CHALLENGES IN TEACHING MATHEMATICS IN SERBIA

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Abstract: The purpose of this paper is to address the critical issue of the shortage of mathematics teachers and professors in Serbia. The old teaching staff is drying up, and there is a lack of new teaching potential. The demoralization of current math teachers is an ongoing concern and as a result, hardly any student want to become math teacher. Soon we will only be able to realize that no one wants to teach mathematics anymore. We will focus on the causes and consequences of the perceived problem.

Key words: mathematics, teacher shortage, education, recruitment, retention

1. INTRODUCTION

It appears that the shortage of certified mathematics teachers and professors is poised to become a major issue in the Serbian education system, creating a substantial gap between supply and demand in the labor market. While not a recent discovery and not confined to a local context, the scarcity of science and math teachers is a global problem. Even the most developed countries recognize this challenge as one of the key impediments to development.

The understanding and remediation of deficiencies in math teaching have drawn researchers from various disciplines. As early as 1986, Arthur Steen, the then-president of the American Mathematical Society, presented data in [1] indicating that mathematics faculties are struggling to meet the expanding demands. He underscored the urgency of revitalizing undergraduate mathematics due to a severe and ongoing shortage of math teachers, a situation expected to worsen. The dissertation [2] offers a comprehensive analysis of various aspects of the issue of unqualified math teachers. Additionally, in [3], Reiss presents a variety of information on doctoral programs in mathematics, highlighting the shortage of doctorates in mathematics education. In Paper [4], the analysis focuses on the challenges faced by higher education institutions in filling positions that require a PhD in mathematics education. The author notes that the imbalance between supply and demand for PhDs in mathematics has led to over 40% of institutional demands for math educators being unsuccessful. R. M. Ingersoll has conducted extensive research, as seen in [5]-[9], on the teaching profession with a particular focus on the shortage of math and science teachers, teacher retention, and the causes and consequences of high teacher turnover rates. His research has illuminated the reasons why math teachers leave the profession, citing factors such as job dissatisfaction, lack of administrative support, better-paying career opportunities in other fields, and challenging working conditions. In particular, he addressed the topics of out-of-field math teaching, as well as issues related to the recruitment and retention of math teachers. In 2019, the Economic Policy Institute published the "Perfect Storm in the Teacher Labor Market", series of reports by E. Garcia and E. Weiss. A comprehensive summary of this extensive research can be found in reference [10]. Additional research [11] and [12] supports a more positive view of undergraduates' motivation and interest in becoming math or science teachers. Paper [13] presents a model for analyzing and comparing teacher shortages in three exemplary countries (Denmark, Germany, and Sweden), highlighting differences in the educational systems and the types of challenges faced by schools in these

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countries. A wealth of relevant literature addressing various
aspects of math teaching problems is available. Interested readers may consult papers [14]-[17] for further insights.

Despite the longstanding importance of this issue, to our knowledge, there has been no serious research conducted on the shortage of math teachers in Serbia, apart from occasional press releases (usually during university entrance exams). The aim of this note is to highlight the problem and its main reasons without making specific recommendations. Comprehensive research for appropriate conclusions would necessitate serious multidisciplinary projects.

2. CHALLENGES OF THE MATHEMATICS EDUCATION SYSTEM IN SERBIA

Arguably, most people would agree that mathematics is the most important subject learned during schooling, serving as the universal language of the past and the future. Proficiency in mathematics increases the likelihood of success in almost every scientific subject, excluding language-related ones. Mathematics skills are crucial filters for careers in science, technology, programming, and engineering. In [1], Steen highlights the urgent need for the revitalization of undergraduate mathematics studies due to the shortage of qualified mathematicians. He emphasizes the foundational role of mathematics, stating, "NSF (National Science Foundation) policy for science and engineering education both pre-collegiate and collegiate must be built on this central fact: *mathematics is not just one of the sciences, but is the foundation for science and engineering*".

The top priority for our country should be the quality education of science, technology, engineering, and mathematics (STEM) students to stay competitive in the modern trends of the global economy. It is evident that math takes precedence here, as all science-based fields, including artificial intelligence, heavily rely on sophisticated mathematical models, making a deep understanding of mathematics crucial. However, producing high-quality mathematicians is a continuous and long-term process, spanning from primary school to doctoral studies. In the following, we will analyze the difficulties encountered on this educational journey, step by step.

2.1. Lower grades of primary school

The irreplaceable role of mathematics in developing critical thinking skills is widely recognized. Basic arithmetic operations teach children patience, precision, logical thinking, decision-making, curiosity, and various problem-solving approaches, among other skills. While the importance of mathematical education in early schooling is unquestionable, this paper will not delve into that aspect. Not to diminish its significance, it is worth noting that for the lower grades of primary school (4 years), a specialized math teacher is not deemed necessary. According to available data, there is no significant shortage of teachers in these lower primary school grades.

2.2. Higher grades of primary school and secondary school

For this level, the education system of the Republic of Serbia requires a certified math teacher with a bachelor's or master's degree in mathematics. And here is where the problems begin.
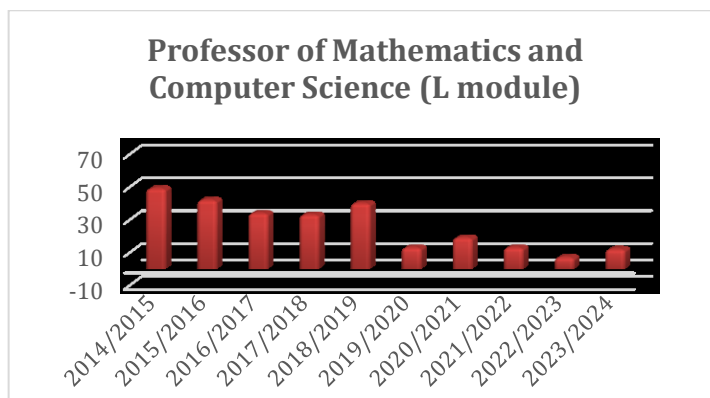

Professor of Mathematics and Computer Science (L module)

Figure 1 – The number of students enrolled in the L module in the last 10 years

The first problem arises at the very beginning – the underproduction of math teachers. In Figure 1, the data on the number of students enrolled in the Professor of Mathematics and Computer Science module at the Faculty of Mathematics, University of Belgrade, is presented. Over the past 5 years, this module has seen an average enrollment of only 12.8 students! When you add the fact that some of them drop out, while others change the module or even the faculty, it is clear that there are reasons for serious concern. Unfortunately, in reality it is even worse. Even among the small number of students who earn a math teacher's degree, most never enter the profession. Some quit after a few years, opting for higher-paying and less demanding jobs. It is important to note that, besides the specialized module for math teachers, there are alternative modules (refer to Table 1) that could serve the same purpose, although this is rarely the case. Additionally, the Informatics module consistently reaches full capacity, reflecting the pragmatic choices of the younger generation to pursue majors with better career opportunities.

Table 1 – Number on enrolled students by module

	2014/15	2015/16	2016/17	2017/18	2018/19	2019/20	2020/21	2021/22	2022/23	2023/24
Informatics	120	120	120	160	160	160	160	160	160	160
Astroinformatics	18	24	14	12	10	14	15	12	11	7
Astrophysics	8	1	11	12	15	11	10	10	9	10
Professor of Mathematics and Computer Science	49	42	34	33	40	13	19	13	7	12
Theoretical Mathematics and Applications	12	16	13	14	16	22	17	13	14	24
Applied Mathematics	24	24	25	27	29	17	7	11	15	6
Computer Science and Informatics	90	90	90	90	90	90	68	90	90	44
Statistics, Actuarial and Financial Mathematics	57	64	60	62	69	54	36	55	44	35

As a consequence, there exists a dramatic imbalance between the supply and demand for mathematics teachers, a disparity that has been increasing in recent years. Persistent shortages in the labor market and the challenges faced by school principals in securing qualified math teachers are becoming commonplace. Faced with unsuccessful recruitment attempts, principals are often compelled to entrust the teaching of mathematics to unqualified individuals-a common occurrence in Serbian schools. Consequently, the damage to math education is already evident, as a gap in mathematical knowledge has been created. As previously noted, mathematics is a subject that requires prior knowledge for the acquisition of new concepts.

Well, what are the main reasons for the limited interest in teaching math in Serbian schools? First and foremost, it's the low salary in education overall, especially when compared to other fields. The low relative pay for teachers is a significant factor contributing to the shortage of math teachers. Given their specific way of thinking, adept problem-solving abilities, and developed math skills, certified mathematicians of any specialization are highly sought after in the IT industry, economy, business, and other sectors, where salaries are typically 3-6 times higher. Even those who aspire to become math teachers often abandon the idea due to the perception that it is not a sufficiently valued and adequately compensated profession in our country. Another important factor is the poor discipline and inappropriate behavior of primary and high school students, and occasionally, their parents. The sanctioning of misconduct and the protection of teachers are at very low levels. Other contributing factors include weak administrative support, limited influence, low student motivation, lack of opportunities for professional advancement, inadequate time for preparation, and more. It can be suggested that the problems of math

teacher shortage are caused not only by an underproduction
of math teachers, but also by high attrition rates. Based on the above, we are convinced that the shortage of math teachers should become a national concern recognized by policy makers.

2.3. Contemporary higher education

At this level, the education system of the Republic of Serbia mandates a PhD in Mathematics. Initiating a university career necessitates a master's degree in one of the math modules (refer to Table 1). Notably, the modules 'Theoretical Mathematics and Applications' and 'Applied Mathematics' are specifically tailored for researchers in mathematics. The average enrollment in the first module over the previous 5 years (see Figure 2) is 18, while the second module sees an average of only 11.2!
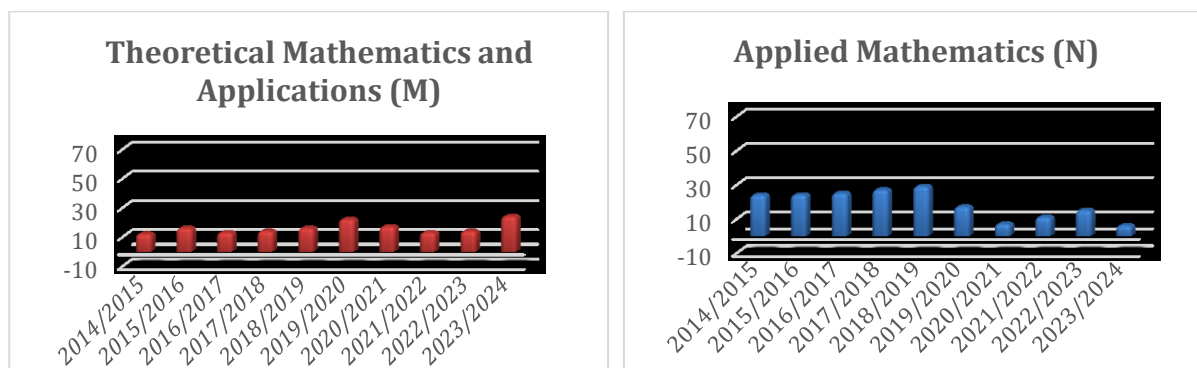

Figure 2 – The number of students enrolled in the M and N module in the last 10 years

At the doctoral level, the number of students in university mathematics departments is steadily decreasing. We are not unfamiliar with the recent difficulties in hiring math teaching assistants, as well as in their retention. A major nationwide mobilization, coupled with increased investment in science, is crucial to attract the brightest young minds to engage in mathematical research.

Doing a PhD in mathematics is not a piece of cake. It takes approximately 5-7 years, after a master's degree. Besides exceptional math skills, becoming a teaching assistant requires substantial effort and personal sacrifice. Doctoral students not only face challenging exams and research but also take on a significant number of classes, often paid at the level of a high school teacher. This period prompts dilemmas and self-reflection among doctoral students, questioning whether continuing on this chosen path is worth it. And one can't blame them. The demanding nature of a PhD program in mathematics, lack of progress or support, difficulties in the relationship with their advisor, pressure of high expectations, getting better offers or opportunities such as positions in the IT industry, are some of the reasons why students decide to withdraw. It must also be emphasized that research in mathematics is not like research in other fields. Mathematics research often involves abstract concepts and rigorous mathematical proofs. As a general rule, undergraduates cannot participate in, or even understand, the research activity of their professors. That is why the advisor's role in doctoral studies is essential. When a PhD is completed, a new set of challenges and opportunities arise for graduates.

One might think that, after overcoming all the aforementioned difficulties to obtain a PhD in Mathematics, the time finally comes to dedicate oneself to professorship and transfer knowledge to students. Graduates can initially secure academic positions as assistant professors or researchers at universities or research institutions. However, they also have diverse job opportunities beyond academia. PhD graduates in mathematics can explore careers in industry, including roles in data science, finance, cryptography, software development, or consulting. If they opt for a university career, they face new challenges: adapting to classroom work, developing courses, creating quality materials for students, engaging in new research, and more. While it may seem appealing, there are clear reasons for potential dissatisfaction. Assistant professors, despite the increased responsibility, are still underpaid, with salaries comparable to those of public transport drivers. In addition, there are mandatory requirements-such as the number of papers published in top SCI journals, participation in international conferences, and receiving excellent grades in student reviews-that must be met to retain the current position or

advance to a higher one. This situation can be quite stressful and adversely affects faculty retention rates. Many faculty members begin to feel listless and undervalued. Some opt to leave the academic career in search of opportunities in IT companies, while others decide to pursue their careers at foreign universities where their work is more appreciated. This phenomenon illustrates the occurrence of brain drain, where, after 20 years of continuous education, instead of contributing to the progress of their home country, promising young scientists choose to leave. There have been recorded cases where even associate professors leave their faculties and academic careers for higher-paying jobs.

2.4. Artificial intelligence and math education

The application of artificial intelligence in education is poised to revolutionize human learning methods. Numerous online AI learning platforms are continually improving, with some even capable of adapting to individual students, offering significant benefits to personalized learning. Educational institutions have widely embraced artificial intelligence to assist teachers and support students in enhancing their knowledge.

However, while AI relies on existing data, humans are characterized by critical thinking, the generation of new ideas, and the creation of original content. Many would argue that, rather than simply acquiring a plethora of information, it is more crucial to develop logical thinking skills and the ability to solve specific problems-skills that are honed through math problem-solving. In discussions about AI educational models, mathematics stands out as the primary subject that exposes the limitations of deep learning algorithms. As AI-based learning platforms become more prevalent, there is a corresponding increase in the demand for math experts who can assess existing content and contribute to the development of more effective learning methods.

While the primary focus of this paper was on the shortage of mathematics teachers in the classroom, another dimension of the problem has been identified: the scarcity of math experts to develop high-quality educational content in mathematics. This shortage not only impacts the classroom but also poses a risk of inaccuracy for students and teachers accessing digital resources. This underscores the crucial role of math experts in addressing these challenges.

3. CONCLUSION

The shortage of math teachers and professors in Serbia is becoming a growing concern. In today's world dominated by artificial intelligence, machine learning, and deep learning—fundamental mathematical disciplines such as linear algebra, mathematical statistics, applied, and numerical mathematics form the backbone. The question is straightforward: If we aim to produce top experts in these fields and remain globally competitive, who will teach them the essential mathematical concepts? Unfortunately, a clear answer to this question is not yet in sight.

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