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CHALLENGES AND OPPORTUNITIES OF THE RAILWAY EDUCATION IN THE REPUBLIC OF SERBIA

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Abstract: *Faced with the challenges of the modern rail industry, the railway education process has to move from being basically theoretical toward in-depth railway knowledge combined with applied skills. Taking the steps from traditional ex-cathedra knowledge transfer toward audio-visual and virtual reality-based learning in labs and on-site learning opens up a variety of significant benefits to students, educational institutions, and railway undertakings. This paper gives an overview of the path that railway education in the Republic of Serbia has passed and summarizes the challenges that rail education is facing by the need to respond to the growing demand for railway specialists. Furthermore, opportunities and constraints for an effective and efficient learning system are underlined.*

INTRODUCTION

Railway education in the Republic of Serbia is strongly connected to the history of railways and trends in railway education in Europe. From a historical point of view, the railway industry greatly impacted schooling systems throughout Europe in the 19th century. The main technological innovations of the First Industrial Revolution (steam machines, telegraph, etc.), especially their fast-growing application in the railway system, influenced many state governments in defining and empowering the new schooling institutions and their capacities, besides already established primary and higher schooling systems. For the whole first half of the 19th century, schooling authorities pushed for the spread of primary schooling (based on rudimentary literacy and numeracy) but resisted the growth of secondary, particularly technical, schooling [1]. But, although it is recognized that economic growth and modernization go hand in hand with the emergence of modern mass schooling, "schooling and economic development had limited impact on each other" [1]. Demands for practical (and marketable) knowledge and skills were growing, but they were not enough to provoke school expansion. The decisions, which came mainly from the top of the political hierarchy, were based on expectations of particular benefits in return for their support.

The main questions at that time, and we can say that they are very relevant today as well, were: what a particular educational system is supposed to achieve concerning socialization, economic, and technological development demands, and who will support its creation and pay for it? Would it be the government that supports tax-based education at all

levels of schooling, or would industry fund and carry out high and higher technical education?

Particular political constituencies supported particular schooling policies [1]. At that time, "the race between education and technology" [2] had started and is still present.

Since railways had, and still have, a great impact on the state economy, awareness of proper railway education at the end of the 19th century moved from private companies` interests toward state interests. During the 20th century, public schooling regulations had a great impact on railway education. There was, and still is, a dilemma: is rail education like any other technical education, or is it somehow specific and demands a multidisciplinary approach to knowledge? Does the railway industry need education with only a higher concentration of practical skills or also higher rates of literacy, which those skills presuppose?

Primary education in the 19th and 20th centuries expanded from two to four, and later to six and eight grades, and relied on public spending as an investment that may or may not be returned. The expectations of high and higher education were that some particular benefits must be achieved in return for the support, either public or private.

High and higher railway education in Europe has come a long way from being a part of general technical education (mechanical, electrical, and civil engineering) to the status of a separate branch of engineering. Since 1990 two approaches to railway education have been recognized in Europe (the Western Europe approach and the Central and Eastern Europe approach, as shown in Table 1.

Table 1

Western Europe railway education	Central and Eastern Europe railway education
General technical education: - No high education institutions for railways - Higher education within faculties of general technical engineering • Civil engineering • Mechanical engineering • Electrical engineering	State funded railway schooling system - High railway schools - Higher railway schools of applied science - Faculties with railway engineering departments: • Railway traffic and transportation • Railway civil engineering • Railway mechanical engineering • Railway electrical engineering • Transport economy • Transport law - Railway universities
Study programs with a small number of railway subjects	Railway-oriented study programs
Outcomes: - General educated engineers without or with a small amount of railway knowledge. - Additional education in railway engineering needed	Outcomes: - Technicians and engineers with highly specialized railway oriented knowledge
Additional learning process in railway company: - Railway oriented training process - Period for obtaining the railway knowledge vary from 2 to 5 years	Additional learning process in railway company: - Work under the supervision for the limited period of time (from 3 to 10 months)

After 1990, the railway education system in the EU member states significantly changed due to railway market liberalization. The fragmentation of the railway sector and changes in ownership of railway companies influenced the new organization of educational and training processes for railway jobs, but unfortunately, some existing programs were closed down. Some Central and Eastern European countries kept the former established railway education system. In some countries, certain railway education institutions, stepping toward job market demands, have downsized their railway programs or even closed them, and have transformed into general technical education institutions. Most of the new railway companies in EU countries (especially railway operators) did not establish a persistent

training process. Companies of infrastructure managers have for many years tried to find an adequate educational model, but without success.

At the beginning of the 21st century, the application of modern technologies in the railway system led to new demands for railway education programs, especially at higher educational institutions (HEIs). According to the TUNRail Study [3], the results of research held from 2008 until 2010 show that in certain EU member states, university education for railway is very rare; around 45% of all railway study programs, subjects, and courses are offered in German-speaking areas; at the universities in Eastern Europe, there are a very small number of railway study programs, but they are comprehensive and extensive; the number of universities with railway study programs (research and teaching combined) is 21, and the number of railway courses offered is 260; universities in the EU embrace the idea of research-oriented teaching; the majority of railway industry companies consider high railway education insufficient and higher railway education mostly adequate (mainly in civil engineering and transportation); most courses concentrate on limited domain areas of knowledge, but there are no specific courses in mechanical and electrical engineering; there are urging demands for highly educated railway professionals (from both high and higher education) and, moreover, engineers with wider system engineering knowledge, skills, and experiences, so-called system engineers.

PAST AND PRESENT RAILWAY EDUCATION IN SERBIA

The appearance of the first educated railway staff in the Republic of Serbia can be dated to the mid-19th century, when the first single railway line, Lisava-Oravica-Bazijas (27 km long), in the Autonomic Province of Vojvodina (at that time in the territory of the Austro-Hungarian Empire) started to operate. This line was in operation from August 20th, 1854, using horse power, and from November 1856, steam locomotives were introduced [4]. The railway staff has received general education in the educational system of the Austro-Hungarian Empire and special technical education (especially education in mechanical engineering) within the railway industry. From that time on, the expansion of railway line construction and exploitation in the territory of AP Vojvodina began. The first single railway line in the southern part of the Republic of Serbia was introduced into operation in 1874 between the settlements Kosovska Mitrovica and Skoplje (at that time in the territory of the Ottoman Empire) [4]. At the Congress of Berlin in 1878, the independence was recognized for the Principality of Serbia, but with the condition of concluding a special convention that imposed an obligation on Serbia to build a single railway line from Belgrade (the capital city) to the borders of Turkey and Bulgaria within three years. The single railway line between settlements Belgrade and Niš was introduced into operation in 1884 [4].

It should be stated that the high and higher education in Serbia was under the influence of the education policies of the Central and Eastern European countries. The first general technical education can be connected with the establishment of the first state-funded High Engineering School in Belgrade (opened in 1846). In 1873, due to plans for future railway line construction, the decision was made to open the Technical Faculty with a higher education study program in mechanical engineering. In 1881, the Government of the Serbian Principality founded the first Railway and Trade School for the purpose of education and training of railway personnel. The first generation of students of this school attended classes for theoretical knowledge in Belgrade, and they had practical training on the railways of the Czech Republic, Austria, Belgium, France, and Italy [4]. The final exam was performed in the language of the host, depending on the country where the students did their practical training.

The establishment of proper higher railway education is connected with the development of the Technical Faculty. In 1922, the Technical Faculty formed four departments of engineering: Mechanical and Electrical, Civil, Architectural, and Technological. In 1948, departments were transformed into faculties. Through this

transformation, the Faculty of Mechanical Engineering formed departments of General Mechanical Engineering, Railway and Shipping Engineering, Aviation, and Motorization Engineering, and in 1946 the Department for Military Engineering was founded. The Faculty of Electrical Engineering had several subjects concerning railway signaling, traction, telecommunication etc. The Faculty of Civil Engineering had a Department for Railway Construction and Maintenance [5].

In 1950, the Government of the FPR Yugoslavia issued a decree establishing the High School of Traffic for the purpose of educating traffic and transportation engineers for all transport modes. In 1960, this School became the Faculty of Traffic and Transportation within the University of Belgrade [6]. From the very beginning, the Department of Railway Traffic and Transportation was a part of the faculty. In 1957, the Government issued a decree establishing the Higher Railway Traffic School in Belgrade as a unique school of railway engineering for the purpose of education and training of railway engineers for the Yugoslav Railways. In 1967, the School was reformed as the Higher Railway School [7]. In 2007, the study programs were accredited according to the new law of higher education (harmonized with the European Higher Education System according to the Bologna Declaration), and the School became the Higher Railway School of Applied Studies. In 2019, by the decision of the Ministry of Education and the Government, the School became a department of the Academy of Technical and Art Applied Studies Belgrade.

The data from June 2023 shows that in the Republic of Serbia, there are three high schools (Table 2), one higher school (Table 3), and seven faculties with full or partial railway programs with a certain number of subjects (Table 4) [8].

Table 2

High school	Study profile
Railway Technical School Belgrade	- Railway traffic technician - Railway transport technician - Railway traffic safety technician - Railway engine driver - Telecommunication technology technician
Traffic School "Pinki" Novi Sad	- Railway traffic technician - Railway transport technician
Technical School "Ivan Sarić" Subotica	- Railway engine driver

Table 3

Higher school	Study program
ATUSS Belgrade-Department School of Railroad Transport (Full railway program)	Level 1-Undergraduate applied studies (180 ESPB) - Railway Traffic and Transportation - Railway Mechanical Engineering - Electrical Engineering in Traffic - Railway Economy and Commercial Business Level 2-Master applied studies (120 ESPB) - Traffic and Transportation Engineering - Electrical Engineering in Traffic - Transport Economy and Commercial Business

Table 4

Faculty	Study program/Module
University of Belgrade Faculty of Transport and Traffic Engineering (Full railway program)	Level 1-Undergraduate academic studies (240 ESPB) - Module: Rail Transport and Traffic Level 2-Master academic studies (60 ESPB) - Module: Rail Transport and Traffic Level 3-Doctoral academic Studies (180 ESPB) - Study program: Traffic Engineering
University of Belgrade Faculty of Civil Engineering (partial railway program)	Level 1- Undergraduate academic studies (180 ESPB) Study program: Civil Engineering (one railway subject) Level 2- Master academic studies (120 ESPB) Module: Road, Railway, and Airports (eight railway subjects)

	Level 3- Doctoral academic Studies (180 ESPB) Study program: Civil Engineering (two railway subjects)
University of Belgrade Faculty of Mechanical Engineering	Level 1- Undergraduate academic studies (180 ESPB) Study program: Mechanical Engineering (four railway subjects) Level 2- Master academic studies (120 ESPB) Module: Railway vehicles Level 3- Doctoral academic Studies (180 ESPB) Study program: Mechanical Engineering (three railway subjects)
University of Novi Sad Faculty of Technical Science Novi Sad (partial railway program)	Level 1-Undergraduate academic studies (240 ESPB) - Study program: Traffic and Transport Engineering Level 2-Master academic studies (60 ESPB) - Study program: Traffic and Transport Engineering Level 3-Doctoral academic Studies (180 ESPB) - Study program: Traffic Engineering
University of Novi Sad Faculty of Civil Engineering Subotica (partial railway program)	Level 1- Undergraduate academic studies (180 ESPB) Module: Transportation Infrastructure (two railway subjects) Level 2- Master academic studies (120 ESPB) Module: Transportation Infrastructure (one railway subject)
Faculty of Mechanical and Civil Engineering Kraljevo (partial railway program)	Level 1- Undergraduate academic studies (180 ESPB) Study program: Mechanical Engineering (three railway subjects) Level 2- Master academic studies (120 ESPB) Module: Machinery Design (two railway subjects) Level 3- Doctoral academic Studies (180 ESPB) Study program: Mechanical Engineering (one railway subject)
University of Niš Faculty of Mechanical Engineering (partial railway program)	Level 1- Undergraduate academic studies (180 ESPB) Study program: Mechanical Engineering (one railway subject) Level 3- Doctoral academic Studies (180 ESPB) Study program: Mechanical Engineering (one railway subject)

The data shows that at most Universities, study programs concentrate on a limited domain area of railway knowledge, which is mostly the case in mechanical and civil engineering. This year, there are no specific railway study programs or modules, not even subjects in the faculties of electrical engineering.

CHALLENGES AND OBSTACLES

From the very begging, education system as a whole, and in particular, was challenged by many questions of social, financial, political, technological, etc., issues. Some challenges remained the same from the past up until the present days, and some new challenges appeared in recent years. Railway education in Serbia deals with an enormous number of challenges, obstacles, and issues that are sometimes opposed to each other. For example, the number of railway students, both in high and higher education, declines, but on the other side, the railway industry lacks railway professionals. The reasons for the decline in the number of students can be found in: poorer working conditions and lower average wages in comparison with most other jobs for the same level of educational degrees; the decline of the domestic railway vehicle industry, the closure of the railway signaling industry, and import-oriented construction and maintenance of the railway system; there is no budget funding for the students on Level 2 and Level 3 (self-budgeting education); the high cost of living in cities that are educational centers; the educational law from 2018 forbids ETCS equivalent among applied and academic types of studies; there is no HEI of Applied Studies accredited for Level 3 studies, etc. The HEIs deal with the following: insufficient state funding and support for the new learning technologies; a lack of experienced railway professionals with a Ph.D.; the current methods of HEI collaboration on the national level are disturbed by the educational law from 2018 which does not recognize the HEIs of Applied Studies as a subject that can form or be part of scientific institutes; the HEIs of Applied Studies international collaboration is focused mostly on internships and guest lecturing; challenges that come from the dual

model of education; status of formal versus non-formal education obtained in training centers; obstacles that are provoked by the late pandemic, etc.

OPPORTUNITIES

The main opportunities for railway education are cooperation between HEIs and strong ties with the railway industry, on the one hand, and the adoption of new learning methods and technologies, on the other. The number of emerging technologies appears endless, and experiencing them will make huge changes in education. Emerging technologies in education pledge to better enhance the way teachers and students work. It was indicated that seven emerging technologies will help reshape education from 2023 on [9]. Those are: Augmented Reality (AR) & Simulations; Adaptive Learning; Education Technologies based on Artificial Intelligence (AI); Usage of 5G Technologies in Education; Automation; Competency-based Education and Learning Analytics. Teachers can use online course platforms to enhance the learning environment. But everybody should be ready to accept these new technologies.

CONCLUSSIONS

Since railway engineering teaching differs from teaching many other fields of engineering, as in the railway system all fields of engineering are interconnected. Teaching railway science must follow an interdisciplinary approach where fundamental knowledge of rail-related aspects of civil engineering, mechanical engineering (rolling stock), electrical engineering (signaling, electric traction, telecommunication), and computer science (signaling, controlling and monitoring systems, e-business) come together in the processes of traffic and transport operation and management. The basis of the new learning approach should rely on permanent investments in "training of the trainers" and the use of new learning technologies. It can be supposed that those will lower the entrance barrier and obstacles in the learning process and move railway education from traditional study to E-learning and virtual classrooms. This will also reduce the physical travel of students and education costs and could lead to joint, internationally recognized railway study programs.

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