiene and bookkeeping. When the structure of the Faculty of Technical Sciences was reorganised in the spring of 1926, the previously scattered chairs or related study subjects were brought together under eleven institutes: the institute of applied mechanics, the institute of physics, the institute of mineralogy, geology and mineral deposits science, the Institute of Chemistry, the Institute of Cave and Land Surveying, the Institute of Technical Mechanics, the Institute of Electrical Engineering, the Institute of General Mechanical Engineering, the Institute of Civil Engineering, the Institute of Architecture and the Institute of Mining, all headed by directors. In addition to professional subjects, technical students also heard legal subjects. With the 1935/36 academic year, the institutes split into centres. This set-up was preserved until 1945. With the 1946/47 academic year, the centres were renamed institutes. All the departments of the Faculty of Technical Sciences shared a similar study programme in the first two years. In this time, the students obtained general technical knowledge, and in higher years, the study focused on their respective specialist disciplines and also provided practical experience in laboratories, institutes and drawing classrooms.

The civil engineering department was founded with the appointment of professor Alojz Král in early 1920. He taught the subjects of technical mechanics & materials research and iron bridges. In September 1920, the department was joined by Miroslav Kasal, who lectured in the following subjects: construction mechanics, reinforced concrete and wooden and solid bridges. Jaroslav Foerster joined them in 1922 as a full professor to teach the subject of building construction and, for quite some time, industrial buildings. Alojzij Hrovat taught the subject of railway buildings from 1922 onward. Water structures were taught at first by Josip Letrič, followed by Ciril Žnidaršič in 1925. In 1930, Milan Fakin taught iron bridges as an assistant professor. Other teachers at the department in the pre-war period were Ladislav Bevc *(elements of the civil engineering discipline)*, Jan Müler Petrič *(railway signalling & safety devices and operation regime)*, Stanko Dimnik *(the encyclopaedia of engineering sciences),* Rudolf Kavčič *(tunnels and railway terminuses),* Stojan Globočnik *(construction elements)* and Goljevšček Milovan *(design guidelines for water structures)*.

The mechanical & electrical engineering department evolved around the figure of Milan Vidmar, a mechanical engineer and expert in large transformers, who was joined in later years by France Vagaja *(special electrotechnology for civil engineers and miners)*, Dušan Sernec *(electrical installations)*, Juro Horvat, Venčeslav Koželj and France Avčin *(electrical measurements)* and Vratislav Bedjanič *(electrical machinery and transformers)*. As a broad education was expected from electrical engineers, the study programme also placed considerable emphasis on encyclopaedic subjects: industrial buildings, an encyclopaedia of basic geodesy, an encyclopaedia of engineering sciences and general subjects. The focus of the study content in the period between the wars was heavy current, with electronics following after 1945, initially developed by Marij Osana and later by professors Mirjan Gruden and Dušan Lasič.

At the joint mechanical & electrical engineering department, mechanical engineering studies comprised only the first four semesters and then had to be continued elsewhere; students mostly went to Zagreb and some also abroad. Besides Milan Vidmar, who taught electrical engineering as well as general mechanical science in the first academic year, the first teachers of mechanical engineering were Stane Premelč, Romeo Fakin (later Strojnik) and Josip Boncelj. A milestone in mechanical engineering studies was the arrival of Feliks Lobet in 1929. He started out in a modest way, but his work aimed to establish a complete mechanical engineering course at the Faculty of Technical Sciences. On 5 April 1941, the mechanical engineering department

was established by a decree of the ministry in Belgrade, but it could not be put into effect as the war broke out the very next day.

The study of architecture was initially organized only as a two-year course; gradually, it evolved into a complete eight-semester course. The architecture department owed its establishment to Ivan Vurnik, who was appointed an assistant professor in 1920. Wanting autonomy for architecture, Vurnik also offered teaching positions to architects Fabiani and Plečnik. Josip Plečnik accepted, was appointed a full professor in 1920 and started working at the Faculty of Technical Sciences in 1921. Together, they laid the foundations of the Ljubljana school of architecture. Josip Plečnik, considered its spiritual father, also left a stamp on the school with his teaching style, which emulated his Viennese professor Otto Wagner. He conceived the school as a series of workshops, collectives of professors and students working through all the steps of the planning process. The system of workshops/seminars has been preserved to this day. Vurnik and Plečnik published its study programme in 1923 in a special publication: *From the Ljubljana School of Architecture*. Other architects working by their side in the department were the painter Matej Sternen as a drawing teacher and the sculptor Ivan Zajec as a part-time sculpting teacher, both academy--trained. From the winter semester of 1936 onward, freehand drawing was taught by Boris Kobe instead of Sternen, and with the summer semester of 1940, the latter was replaced by Filip Kumbatovič.

The chemistry department formed around professor Samec, whose erudition and great creative energy helped set up *Samec Chemistry School* a few years later. His first co-worker was Marij Rebek. As soon as they settled in Ljubljana, they continued the research work they had started in Vienna. In the first two years, they lectured in all the chemistry subjects, but then the department acquired several permanent and contractual employees: Evgen Kansky *(food and stimulants chemistry)*, Vasilij Isajovič *(coal and petroleum chemistry for mining students)*, Josip Turk *(chemical technology for inorganic industry)*, Salvislav Jenčič *(selected chapters of organic chemical technology),* Ignacij Majdel *(inorganic technical analysis)*, Franc Jesenko *(raw materials and technical microscopy),* Albin Cotič *(technical mycology)*, Josip Humel *(combustion and combustion chambers),* Janko Kavčič *(selected chapters of inorganic chemical technology)*, Ladislav Guzelj *(analytical chemistry),* Klemen Rihard *(chemistry of fermenting enzymes),* Ivo Ribarič *(the leather and tanning industry)*, Đorđe Mandrino *(organic colourants),* Štefan Horvatič *(technical botany),* Ladislav Klinc *(food and edibles chemistry),* Marta Blinc *(practical work in technical microbiology)*, Maks Wraber *(the basics of technical botany).*

At the mining department, the only one of its kind in Yugoslavia until 1939, students only heard lectures in mining and geological subjects and subjects from the field of mechanical and electrical engineering. Due to the lack of domestic staff, mostly foreign experts worked with Karl Hinterlechner at the department in the first years: Josip Kropač *(the science of mining)*, Aleksander Nikolajevič Mitinski *(mining mechanical science).* In anticipation of the establishment of a complete department of mining science with a metallurgy section in accordance with the current pedagogical and organisational principles, the first two professors of metallurgical subjects were appointed: Anton Danihelka *(general smelting)* and Josip Humel *(metallurgy)*. However, a metallurgy section was not formed, so both of them returned to the college of mining science in Přibram. Due to the bad working conditions, Kropač and Mitinski had also left by the mid twenties. Mining mechanical science was taken over in the winter semester of 1925/26 by Aleksej Kopylov, joined by Viktor Kersnič in 1937, while most of the professional subjects and subjects in the field of mechanical and electrical engineering were taught by Viktor Gostiša. From 1929 onward, mining was lectured by Igo Pehani. In the late twenties, the encyclopaedia of iron casting was taught by Ignacij Majdel for two years until the summer semester of 1933, when Matija Žumer took over and managed to revive the mining science section in 1938. The section's study programme was modelled on the mining science colleges in Přibram and Leoben, which allowed Yugoslav students who had to return home when Czechoslovakia and Austria were occupied by Hitler, to continue their studies in Ljubljana. In the summer semester of 1943, Ladislav Guzelj joined the department as an associate professor for metalwork. After the war, Žumer drew in two new colleagues, Viktor Fettich and Ciril Rekar.

Due to the great shortage of land surveying experts, a two-year geodesy course had already been established within the technical university course, with the technical secondary school teacher Leo Novak lecturing in basic geodesy. Geodesy studies continued as a two-year course after the faculty's establishment, and all the professors of geodesy subjects were part-time faculty associates. In the first academic year, Leo Novak was joined by Alfonz Gspan, the senior land surveyor at the Ljubljana cadastral office, who taught the subjects of error theory & the minimum quadrant method and cadastral technique. The senior commissioner of the town building office Matko Miklič began teaching land survey drawing in 1921; in the same year, the senior building commissioner Ciril Pirc took up the post of part-time lecturer in advanced geodesy. Geodesy subjects, which were grouped with mathematical subjects in terms of organisation for the first few years, were brought together under the Institute of Cave and Land Surveying in 1926, which was also responsible for the subjects of mining measurement, taught by Dimitrij Frost, and the encyclopaedia of basic geodesy for architects and mechanical and electrical engineers, taught by Stanko Dimnik. With the winter semester of 1927, lectures in advanced geodesy were taken over from Pirc by Josip Črnjač. In 1928, the cultural geodesy department was established with an eight-semester study programme, but geodesy studies were abolished soon after, in 1931. Only the subjects of basic and advanced geodesy survived within the framework of an institute for land surveying and were taught by Leo Novak and Josip Črnjač in lectures for students of civil engineering and students of architecture (basic geodesy only).

Study and Examinations

Once the faculty was established, special attention was paid to the arrangement of curricula, which varied with the number of student places filled and the procedures for all types of examination within a department. In accordance with the Ljubljana university establishment act, the university was governed by the acts and decrees of the Belgrade university of 1906 until new ones were passed, though in practice the faculty also followed the decrees and regulations of the Technical College in Vienna. On 9 January 1920, the University Council adopted the Temporary Examination Procedure for the first part of

the diploma examination and for the land surveyor examination, to be applicable until 1 August 1921. The diploma exam was divided into two parts: the preparatory, which was taken on completing the fourth semester and the professional, after the eighth semester of a course. The exam subjects were grouped into Levels I, II and III. Candidates for the first part of the diploma exam, who had passed a Level I exam with the mark "good" were exempt from the diploma examination in that subject before a board, and the minimum mark to be achieved for all Level II subjects was "satisfactory". Furthermore, the students could only enter the preparatory diploma exam on presenting lecturers' certificates of the regular attendance of all exam subjects and any related practical work, especially for all Level III subjects. Candidates who had done more than a year's military service were exempt from the diploma examination in Level I subjects based on as little as a "satisfactory" mark in their midterm exam report. In May 1921, as a new university act was in preparation, the faculty council extended the effectiveness of the temporary examination procedure from 1 August until revoked. In the summer semester of 1923, an examination procedure for the preparatory part (I) of the diploma exam was adopted for all the departments and for the professional part (II) of the diploma exam in the mining department. It put an end to military exemptions. The exam procedure for the professional part of the diploma exam specified five professional exam subjects and that candidates could only enrol into the second four of the overall eight semesters after passing part I of the diploma exam and could only enter for the exam by presenting midterm exam reports for Level II subjects and attendance certificates for Level III subjects and producing a diploma thesis. A procedure was also adopted for midterm exams, setting out that an exam in each individual subject would be taken at the end of the semester in which the candidate attended the class or in the following two semesters on fixed exam dates. Thus a student who failed an exam on the fixed dates would have to repeat a class in order to re-enter the exam. In the summer semester of 1923, the first candidates were sitting for the professional part of the diploma exam; in the mining department, four students passed it and two in the chemistry department.

The special act for the Ljubljana university, which had been promised on its establishment, never came to be. Instead, a general university act was passed in 1930, applicable to the whole state, and this served as a basis for the General University Decree of 12 December 1931, which laid out the rights and responsibilities of university authorities, the teaching, administrative and other staff and the students. It was also the foundation for decrees on the lower and higher disciplinary tribunal, the number of chairs at the respective faculties, the lecturer selection procedure and other matters. On the other hand, the organisation of respective faculties, their study systems, exam rules, graduation regulations and student decrees were specified in special faculty decrees. The first concept for the decree for technical faculties was prepared by the Belgrade faculty in 1932. In 1934, the Ljubljana university produced a new concept that followed both the guidelines of the Belgrade faculty to a certain degree and the tradition of the Faculty of Technical Sciences in Ljubljana. After prolonged coordination between representatives from all three faculties in the state, the decree for technical faculties was passed on 17 April 1935, which complied with Ljubljana's demand that the faculty decree should not be too restrictive to the development of individual faculties but should leave the syllabus and exam details up to respective faculties, especially as regards the professional part of study courses. The faculty in Ljubljana was accredited for the departments of architecture, civil engineering, mechanical & electrical engineering, chemistry and mining. Most important of all was saving the mechanical & electrical engineering department, which had met with strong opposition in Belgrade in 1932. As regard examinations, the views of the Belgrade faculty prevailed. Since their demand for entrance exams was abandoned, the preparatory part of the diploma exam in the first study year was split into two for selection purposes. The first part comprised the main first-year theoretical subjects and had to be passed on the June or October exam date on completing the first semester as a requirement for entering the third semester. Students who failed the first part of the preparatory exam had to repeat the first year. The second part of the preparatory diploma exam, which comprised the main theoretical and some basic professional second-year exams, could be sat until the sixth semester, but had to be completed before a candidate entered the individual exams. The professional part of the diploma exam consisted of a final exam, which only included the main professional subjects and a completed diploma thesis plus its defence. Exams in secondary subjects were taken individually before entering for the final exam. Respective exams could be taken three times and the final exam could be repeated three times before an examination board. After three unsuccessful attempts, the professional exam could no longer be taken. The diploma thesis could be begun after passing the final exam and had to be completed in 2-3 months and then, if positively assessed, defended before an examination board. The decree was intended to apply to students who entered the first year in the 1935/36 academic year and was to come into full effect in 1939. The new regulations satisfied neither the faculties nor the students, who held a public protest and a student strike, which was joined by students from other faculties in a feeling of solidarity. Though the education minister deferred the new decree's effective date until the 1936/37 academic year, the faculties of Zagreb and Ljubljana proposed changing the decree. The main issue was that students would have to take individual exams right after the semesters ended and were only allowed two exam dates on which to do so. The Faculty Council felt that this reduced the faculty to a secondary-school level and urged for a single preparatory diploma exam without individual exams or an extended time limit. In the view of the Faculty Council, this arrangement was better suited to the requirements of higher education in technical studies and still restrictive enough to force students into serious study. Finally all three faculties agreed on the amendments to the faculty decree, which were signed by the minister on 18 June 1937. The preparatory exam remained in two parts, consisting of individual and combined exams, as specified by the Faculty Council. The first part of the preparatory exam was required to enter the fifth semester and its second part for the seventh semester.

Premises

As regards the premises of the future Faculty of Technical Sciences, the Craft School was depended on ever since it was first suggested by the engineer Šuklje in late 1918. The subcommittee for faculty accommodation likewise felt that it was best suited for a technical faculty, since

it could also facilitate the temporary use of all the school's equipment as necessary. The temporary technical university course obtained 2 classrooms, 1 drawing hall and one teachers' room. For the first academic year, an intercession of the Provincial Government gave the Faculty of Technical Sciences three halls and two studies in the Craft School, so that it used 8 of its rooms in total. In addition to these, the Faculty of Technical Sciences could use the drawing hall and chemistry lecture hall in the "Realka" secondary school for a few hours a week, and the Kranjska hranilnica bank, as the owner, offered the use of the basement rooms in the south wing of its main building. With support from the industry and individual patrons, the total of 12 rooms were, in a short time and with modest funds, renovated and converted into a modern chemistry institute with contemporary equipment and several laboratories (for analytical chemistry, organic chemistry and a laboratory for scientific projects). The Institute of Mineralogy and Petrography was allocated premises on the ground floor of the Deželni dvorec mansion. These also were renovated and equipped with the help of donors with apparatus, a library and collections for mineralogy, petrography and the deposits science, making them comparable with foreign institutes.
During the preparations for the second academic year, it became clear that it was impossible for a secondary school and a faculty to co-exist in the same building. Since no other public building could be acquired for the faculty, the initiative to solve the grave housing problem was once again taken by the technical community; they set up a *committee for building a faculty of technical sciences in Ljubljana*, which undertook to arrange temporary premises. They obtained financial support from financial institutions and the industry, various types of support in kind, particularly building material, and a suitable location along Aškerčeva Road, which was owned by the Teutonic Order. Construction work began in August 1920. In 1920/21 the faculty still occupied rooms at the Craft School, but in the third academic year it was only allowed to use a single room there. The new building was constructed so quickly that it was ready for occupancy by the autumn of 1921. Due to the current financial crisis, the building costs had increased and the building committee faced a large debt that it had no cover for. Once again, individuals from the technical community saved the day. The committee was rearranged into the *Society for Building Premises Serving the Faculty of Technical Sciences in Ljubljana*. A society committee was set up, which took on the building along with all its financial burdens. It made an arrangement with the Mestna hranilnica bank for a mortgage, but it was difficult to pay off and was a serious material and moral burden to the society members until 1927, when the debt payments were shifted to the state budget.
In the autumn of 1921, the faculty moved into its new building. The east-wing ground floor went to the second division of the chemistry institute (an organic technology laboratory and an inorganic technology laboratory) and the west-wing ground floor went to the institute of electrical engineering. Both institutes contributed their own resources to cover the building costs. One room was taken by the land surveying institute with its collection of measuring apparatus and one room was allocated to the institute of technical mechanics. On the first floor, there were general lecture halls and studios were arranged for the architecture department at the end of the west wing. Since the need for new premises was still great, there were plans to enlarge the building in Aškerčeva Road and the faculty endeavoured to obtain premises for the mining department in the unfinished and decaying *Dečjega Dom* building opposite the Faculty of Technical Sciences in Aškerčeva Road, which the social welfare department started building in 1922 but which was never completed due to a lack of funds. After initial resistance, the faculty obtained the building for temporary use on 12 April 1927 but it was later handed over by the state to the faculty for good. In 1925, when the last of the administrative bodies moved out of the Deželni dvorec mansion, the Faculty of Technical Sciences gained the entire raised ground floor for its physics and mathematics institutes. In 1927, an extension to the faculty building was all but completed. In the spring of 1928, the remaining plot of land between the faculty building and the Roman wall was purchased from the Teutonic Order.
Solving the housing problems of individual departments was also actively joined by their heads. In July 1930, professor Samec presented the rectorate with building plans for a chemistry institute opposite the old faculty building in Aškerčeva Street. In 1933, Vurnik and he first planned a one-storey extension to the old faculty building, which was to house a lecture hall and a teachers' room, and later a three--storey building in Murnikova Street. When the latter idea won strong support from the students within a student campaign for university improvement, the ministry approved a loan for the first construction phase in early 1938. In the following year, a concrete shell was built but it remained unfinished.
A campaign to build premises for the electrical engineering institute was launched in 1939 by professor Koželj. The building was to stand at the corner of Aškerčeva and Snežniška Street as the furthest wing of the central building of the Faculty of Technical Sciences. Its conceptual draft was made just before the war by the engineer Štrukelj in intensive collaboration with professors Koželj and Lasič.
The institute of mechanical engineering had 3 rooms in the Faculty of Technical Sciences building, one on the ground floor serving as the director's room as well as a laboratory and store room for numerous devices, and two attic rooms. In 1933, professor Lobe and the director of the institute of water structures, Milovan Goljevšček, prepared a joint plan, which could not be carried out however for want of money. The institute of mechanical engineering yielded a portion of its funding to the institute of water structures, which arranged make-do premises for itself in the abandoned garages of the brick factory on the Cesta dveh cesarjev Road. Mechanical engineering was expected to get premises in a new building planned by the faculty in the purchased plot between the old building and the Roman wall for all its institutes. But since one of the plans envisaged a technology laboratory with several heavy machines on the third floor, professor Lobe opted for his own plan. He had plans made for two buildings: for the central building of the Centre of Mechanical Engineering and for the Aero & Hydrodynamic Laboratory. The Aero & Hydrodynamic Laboratory along the Gradaščica stream, designed by architect M. Mušič and envisaged by Lobe, was never built. A plan for a central building intended to meet the teaching needs of third and fourth-year students and to accommodate a thermal and a technology laboratory was designed in 1937 by architect F. Tomažič. Professor Lobe received approval for these plans and the beginning of construction. By the beginning of the Second World War, the building was more or less built but not quite finished. Several processing machines were installed in the technology laboratory and the thermal laboratory was partly equipped.

The Faculty of Technical Sciences During the Second World War

After the Italian occupation, the Ljubljana university was closed for a while. On 3 May 1941, the Italian high commissioner for the Ljubljana region Emilio Grazioli allowed the university to recommence activities and the rector announced that lectures would begin in full on 12 May. The university was one of the strongholds of the liberation movement, which included both students and professors and other university staff. Electrical engineering students used their knowledge to secretly manufacture various devices, such as an adapter that made it possible to listen to the free world with radio equipment that was locked by the occupier to its own station. The department also designed the *Kričač* radio, which operated for over five months. A day after its first regular broadcast on 17 November 1941, the Italians surrounded the old faculty building and broke into the electrical engineering class, but the students had already taken all the radio material and clothing for the partisans to the latter. However, illegal literature was found, so everyone present was arrested. All lectures were banned on 29 November and the dean Alojzij Hrovat was discharged. The detainees were released for lack of evidence. In court a testimony in their defence was also made by professor Milan Vidmar, who was selected as the new dean by the faculty council. The faculty was closed until 11 May 1942 when, on the repeated requests of the rectorate, Grazioli once again allowed lectures at the faculty. However, General Rupnik ordered a temporary halt to all lectures at the university with a special injunction on 11 October 1943. Thus the Ljubljana university remained closed until the liberation. The students were only allowed to take exams.

In the war years, the Faculty of Technical Sciences suffered human casualties as well as great material damage to its facilities. During the Italian occupation, its chemistry laboratories in the basement and ground floor of the "Realka" school were taken over by the carabinieri. After Italy capitulated, the department made some repairs to the laboratories, but in the last days of German occupation, Slovenian Home Guard troops, which were staying in the "Realka" school, completely destroyed the chemistry department's premises. The building of the Faculty of Technical Sciences and the mining department in Aškerčeva Road was occupied by German troops in 1943; most of the institutes had to move out and only the institutes and laboratories with rooms unsuitable for military purposes could stay. To top it all, the mining institute was hit by a bomb during an air raid at the close of the war.

All work on the building of the mechanical engineering department had stopped when the war broke out. The purchased but not yet installed fittings and fixtures were hidden to make the building unsuitable for living in and the staff also hid all the equipment and tools that could be of use to the occupier. Finally, after the German army evicted all the departments that had premises more suitable for living in, it also occupied the building of the mechanical engineering department, which was left with just the technology laboratory. It was rebuilt in a way that cut off all inside access to the parts occupied by the army, which probably saved it from demolition. When the rooms in the old faculty building were vacated, it was used to store all the equipment, the library and the archives. In the days before Germany's capitulation, when the last German units retreated from Ljubljana, all the buildings were seized by Vlasov army troops who, on leaving, carried off what they could and destroyed everything else.

The Post-Second World War Period

The liberation and the desire of the new government to industrialise and modernize the country were attended by the growing importance of the Faculty of Technical Sciences. The government's favourable disposition was felt in the tenfold increase of funding compared to pre-war times, and the number of students at the faculty, already the largest faculty of the Ljubljana university before the war, tripled, while the number of teachers almost doubled in the first few post-war years. The faculty expanded by introducing new study courses.

Immediately after the war was over, work on the building of the mechanical engineering department recommenced and its official opening was held on 15 March 1946. In June 1945, a resolution issued by the faculty's council expanded the mechanical engineering curriculum to 8 semesters. At the same time, the electrical engineering curriculum started changing in terms of greater specialization, so that two years of joint studies for both courses were no longer practicable. Mechanical engineering studies thus had to be organized for all semesters, which created new problems for the mechanical engineering department, mostly concerning housing and staffing. Ever since the liberation, it had sought a location for a new building. In the late fifties, it was decided that the new building would be located in Aškerčeva Road. Its construction began in the mid-sixties but it was not occupied until 1971. Besides professor Lobe, the first teachers of professional subjects were mechanical engineers Leopold Andrée, Boris Černigoj, Franček Kovačec, Bojan Kraut, Boleslav Likar, Zoran Rant, Albert Struna and Dobromil Uran.

With the 1945/46 academic year, study at the electrical engineering department was divided into heavy and light current. As the pre-war location of the department building was no longer possible, the architect Ravnikar created designs for two buildings for heavy and light current in a new location between the Gradaščica stream and Tržaška Road. The next year, construction of the light current building began, to be finished in 1957 and until then the housing issue was relieved by borrowing premises from architects in Aškerčeva Road and with two huts on Jamova Road. In the spot intended for the heavy current building, the *Institute of Electrical Industry* was built instead, with Milan Vidmar as director. The housing problem of the heavy current division was temporarily relieved with a provisional wooden building that was built for the old faculty. The situation improved somewhat in 1958 when a large lecture hall was built on Tržaška Road and the housing problem was fully solved in the sixties, when a new location and a new building design were used to erect a building for heavy current, linked to the new lecture hall. After the war, the electrical engineering department's staff was reinforced with the addition of Roman Poniž, Ernest Pehani and Henrik Čopič.

Plečnik's designs were used to restore the classical building of the school in Graben, which housed classrooms for general subjects and the department of architecture. In the post-war years, architecture staff included Edo Mihevc, Edvard Ravnikar, Marjan Mušič, Dušan Grabrijan, Svetko Lapajne, Janez Valentinčič and Boris Kobe.

The civil engineering department resided in the old faculty building. In the post-war period, its water structures division had a complex built on 28 Hajdrihova Street in Mirje, based on the designs of architect Valentinčič and the draft concept of professor Milovan Goljevšček, with 5 lecture halls, a drawing hall and laboratories, rooms for teaching and other staff, and moved into it for the 1948/49 academic year, while its soil mechanics laboratory was located in Lepi pot Street. Other teachers of the civil engineering department included Drago Leskovšek, Emil Kovačič, Janko Bleiweis, Marjan Ferjan, Julij Gspan, Rudolf Jenko, Miloš Marinček and Srdan Turk.

1948 saw the completion of the building at 20 Aškerčeva Road, which was begun before the war. It was occupied by the mining department and, partly, by the metallurgy institute, both of which had temporarily lodged in the secondary technical school since the liberation. In 1947, the Ljubljana university started building a new building for the metallurgy institute, which was to be used for research for Yugoslav metallurgy as well as by the metallurgy school. The industrial research wing was opened in 1950 and the school wing only in 1954. However, the metallurgy division was only allocated a few of its rooms, having to give up most of them to general subjects. In the post-war period, mining was also taught by Ivan Kralj, Jože Duhovnik, Drago Matanović, Anton Homan, Karel Slokan and Josip Baturić, while professor Žumer at the metallurgy division was joined by Ciril Rekar and Viktor Fettich.

The chemistry department started renovating rooms in the Realka in 1946 and the department's building at 6 Murnikova, which was begun before the war, was completed and occupied in the 1950/51 academic year. After the war, the chemistry department's teaching staff was increased by: Vinko Kramaršič, Branko Brčić, Tibor Škerlak, Marija Perpar and Franc Premerl.

An independent geodesy department was established in the 1945/46 academic year. It was allocated premises in the former mining pavilion, which opened up the possibility of adding to the teaching force. Soon, in 1946, professors Novak, Černjač and Gosar were joined by Ivan Čuček, who took over the photogrammetry chair, and Rado Dvoršak and Vladimir Vazzaz, who took over basic and advanced geodesy. The Institute of Geodesy and Photogrammetry was housed in provisional wooden buildings on the Cesta na Brdo Road.

The Reorganisation of Higher Education in Ljubljana and the Technical College

As the liberation and the new form of government in 1945 also called for new legislation in all areas, regulatory changes were likewise to be expected at the university. With all the energy in the first weeks focused particularly on repairing war damage and ensuring conditions for lessons to begin as early as possible, the old Yugoslav legislation temporarily remained in force while preparations for a new federal act on higher education were begun. Since the preparation of the federal university act came to a standstill, the People's Assembly of the People's Republic of Slovenia (PRS) adopted the Act Regulating Higher Education in the PRS on 21 October 1949, which radically changed the traditional organisation of the Ljubljana university, since it was a basis for the decrees of 27 December 1949 that laid out a new structure for the higher education system in Ljubljana. The university was reduced to four faculties, as well as there was a Medical and a Technical College with several faculties, while the Faculty of Agronomy and Forestry and the Faculty of Theology were made independent. The changes were put into effect for the 1950/51 academic year. The Technical College operated as an independent institution headed by a rector and comprising faculties of architecture, electrical engineering, civil engineering and geodesy, chemistry, mining and metallurgy and mechanical engineering. Studies at some of the Technical College faculties were divided by departments in the senior years. The Faculty of Electrical Engineering had two: the heavy and light current departments, the Faculty for Civil Engineering and Geodesy had four: geodesy, hydraulic engineering, construction and transport. The Faculty of Mining and Metallurgy had a mining and metallurgy department, while the Faculties of Architecture and Mechanical Engineering had none. At the proposal of the Technical College Council, the Ministry of Science and Culture of the PRS issued a decision establishing a physics department as a new branch of technical study for the purpose of training experts in measurement techniques and research using physics tools and methods in technical and science laboratories. With its establishment, the chemistry department now had two departments. The first to become a rector of the Technical College was the full professor Alojzij Hrovat, who was succeeded two years later by Dr. Anton Kuhelj. The TC Rectorate was located at 13 Knafljeva Street (later 13 Tomšičeva) and the deans' offices were in the faculty buildings. In terms of organisation, the Technical College also included, besides the six faculties, a department for the general subjects of all the faculties, which operated in the building of the Faculty of Architecture. This set-up lasted for four academic years. With the 1954/55 academic year, the general federal university act required a restoration of the university, which involved reintegrating the entire Technical College as the Faculty of Technical Sciences with six departments. Even though only two years had passed since the general university act was effected and a debate over the organisational make-up of the university and faculties was held prior to its adoption, the committees for a republic-level act and statute at the University Council and the university administration drew up a new bill on the University of Ljubljana and presented it to the faculties for discussion. The faculty administration of the Faculty of Technical Sciences twice counted a majority vote in favour of a single faculty with several departments. In the end, the executive council of the PRS passed an act that established three technical faculties: the Faculty of Architecture, Civil Engineering and Geodesy, the Faculty of Electrical and Mechanical Engineering and the Faculty of Mining, Metallurgy and Chemical Technology. The new organisation was applied in the 1957/58 academic year, but practice immediately showed that changes would be necessary, since the Faculty of Natural Sciences and the Faculty of Mining, Metallurgy and Chemical Technology soon started talking about bringing classes in common subjects and similar institutes together under a single faculty to allow a more rational distribution of human and material resources. With the act on reforming some of the University of Ljubljana faculties, passed on 24 June 1960, the divisions of biology and geography were removed from the Faculty of Natural Sciences, and its divisions of mathematics and physics, chemistry and geology merged with the Faculty of Mining, Metallurgy and Chemical

Technology into a new faculty named the Faculty of Natural Sciences and Technology, which consisted of a department of mining science with a metallurgy and a geology division, a department of chemistry with divisions of chemistry, chemical technology and pharmacy, a department for textiles technology and a mathematics & physics department. The same act split the Faculty of Electrical and Mechanical Engineering into two independent faculties. These changes in 1960 completed the period of reorganizing the higher education system in Ljubljana for the next fifteen years. The University now consisted of nine faculties: the Faculty of Arts, the Faculty of Economics, the Faculty of Law, the Faculty of General and Dental Medicine, the Faculty of Agronomy, Forestry and Veterinary Medicine, the Faculty of Architecture, Civil Engineering and Geodesy, the Faculty of Electrical Engineering and the Faculty of Natural Sciences and Technology, the last four stemming from the tradition of the former Faculty of Technical Sciences.

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