

THE DEVELOPMENT OF HIGHER EDUCATION IN CHEMICAL ENGINEERING IN FORMER YUGOSLAVIA

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Summary. The article presents the results of research into the development of higher (tertiary) education in Chemical Engineering in former Yugoslavia. It focuses on the three oldest schools in the country, established during the interwar period at the Universities of Zagreb, Ljubljana, and Belgrade within the Kingdom of Serbs, Croats and Slovene / Yugoslavia. Although the oldest school of engineering, the University of Belgrade, was the last one to establish a chemical engineering programme after initially providing education in this field within the school of mechanical engineering. In contrast, universities in Zagreb and Ljubljana initiated these programs from their founding in 1919. The paper also explores the important role of foreign-educated chemical engineers who had their degrees formally recognised in Yugoslavia. This study contributes to the history of engineering/chemical engineering in former Yugoslavia.

Keywords: Yugoslavia, higher education, chemical engineering, Zagreb, Ljubljana, Belgrade.

Introduction

The early 19th-century advances in chemistry led to the development of the chemical industry, a major engine for growth in Germany, Europe, and the USA. The chemistry laboratories of German universities trained several chemists who played a prominent role in the field. Justus Freiherr von Liebig (1803–1873) (see Figure 1) played a major role in the establishment of the Chemistry Laboratory at the University of Giessen in 1825 [1], [2], followed by Friedrich Wöhler (1800–1882) (see Figure 2) at

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the University of Göttingen [3], and Robert Wilhelm Eberhard Bunsen (1811–1899) (see Figure 3) [4] and Gustav Robert Kirchhoff (1824–1887) (see Figure 3) [5] at the University of Heidelberg. Initially, the development of new products in Germany and Europe was based on the partnership between (industrial) chemists, who provided the scientific foundations, and mechanical engineers, who helped facilitate the manufacturing processes [6]. Over time, this resulted in the development of a new and distinctive discipline of chemical engineering.

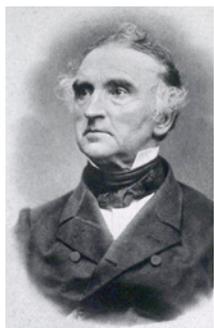


Figure 1. Justus Freiherr von Liebig. C. 1866.



Figure 2. Friedrich Wöhler. C. 1856.



Figure 3. Gustav Robert Kirchhoff (left) and Robert Wilhelm Eberhard Bunsen (right). C. 1850.



Figure 4. George Edward Davis. C. 1890.

In 1880, George Edward Davis (1850–1907) (see Figure 4) proposed the establishment of the Society of Chemical Engineers in the United Kingdom (UK), which eventually led to the foundation of the Society of Chemical Industry in 1881. In 1887, G. E. Davis founded the Chemical Trade Journal, where he publicised his ideas on chemical engineering, which were presented in 1887 as a series of 12 lectures at the Manchester Technical College (now, UMIST – University of Manchester Institute of Science and Technology). Expanded, these lectures were published in 1901 as ‘Handbook of Chemical Engineering’, which is the foundation of chemical engineering. His original proposal of 1880, 42 years later, managed to get sufficient support, which led to the establishment of the Institute of Chemical Engineers in the United Kingdom in 1922, with G. E. Davis considered the ‘father’ of chemical engineering [7, 8, 9]. Yet, chemical engineering, as a distinct profession from that of the chemists and the mechanical engineers, was adopted earlier in the USA, when they established the American Institute of Chemical Engineers in 1908 [1].

Three years before G. E. Davis' lectures in Manchester, in 1884, a university-level course called Chemical Engineering was announced by the Central Institution, a college funded by the Livery Companies of London. Their degree course in Chemical Engineering leading to the Diploma of Chemical Engineer was short-lived (1884–1888) when the Department of Chemical Engineering was renamed to the Chemical Department [10]. On the other side of the Atlantic, Lewis Mills Norton (1855–1893) of the Chemistry Department at the Massachusetts Institute of Technology (MIT) in 1888 introduced a curriculum for Course X on Industrial Chemical Practice, which became the first one in chemical engineering taught at MIT, with the first degrees awarded in 1891. In 1898, L. M. Norton's successor, Frank Hall Thorpe (1864–1932), an MIT graduate with a PhD from the University of Heidelberg in 1893, published 'Outlines of Industrial Chemistry', a chemical engineering textbook. The original courses focused on industrial chemistry and mechanical engineering, but without the characteristic unit operations laboratory [6]. This eventually led to the definition of chemical engineering as a distinct discipline underpinned by a special training method, for which the Americans Arthur Amos Noyes (1866–1936) [11], Arthur Dehon Little (1863–1935), William Hultz Walker (1869–1934), and Warren Kendall Lewis (1882–1975) [12] are particularly credited.

The emergence of this new discipline inspired the development of higher education in chemical engineering in former Yugoslavia in the interwar period, and the Universities of Zagreb, Ljubljana, and Belgrade represented the first three schools in the country. This paper contributes to the history of higher education in chemical engineering in former Yugoslavia.

Methodology

The research is based on a combination of primary and secondary sources, including archive material, historic publications, and materials provided by the university/faculty libraries at the Universities of Zagreb, Ljubljana, and Belgrade.

Within this paper, the term Yugoslavia is used in relation to the Kingdom of Serbs, Croats and Slovenes (1918–1929), Kingdom of Yugoslavia (1929–1941), Federal People's Republic of Yugoslavia (1945–1963), and the Socialist Federal Republic of Yugoslavia (1963–1991). All original words in Cyrillic script within this paper have been romanised using the BGN/PCGN 2005 and the BGN/PCGN 2013 Agreements for Romanisation of Serbian and Macedonian Cyrillic, respectively.

The term 'chemical engineering' is used to indicate the appropriate and higher level of education than 'chemical technologists' in the English-speaking world. Both historically and currently, within former Yugoslavia and the successor states, the term 'technology' has been predominantly used to describe '(chemical) technology engineering'. In the post-WWII period and up to the implementation of the Bologna Accord, the higher education programs in technology were delivered through universities. The five-year full-time programmes led to the qualification of Graduate Technology Engineer (e.g., Diplomiran Inženjer Tehnolog).

This language-related terminological difference is reflected in the evolution of the national association name. The Association of Chemists-Technologists of the Federal People's Republic of Yugoslavia (Savez hemičara-tehnologa Federativne Narodne Republike Jugoslavije), founded in 1953, was renamed into the Association of Chemists and Technologists of Yugoslavia (Savez hemičara i tehnologa Jugoslavije) in 1961, the Association of Chemical Engineers (Savez hemijskih inženjera) in 2003, and the Association of Chemical Engineers of Serbia (Savez hemijskih inženjera Srbije) in 2009, since Serbia is the legal successor of the Yugoslav association.

The current names of the original three schools for chemical engineering in the analysed countries of former Yugoslavia are:

- University of Zagreb – Faculty of Chemical Engineering and Technology (Fakultet kemijskog inženjerstva i tehnologije);
- University of Ljubljana – Faculty of Chemistry and Chemical Technology (Fakulteta za kemijo in kemijsko tehnologijo);
- University of Belgrade – Faculty of Technology and Metallurgy (Tehnološko-metalurški fakultet).

Limitations

The research limitations of this paper are:

- Unless specifically stated, the gender of the students was determined by their names and surnames as recorded in the available documents. If the first/given names are considered to be unisex (e.g., Vanja), and in the absence of other available information, the gender of the graduate was counted as male based on the prevalence of male students among the graduates.
- The number of graduate chemical engineers from the University of Belgrade is based on the available information from the register that covers only those who graduated up to and including 1938. There was limited available information to cover the remainder of the analysed period in detail. Due to missing pages in the register,

it has not been possible to establish the gender of the graduates for the year 1932. Due to the prevalence of male graduates, it has been assumed that all six graduates were males.

- The number of foreign graduates who had their degrees formally recognised in Yugoslavia is limited only to those who were recognised by the University of Belgrade in the period 1919–1938. No information was available for the period 1939–1945, before 1919, or if any such recognitions were made by the Universities of Zagreb and/or Ljubljana. Although the Universities of Ljubljana and Zagreb were approached, to date, no access to similar registers, if in existence, has been possible. For this research, only those whose recognised degrees are listed as chemical engineer (hemijski inženjer), technology engineer (inženjer tehnolog), or 'inženjer tehn (assumed, technology engineer) were included in the analysis, but not those whose recognised degrees are listed as 'chemists' (hemičar).

Higher Education in Chemical Engineering in Former Yugoslavia until 1945

The development of tertiary education in chemical engineering in former Yugoslavia can be traced back to the interwar period in the three main constituent parts of the Kingdom: Serbia, Croatia, and Slovenia. Until the end of World War I (WWI), Slovenia and Croatia were part of the Austria-Hungary Empire, with limited opportunities for tertiary education in engineering in their territories. Although the Principality of Serbia was established in 1817 as an autonomous province within the Ottoman Empire (de facto until 1867 and de jure until 1878), it was engaged in several wars from the early 19th century until the end of WWI. This interfered with the development of engineering education despite the establishment of the first school of engineering in 1846.

University of Zagreb (*Universitas Studiorum Zagrabiensis*), Croatia

The history of tertiary education in engineering and chemical engineering in Croatia is associated with the foundation of the Royal High Technical School (*Kraljevska visoka tehnička škola*) in Zagreb by the decree of 10 December 1918, leading to the 1919 opening in the Kingdom

of Serbs, Croats and Slovenes (see Figure 5). Due to a lack of funding, the 1899 attempt to establish a High Technical School in Zagreb (Technische Hochschule in Agram), initially for civil engineering only, under the Austria-Hungary Empire was postponed, allowing for the High Technical School in Brno (now in the Czech Republic) to be established instead [13, 14].

The first three professors at the Royal High Technical School in Zagreb were the civil engineer Milan Čalagović (1878–1945), mechanical engineer Jaroslav Havliček (1879–1950) and architect Martin Pilar (1861–1942). Later on, (the same year) professorship was attained by architect Edo Šen (Edvard Schön; 1877–1949), who was the first Rector of the School (1919–1920); civil engineer and surveyor Pavle Horvat (1879–1936); mathematician Marije Kiseljak (1883–1947); and chemist Vladimir Njegovan (1884–1971). A few departments were established at the school covering Architecture, Civil Engineering, Urban Engineering, Chemical Engineering (see Figure 6), Surveying, Mechanical Engineering, Electrical Engineering, Naval (Architecture) Engineering and Maritime Engineering. Out of the 255 students enrolled in 1919, 18 graduated by the end of the academic year 1925/1926. The first graduate was architect Alfred Albini (1896–1978) in 1923, who transferred from the High Technical School in Vienna (Technische Hochschule - TH Wien, now Technical University - TU Vienna), and the first PhD was (now) Ukrainian civil engineer Konstantin Čališev (1888–1970) [13, 14].

As the existence of the school was brought into question by the central government, in 1926, the Royal High Technical School in Zagreb became a Technical Faculty at the University of Zagreb. The university goes back to 23 September 1669, when it was established as the Jesuit Academy of the Royal Free City of Zagreb by the Holy Roman Emperor Leopold I (1640–1705) [15].



Figure 5. Rector's Office and Faculty of Law of the University of Zagreb. 2007.



Figure 6. Entrance to the Faculty of Chemical Engineering and Technology of the University of Zagreb. 2008.

V. Njegovan was the first professor appointed at the Department of Chemical Engineering at the Royal High Technical School in Zagreb. He graduated from TH Wien in 1907, specialised in agricultural chemistry at the Federal Technical High School (Eidgenössische Technische Hochschule – ETH) in Zürich (1908–1910) and got a PhD from the TH Wien in 1912. In 1912, he became the Head of the Agricultural Chemical Institute at the Royal Commerce and Forestry School in Križevci (now Croatia, then Kreutz / Körös in the Austria-Hungary Empire), and from 1913 a secondary school professor initially at the II and later at the I Real School (Realschule) in Zagreb. His expertise was in the area of analytical and physical chemistry, and he is considered to be the founder of education in chemical engineering and technology in Croatia. Between 1920–1943, he established and led the Institute for Analytical and Physical Chemistry within the Department. Until his retirement in 1943, he undertook a few leadership functions within the Department, School, and Faculty [13, 14, 16].



Figure 7. Wilhelm Friedrich Ostwald.
C. 1913.



Figure 8. Franjo Hanaman
(seated) and Alexander Friedrich
Just. No date.

Apart from the Institute led by V. Njegovan, the three other original institutes were: for Organic Chemistry led by Ivan Marek (1863–1936), Physics and Physical Chemistry led by Ivan Stepanovič Plotnikov (Plotnikow; 1878–1955), and Inorganic Chemical Technology and Metallurgy led by Franjo Hanaman (1878–1941), who became a professor in 1922. I. Marek [13, 14] graduated as one of the first chemists from the Faculty of Philosophy at the University of Zagreb in 1886 before becoming a secondary school professor in Zemun (now Serbia) and Zagreb.

I. Stepanovič Plotnikov [13, 14] (See Figure 7) graduated in physics and mathematics in Moscow in 1901, before studying under the Riga-born, 1909 Nobel Prize Chemistry holder, Wilhelm Frederich Ostwald (1853–1932) [17] at the University of Leipzig, where I. Stepanovič Plotnikov obtained his first PhD in 1906. His second PhD was in photochemistry from Odesa in 1915, before becoming a full professor in 1916. German scientists helped him move to the factory Agfa in Berlin after the 1917 October Revolution, before he accepted V. Njegovan's invitation for a professorship in Zagreb. F. Hanaman [13, 14] was an inventor, engineer and chemist who co-invented the first patented applied electric lightbulb with a tungsten filament in 1904 with his assistant Alexander Friedrich Just (1874–1937) (see Figure 8). F. Hanaman graduated from the Chemistry Department at TH Wien and obtained a PhD from the High Technical School Charlottenburg in Berlin in 1913. He was the Head of the Institute for Material Research in Vienna (1911–1915).

In 1927, the Institute for Organic Chemical Technology was established, which was led by Matija Krajčinović (1892–1975), a professor from 1944. He graduated from the Department of Chemical Engineering in Zagreb in 1925, specialised at the Chemical Institute of the University of Nancy (1926–1927) under Gustave Vavon (1884–1953), and obtained a PhD from the University of Zagreb in 1927 [13, 14].

University of Ljubljana (*Universitas Labacensis*), Slovenia

Slovenians had long-standing aspirations for higher education in their homeland. The Jesuit College at St Nicholas Church in Ljubljana operated between 1597 and 1773. In the early 18th century, a three-year programme in Philosophy was offered, but no degrees were conferred. Following the dissolution of the Jesuit Order by the Pope in 1773, the Jesuit schools were taken over by the state. Later in the 18th century, the Imperial-Royal Lyceum in Ljubljana was established, followed by the short-lived Central School (*École Centrale*) between 1809 and 1813, when Ljubljana was the capital of the Illyrian Provinces under France. However, no one graduated from the school by 1814 when the Austrians took over from the French [18, 19].

After WWI and the establishment of the Kingdom of Serbs, Croats, and Slovenes, the University of Ljubljana was founded. The signing of the 'Act for the University of the Kingdom of Serbs, Croats and Slovenes in Ljubljana' by the Regent Aleksandar Karađorđević on 23 July 1919 led to the establishment of the third and newest university in the country (see Figure 9). The 18 founding members of the faculty were led by mathematician Josip Plemelj (1873–1967) as the first Rector. J. Plemelj (see

Figure 10) was a mathematician with a PhD from the University of Vienna (1896) and postdoctoral studies in Berlin (1899/1900) and Göttingen. Known for the Sokhotski-Plemelj theorem, he started the lectures on 3 December 1919 across the four schools: law, philosophy, medicine, and theology. Out of the 942 enrolled students, 28 were women and 914 were men. Most of the faculty were those who taught at the universities in the Austria-Hungary Empire, lost their jobs at the demise of the country, and returned home. Half of the initial students transferred from Vienna. Among them was Ana Mayer (married Kansky; 1895–1962), who was the first to obtain a doctorate from the University of Ljubljana with her doctoral thesis 'About the effect of formalin on starch' on 15 July 1920 [18, 19, 20].



Figure 9. The State Crafts School in Ljubljana that initially hosted part of the Department of Chemical Engineering in Ljubljana. C. 1918.

In anticipation that the Austrian model would be followed, whereby the technical sciences (engineering) are studied outside the universities within the High Technical Schools, a separate High Technical School in Ljubljana was established on 19 May 1919. However, the new university followed the University of Belgrade model, whereby technical sciences were studied within the university too. Apparently, changes to the higher education models created problems in practice that led to adjustments to the exam provisions in some of the faculties to help the transferring

students from Austria complete their degrees. The University of Ljubljana also struggled for its survival, especially before 1929 [18].

The first three professors at the Technical Faculty of the University of Ljubljana were: Karel Hinterlechner (1874–1932) [21], geologist at the Institute of Geology in Vienna and the first Dean; Maks Samec (1881–1964) (see Figure 11) [22], chemist, biochemist and meteorologist with a PhD in chemistry from the Faculty of Philosophy at the University of Vienna (1904), who became grammar school professor at the Real Schools in Vienna; and Milan Vidmar (1885–1962) (see Figure 12) [23], electrical engineer and chess player with a degree in mechanical engineering from the University of Vienna (1907) and a PhD from the High Technical School in Vienna (1910) with specialism in three phase transformers.

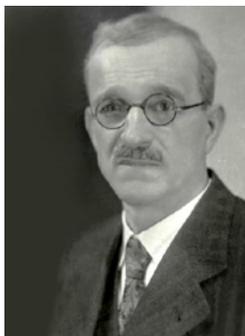


Figure 10. Josip Plemelj. C. 1920s.



Figure 11. Maks Samec. 1920–1940.



Figure 12. Milan Vidmar. C. 1930s.

In the initial post-establishment period, chemistry was studied at two faculties of the University of Ljubljana: Chemical Engineering at the Technical Faculty and Chemistry (for research and teaching) at the Faculty of Philosophy. However, the latter did not have regular lecturers until WWII. At the Technical Faculty, the situation was somewhat better, whereby M. Samec and Marij (Marius) Rebek (1889–1982), professor since 1933, lectured all chemistry-related courses [24]. M. Rebek studied chemistry and physics at the University of Vienna, where he got a PhD in 1913. Before WWI and after demobilisation, he was an assistant to Guido Goldschmidt (1850–1915) and Wilhelm Johann Schlenk (1879–1943), both at the Second Chemical Laboratory at the University of Vienna [25].

University of Belgrade (Universitas Belgradensis), Serbia

Higher education in engineering in the Principality of Serbia commenced on 19 June 1846, when Prince Aleksandar Karađorđević

(1806–1885) established the Engineering School (Indzinirska škola) in Belgrade. The study programme was three years long, and the study of German was mandatory. The initial nine students transferred from the second year of the Philosophy programme at Principality of Serbia Lyceum (Liceum Knjaževstva Serbskog), between 1838 and 1841 in Kragujevac, and from 1841 in Belgrade. Later, on 24 September 1863, the Great School (Velika Škola) in Belgrade was founded with Konstantin Branković (1814–1865) as its first Rector. He held degrees in Philosophy from Szeged and Law from Pest, both in Hungary. Initially, the Great School had three faculties/schools: Philosophy, Engineering, and Law. The Philosophy studies were three (four from 1880) and the Technical and Law studies were four years long. From 1873, the Faculty of Philosophy had two departments: History and Philology, and Natural Sciences and Mathematics, and from 1896, seven, including Chemistry and Natural Sciences. From 1897, three departments were established within the Technical School: Architecture, Civil Engineering, and Mechanical Engineering. The new High School was accommodated in the Captain Miša Mansion, constructed between 1857/1858 and 1863 (see Figure 13). This building was donated to the country for educational purposes by Mihajlo Anastsijević – Captain Miša (1803–1885), a Serbian merchant, teacher, and philanthropist, and one of the richest men in Serbia and the Balkans. Now the building houses the University of Belgrade Rectorate [26, 27].



Figure 13. The Great School (now Headquarters of the University of Belgrade) in Captain Miša Mansion (the building with the lantern). C. 1890.

Over time, the work of the Great School laid the foundations for the establishment of the University of Belgrade by Decree of King Petar I (1844–1921) on 27 February 1905 [26]. The first Rector was Sima Lozančić

(1847–1935) [28], who held a Law degree from Belgrade, studied chemistry under Johannes Wislicenus (1835–1902) [29] in Zurich and August Wilhelm von Hofmann (1818–1892) [30] in Berlin before obtaining a PhD from the University of Zurich in 1870. He was one of the first eight founding professors at the University of Belgrade (see Figure 14).



Figure 14. The first eight full professors at the University of Belgrade in 1905. Seating (from left): Jovan Žujović, Sima Lozančić (Rector), Jovan Cvijić and Mihailo Petrović Alas. Standing (from left): Andra Stevanović, Dragoljub Pavlović, Milić Radovanović, and Ljubomir Jovanović.

The foundations for the establishment of the Department of (Chemical) Technology (Engineering) at the University of Belgrade were laid between 1905 and 1924 within the Department of Mechanical Engineering at the Faculty of Engineering, initially through the establishment of the Chemical Technology Cabinet in 1910 (Institute of Chemical Engineering from 1912). This was supported by the appointment of engineer Dušan Tomić (1875–1947) in 1905 as a lecturer in mechanical technology and engineer Kosta Todorović (1876–1953) in 1908 as a lecturer in chemistry, chemical technology, and metallurgy. However, this development was interrupted by WWI, when the University was closed between 1914 and 1919 [31, 32].



Figure 15. The University of Belgrade Technical Faculty in the interwar period.



Figure 16. The University of Belgrade Faculty of Technology and Metallurgy. 2007.

In late 1923, within the Department for Mechanical and Electrical Engineering, the Technology (Engineering) unit was established, allowing for research and teaching to take place within the Laboratory for Chemical Engineering. This was supported by the appointment of

Dr Aleksandar Marko Leko (1890–1982), a lecturer in chemistry. Initially, the curriculum for all three Units (Mechanical, Electrical, and Technology) was fairly general during the first two years, whilst the final two years of the studies were focused on the selected specialism. The first 15 students enrolled in the Technology (Engineering) unit in 1922 graduated from the Department of Technology (Engineering) established on 16 November 1925. Twenty new students enrolled, and 20 students transferred from the Mechanical Engineering Unit. In 1925/1926, the prominent appointment of engineer Panta Tutundžić (1900–1964), who held a degree and doctorate (1925) from the High Technical School in Berlin, led to the establishment of the Laboratory of Physical Chemistry and Electrochemistry within the Department of Technology [33].

Those who graduated in 1925 and 1926 after transferring from the Mechanical Engineering Unit got mechanical engineer–technologist degrees, while the first technology engineers graduated in 1927. Despite the increased student interest, initially, the enrolment numbers were restricted by the limitations imposed by the available laboratory facilities. As a result, about 30 students were enrolled each year until the academic year 1936/1937. Afterwards, the number of enrolled students increased and reached 170 in the last pre-WWII academic year 1940/1941. In total, between 1925 and 1941, 221 students graduated as technology engineers and a further 25 who graduated during 1942/1944 when the University of Belgrade was formally closed. The Department of Technology suffered heavy losses during the 1941–1944 occupation. A lecturer from Munich is alleged to be responsible for taking the department's possessions, including books, journals, instruments, etc. In addition, an Anglo-American bombing raid in 1944 resulted in partial demolition of the Technical Faculty and most of the chemical and chemical engineering laboratories. Forty-four persons from the Department of Technology lost their lives during WWII, including the first graduate, Jovan Božović, whilst four became National Heroes [32].

Recognised Foreign Educated Chemical Engineers

The Act of Equivalence (Recognition) (Zakon o nostrifikovanju (priznanju)) from 11 July 1930 allowed for the degrees from foreign Universities and (tertiary) High Schools to be recognised as being equivalent to those of the Technical Faculty in Belgrade [34]. This allowed for a few foreign graduates to formally have their qualifications recognised in the country. This applied mainly to those from former Yugoslavia who have studied abroad or those who moved to Yugoslavia from abroad. The second category covered several emigrées, especially from the Russian Empire, following the 1917 October Revolution and the

subsequent Civil War. One of those with a recognised degree in (chemical) technology engineering is Konstantin Mironov, who graduated from the Riga Technical School (Riga Polytechnic Institute) [35].



Figure 17. Fritz Pregl.
No date.



Figure 18. Leopold
Ruzicka. C.1935.



Figure 19. Vladimir Prelog.
No date.

Number of Graduates and Those with Recognised Foreign Degrees

The number of graduated students from the three schools of chemical engineering within the period 1919–1945 is shown in Table 1, along with their gender breakdown where available. For the University of Belgrade, the total number of graduates is 246: 221 between 1925–1941 and 25 during 1942–1944 when the University was formally closed due to WWII [14, 24, 34].

2025/9

Table 1

Number of Recognised and Graduate Chemical Engineers in former Yugoslavia until 1945
(Tot – total, M–Male, F – Female)

Place Year	Uni. of Belgrade, No of recognised degrees [34]			Uni. of Belgrade, No of graduates [32, 34]			Uni. of Ljubljana, No of Graduates [24]			Uni. of Zagreb, No of graduates [14]		
	Tot	M	F	Tot	M	F	Tot	M	F	Tot	M	F
1919	NA	NA	Founded	Founded								
1920	0	0	0	NA	–	–	–	–	–	–		
1921	0	0	0	NA	–	–	–	–	–	–		
1922	1	1	0	NA	–	–	–	–	–	–		
1923	0	0	0	NA	2	2	0	10	10	0		
1924	0	0	0	NA	5	5	0	15	12	3		
1925	0	0	0	9	8	1	8	6	2	14	14	0
1926	1	1	0	4	4	0	14	13	1	17	14	3
1927	3	3	0	4	4	0	3	3	0	18	14	4
1828	1	1	0	1	1	0	10	10	0	15	15	0
1929	3	2	1	6	6	0	12	11	1	11	10	1
1930	20	16	4	11	10	1	8	6	2	12	11	1
1931	14	13	1	13	10	3	8	8	0	15	13	2
1932	9	8	1	6	6	0	11	11	0	14	13	1
1933	1	1	0	11	10	1	1	1	0	11	9	2
1934	5	4	1	10	6	4	5	4	1	15	13	2
1935	9	9	0	15	7	8	13	13	0	15	13	2
1936	5	5	0	24	17	7	8	8	0	6	5	1
1937	2	2	0	23	12	11	10	8	2	10	6	4
1938	8	8	0	24	20	4	14	12	2	16	11	5
1939	NA	ND	ND	N/D	14	13	1	29	20	9		
1940	NA	N/D	N/D	N/D	8	8	0	21	18	3		
1941	NA	Closed (WWII)	19	16	3	24	21	3				
1942	NA	Closed (WWII)	14	13	1	8	6	2				
1943	NA	Closed (WWII)	12	9	3	52	41	11				
1944	NA	Closed (WWII)	11	8	3	15	9	6				
1945	NA	Closed (WWII)	1	1	0	8	3	5				
Total	82	74	8	161	121	40	211	189	22	371	301	70
1939– 1941				60	ND	ND						
1942– 1944				25	ND	ND						
Total	82	74	8	246			211	189	22	371	301	70

Nobel Prize Winners

Three Nobel Prize winners in Chemistry were born in the territory of former Yugoslavia in the past:

Fritz Pregl (1869–1930) (see Figure 17), Nobel Prize in Chemistry 1923 “For his invention of the method of micro-analysis of organic substances.” Born in Laibach, Austria-Hungary (now Ljubljana, Slovenia) and passed away in Graz, Austria. Received an MD in 1894 from the University of Graz. He studied for short periods in Tübingen, Leipzig, and Berlin, and taught at the Universities of Innsbruck and Graz. Initially, his research focused on physiology and physiological chemistry, and later on the constitution of chemical components, e.g., bile acids [36].

Leopold Ruzicka (Lavoslav Stjepan Ružička; 1887–1976) (see Figure 18), Nobel Prize in Chemistry 1939 “For his work on polymethylenes and higher terpenes.” Born in Vinkovci, Austria-Hungary (now Croatia) and passed away in Mammern, Switzerland. He studied at the High Technical School (Technische Hochschule) in Karlsruhe, Germany, where he obtained his PhD in 1910. His research in biochemistry resulted in teaching appointments at the ETH (Eidgenössische Technische Hochschule) in Zurich and the University of Utrecht [37].

Vladimir Prelog (1906–1998) (see Figure 19), Nobel Prize in Chemistry 1975 “For his research into the stereochemistry of organic molecules and reactions.” Born in Sarajevo, Austria-Hungary (now Bosnia and Herzegovina) and passed away in Zurich. He received his diploma in chemical engineering from the Czech Technical University in Prague in 1928 and his doctorate in 1929. Between 1935 and 1941, he lectured in organic chemistry and chemical engineering at the Technical Faculty in Zagreb before moving to Switzerland, where he started working in the Organic Chemistry Laboratory at ETH Zurich, where he became a full professor in 1952 and, in 1957, succeeded L. Ruzicka as the Head of the Laboratory [38].

Unfortunately, out of the three Nobile Prize in Chemistry holders born in the territory of former Yugoslavia, only Vladimir Prelog taught there at the University of Zagreb.

Conclusions

This paper presents the findings of the research into the development of higher (tertiary) education in Chemical Engineering in former Yugoslavia. The focus of the research is on the early developments during the period of First Yugoslavia, the Kingdom of Serbs, Croats, and Slovenes/Yugoslavia, up to the end of WWII. The new country emerged on the ashes

of WWI and effectively resulted in the merger of territories belonging to the two opposing sides in WWI. Slovenia, Croatia, Bosnia and Herzegovina, and Vojvodina (now an autonomous province of Serbia) were part of the Austria-Hungary Empire, while Serbia, Montenegro, Kosovo (considered a province of Serbia by Serbia), and North Macedonia were part of the Kingdom of Serbia. The latter territories were part of the Ottoman Empire until the mid-to-late 19th century and the early 20th century.

This past history played a significant role in the development of higher education in Chemical Engineering in the Kingdom. The degree programmes in Chemical Engineering were offered by the newly founded High Technical Schools in Croatia (from 1926 part of the University of Zagreb) and the Technical Faculty of the University of Ljubljana, both in 1919. They benefited from being part of the Austria-Hungary Empire: the 18 faculty members of the University of Ljubljana were past professors and lecturers in the Austria-Hungary Empire who lost their appointments and were left unemployed at the end of the Empire and had to return home to seek employment, and half of the enrolled students at the University of Ljubljana in 1919 were those who transferred from their studies in Vienna. This, in part, was the case with the High Technical School in Zagreb.

The older University of Belgrade could not benefit in a similar way, and this may account for the slightly later foundation of the degree programmes in Chemical Engineering. The first graduates completed their studies and graduated with the degree of mechanical engineering technologist, although they had attended the course on the newly created third study pathway in chemical engineering. Those in Serbia benefited from the support provided by the Allies of the Entente that supported the enrolment in the universities of their countries after the end of WWI, as well as from scholarships to study abroad by the Kingdom's government.

All three early schools benefited to varying degrees from the refugees from the Russian Empire following the 1917 October Revolution and the later Russian Civil War, or from the Russian Empire WWI prisoners interned in Slovenia, Croatia, and Bosnia and Herzegovina who decided to stay in the newly created state at the end of WWI rather than return to their homeland.

The analysis of the degrees conferred in Chemical Engineering clearly shows that the largest number of graduates comes from the High Technical School/University of Zagreb (371), followed by the University of Belgrade (246) and the University of Ljubljana (211). The lower number of graduates from the University of Belgrade can be attributed to the later commencement of the programme and the fact that the school was closed during WWII.

Eighty-two foreign graduates had their degrees in Chemical Engineering/Technology recognised by the University of Belgrade in the interwar period. Based on their names and surnames, the majority of the foreign graduates appear to originate from former Yugoslavia and studied abroad, whilst a smaller number were foreign nationals who moved to former Yugoslavia. The majority of those who had their qualifications recognised came predominantly from several countries (based on the current borders): France (35 per cent), the Czech Republic (24 per cent), and Germany (11 per cent), with the University of Toulouse, and the High Technical Schools in Prague and Brno being the prime alma mater for these graduates. A similar number of graduates from Germany came from the Russian Empire, or 8.5 per cent from current Ukraine and 4 per cent from current Russia. However, in the absence of personal data but based on the names of the graduates, most of those from the Russian Empire are most likely to be of Russian Empire origin but who emigrated to the Kingdom of Yugoslavia, whilst most others who completed their degrees abroad and had them recognised by the University of Belgrade appear to be nationals of the Kingdom. Only one of the foreign graduates, Konstantin Mironov, who had their degree in chemical engineering recognised at the University of Belgrade, has graduated from the Riga Technical School.

Three Chemistry Nobel Prize winners have originated from the territories of former Yugoslavia in the past: Fritz Pregl, born in Ljubljana, Slovenia; Ladislav Ruzicka, born in Vinkovci, Croatia; and Vladimir Prelog, born in Sarajevo, Bosnia and Herzegovina, then the Condominium of the Austria-Hungary Empire. Unfortunately, only Vladimir Prelog was able to contribute to teaching and research at the schools of Chemical Engineering at the Faculty of Chemical Engineering in Zagreb, in the Kingdom of Yugoslavia, between 1935 and 1941.

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This paper is dedicated to the memory of my late father, Professor Dr. sc. Boro Ladinski (1922–1990), Professor and one of the founding members of the Faculty of Technology, Ss. Cyril and Methodius University in Skopje, North Macedonia, and the past President of the Association of Chemists and Technologists of Yugoslavia (1979–1981).

Ķīmijas inženieru augstākās izglītības attīstība bijušajā Dienvidslāvijā

Rakstā prezentēti pētījuma rezultāti par ķīmijas inženieru augstākās (terciārās) izglītības attīstību bijušajā Dienvidslāvijā, uzmanību pievēršot trīs vecākajām augstskolām valstī, kas izveidotas starpkaru periodā – Zagrebas Universitāte, Ļubļanas Universitāte un Belgradas Universitāte Serbu, Horvātu un Slovēņu Karalistē (1918–1929), Dienvidslāvijas Karalistē (1929–1941). Lai gan Belgradas Universitāte ir vecākā inženierzinātņu augstākās izglītības iestāde, tā bija pēdējā, kurā izveidota ķīmijas inženierijas programma pēc tam, kad sākotnēji izglītība šajā jomā tika nodrošināta mašīnbūves izglītības ietvaros. Zagrebas un Ļubļanas universitātes šo programmu ieviesa jau kopš to dibināšanas 1919. gadā. Rakstā pētīta arī to ķīmijas inženieru loma, kuri zinātnisko grādu ieguvuši ārzemēs un kuru zinātniskie grādi oficiāli atzīti Dienvidslāvijā. Šis pētījums sniedz ieguldījumu inženierzinātņu, īpaši – ķīmijas inženierijas, vēsturē bijušajā Dienvidslāvijā.

Atslēgvārdi: Dienvidslāvija, augstākā izglītība, ķīmijas inženierija, Zagrebas Universitāte, Ļubļanas Universitāte, Belgradas Universitāte.