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MATHEMATICS IN HIGHER EDUCATION- A BASIS FOR A KNOWLEDGE-BASED SOCIETY¹

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Abstract. The main challenge to the teachers in the field of mathematics in higher education is the fact that they are often confronted with the generally negative attitude of the students towards mathematics. This is partially due to their inadequate experience in the previous periods of learning mathematics that results in a certain mixture of essential mathematical illiteracy and personal animosity towards the subject. It is the main reason why mostly of the mathematics teachers in higher education are not able to achieve the needed efficacy in teaching mathematics. In this paper part we will envisage part of the problems we had to deal with in our efforts in making mathematics in higher education more approachable and more acceptable to our students. The main goal is to present suggestions for overcoming the existing problems and drawbacks that we are facing as mathematics teachers, mainly in faculties in technical sciences.

Key words: higher education, mathematics, teaching

¹ professional paper

INTRODUCTION

In the modern societies the acquisition of different competences as well as in the Mathematics are greater and greater and therefore they invest a lot of efforts and means for increasing of the mathematical literacy of their students. This can be seen in the more present distinguishing of the so called STEM (science, technology, engineering, mathematics) skills by all the relevant factors in the planning creating and conducting of their scientific educational policies.

In our country too in the last years there is an increased tendency for advancing of Mathematics in the higher education and accordingly the reforms and reorganization are conducted in teaching Mathematics. Beside all the efforts the expected rise is missing and it seems that there are many oversights in the Mathematical education. The factors and reasons that contribute for this situation are multilayered deposited years back and they are entangled among themselves, starting with the problems that originate from decision makers, curricula, the problems with the teaching staff all the way to the problems related with the students themselves. As always when in a certain process the human factor is included different social and economic factors that bring to certain situations cannot be neglected.

The Mathematical education of the young people as no other is upgraded gradually, starting from preschool age through the elementary education, high school to the higher education and even after that. The pyramid of the mathematical notions and ideas is gradually constructed and the most important is the pyramid to have a solid basis but also the solid upgrading too, [1].

As authors of this paper we work with students that finished their high school education in the vocational secondary schools of technical sciences or in the high schools. The numerous researches through many diagnostic tests done at the each new academic year given to the students that begin their studies at the Faculty of Technical Sciences Bitola create the general impression that the students who come from the high schools have acquired greater knowledge compared to the students who come from the vocational secondary schools of technical sciences. We are convinced that is due to the fact that the weekly fund of lessons in Mathematics in the first and second year is the same i.e. 3 lessons

and also the teaching content is matched. But in the third and fourth year the weekly fund of lessons in Mathematics in the high schools is the same 3 and in the vocational schools of technical sciences is decreased to 2, and the students have the option to choose two optional lessons in Mathematics, [1].

In this paper will be elaborated the problems that appear in the teaching in the field of Mathematics in the higher education, more specifically at the Mechanical Engineering department of the Faculty of Technical Sciences in Bitola.

**SHORT SUMMARY OF THE PROBLEMS IN TEACHING
MATHEMATICS AT THE MECHANICAL ENGINEERING
DEPARTMENT OF THE FACULTY OF TECHNICAL SCIENCES IN
BITOLA**

In addition we will make analyses of the reasons for the problems that appear in the higher education at one of the departments of the Faculty of Technical Sciences in Bitola, i.e. Mechanical Engineering department that we as teachers of the subjects in the field of Mathematics deal with every day. We shall notice that the Mechanical Engineering department of the Faculty of Technical Sciences in Bitola until 1991 was a part of the same educational system of the former SFRJ and it was side by side with the Mechanical Engineering faculties of the universities in Skopje, Nis, Belgrade, Zagreb and Ljubljana.

Ever since until now, we have been silent witnesses to numerous accreditations made without previous serious analyses and consultation with relevant factors – teachers of subjects in the field of Mathematics. All that obviously led to incomplete adaptation of the students and teachers to the changes and as a result we have created generations of students in engineering that have oversights in the acquired mathematical knowledge and skills that cannot be ignored as well as great problems in using the mathematical apparatus in the professional subjects. The tendency in each following accreditation is decreasing of the lessons in the field of Mathematics as well as discarding of a big number of mathematical contents of great importance for engineer profiles, which has shown its drawbacks in very little time and it has created long term and fiery problems in teaching Mathematics. The biggest problems in the

teaching arose from the before mentioned decrease of the lessons fund was not always directly proportional with decrease in Mathematical contents. We were put in position in interest of the mathematical contents to teach them in smaller number of lessons though to the students who show serious oversights in their basic mathematical knowledge. Besides that with the changes in the curricula, the price that the students paid was missing of many important topics in mathematics which resulted in insufficient preparation of the students for acquiring the abstract notions and their recognition and application in the other subjects. As a result of that we were in absurd situations when strictly mathematical notions like: surface and curve integral, theory of field, differential equation from higher order and complex analyses concretely at department of Mechanical Engineering were needed to be explained to students by teachers – engineers in the field of mechanical engineering.

**COMPARATIVE ANALYSES OF TEACHING MATHEMATICS AT
FACULTIES OF MECHANICAL ENGINEERING IN OUR COUNTRY
AND THE COUNTRIES IN THE FORMER SFRJ, COMPATIBLE WITH
THE DEPARTMENT OF MECHANICAL ENGINEERING AT
FACULTY OF TECHNICAL SCIENCES BITOLA**

In the period from 1996-1998 at Faculty of Technical Sciences Bitola at the department of Mechanical Engineering there were 4 compulsory one semester subjects in Mathematics, that is: Mathematics 1 with weekly fund of 4 + 4 lessons, Mathematics 2 with weekly fund of 2 + 2 lessons and Mathematics 3 and 4 with weekly fund of 4+3 lessons, [2]. This was the situation until the ECT system was introduced when at the department of Mechanical Engineering were kept subjects Mathematics 1 and Mathematics 2 with decreased weekly fund of 3+ 2 lessons, [3,4,5].

In the paper below is made a summary of the subjects in the field of Mathematics with weekly fund of lessons that are being taught at the faculties of Mechanical Engineering in the region, compatible with the department of Mechanical Engineering at the Faculty of Technical Sciences Bitola as well as the universities in Skopje, Nis, Belgrade, Zagreb and Ljubljana, [5,6,7,8,9,10,11].

Table. A summary of the subjects in the field of Mathematics that are being taught at the faculties of Mechanical Engineering at universities in Ljubljana, Zagreb, Belgrade, Nis and Skopje, compatible with the department of Mechanical Engineering at the Faculty of Technical Sciences Bitola

University	Faculty	No. of sem. and ECTS	Subject	Sem.	No. of lessons (L+T)	ECTS	Total No. of lessons
University of Ljubljana	Faculty of Mechanical Engineering	6 (180)	1. Calculus and simple differential equations 2. Linear algebra and vector analyses	I	5+4	9	16
				II	4+3	7	
University of Zagreb	Faculty of Mechanical Engineering	7 (210)	1. Mathematics I 2. Mathematics II 3. Mathematics III	I	5+4	10	20
				II	4+3	7	
				III	2+2	5	
University of Belgrade	Faculty of Mechanical Engineering	6 (180)	1. Mathematics I 2. Mathematics II 3. Mathematics III	I	3+2	6	15
				II	3+2	6	
				III	3+2	6	
University of Nis	Faculty of Mechanical Engineering	8 (240)	1. Mathematics I 2. Mathematics II 3. Mathematics III	I	4+3	7	20
				II	4+3	7	
				III	3+3	7	
University of Skopje UKIM	Faculty of Mechanical Engineering	8 (240)	1. Mathematics I 2. Mathematics II 3. Linear algebra and vector analyses	I	3+2	7	14
				II	3+2	7	
				III	2+2	5	
University of Bitola UKLO	Faculty of Mechanical Engineering	8 (240)	1. Mathematics I 2. Mathematics II	I	3+2	6	10
				II	3+2	6	

From the summary made in the field of Mathematics we can see that at the Faculty of Technical Sciences Bitola at the Mechanical Engineering department, Mathematics is taught with lowest weekly fund of lessons in total 10. With this number of lessons according to the last accreditation we should teach the following mathematical contents: elements of linear algebra, elements of vector algebra, basic functions, limes, continuous function, derivative and differential of the functions with application of the derivatives, indefinite integral, definite integral, functions of many variables, multiple integrals, differential equation of first order, orders, [5]. In the terms of teaching of these contents in the fund of lessons predicted there is significant number of

problems and difficulties which will be presented and elaborated in details below in the paper.

After the summary and analyses made of the curricula of Mathematics in the higher education in our country and in the region, i. e. the countries of the former SFRJ, we have decided in the focus of the paper to be only the Faculty of Mechanical Engineering of the University in Nis and the Faculty of Mechanical Engineering from UKIM in Skopje, which according to the number of the semesters and credits are the most suitable with the Mechanical Engineering department at the Faculty of Technical Sciences Bitola.

With three mathematical subjects (Mathematics I,II,III) and total fund of lessons 20, students at the Faculty of Mechanical Engineering in Nis study the following mathematical contents: mathematical logic and sets, polynomials, vector algebra, differentiating and integrating of real function of one variable, linear algebra and analytical geometry, ordinary differential equations, multiple, curve, surface integrals, theory of field, complex functions, Laplace transform and higher order differential equations, [10].

At the Faculty of Mechanical Engineering at UKIM in Skopje with three mathematical subjects (Mathematics I,II Linear Algebra and vector analyses) and total fund of lessons 14 the students study the following mathematical contents: basic notion of vector algebra and analytic geometry in space, notion of function and functional dependency, basic elementary functions, notion of limit, limit processes, continuity and differentiability of real function of one true independent variable, definite integral and application of the technique, true function of two or more independent variables, basic features, notion for limit, continuity and differentiability, multiple integral and its use, differential equations and basic types of equations which are used in the engineering matrices and matrices operations and their use in the engineering practice, systems of differential equations, notion for partial differential equation, vector analyses, curve and surface integrals, Theorems of Green Stocks and Gauss Ostrogradski, [11].

From the above it is obvious that the curricula in Mathematics at the Faculty of Mechanical Engineering in Nis and Skopje beside that are being more compatible between each other a lot more address the necessity of the mathematical knowledge of the students in engineering, compared to curriculum at the department of the Mechanical Engineering at the university in Bitola.

Hence their students can acquire the necessary knowledge in Mathematics and they can use appropriate methods of studying the engineering subjects like mechanics, automatics thermodynamics.

The comparative analyses shows that teachers at the Faculty of Mechanical Engineering in Nis and the Faculty of Mechanical Engineering UKIM in Skopje have spent twice or once and a half more time in lessons i.e. time spent with the students in the classroom than the teachers at the department of Mechanical Engineering in Bitola. Taking into consideration that the time spent in the classroom is of special significance for the students in teaching mathematics, it is clear the enormous advantage of the teachers at the Faculty of Mechanical Engineering in Nis and the Faculty of Mechanical Engineering UKIM in Skopje, although their curriculum contains 30% more contents. Besides that, the work of the teachers at the Faculty of Mechanical Engineering Bitola is burdened with the fact that in general they work with students who have lower prior knowledge in Mathematics. Therefore for these students is extremely difficult to attend strongly tight curriculum in Mathematics. Besides that, those 30% of the mathematical contents that are missing in the curriculum in Mathematics are disabling the students and they also create frustration with the students because later the students cannot understand the more complex engineering concepts and theories. Additional obstacle in acquiring successful teaching of Mathematics is the lack of professionals in teaching like student teaching assistants and teaching assistants.

That lack stands out even more because of the incompatibility of the curriculum of Mathematics at the department of Mechanical Engineering with the other departments at the Faculty of Technical Sciences in Bitola and not having the possibility for proper distribution of the number of groups and teachers.

From our experience and our work until now we can deduce (general) conclusion that the knowledge and skills acquired in Mathematics at very big part of our students are not at the satisfactory level for them to be able to attend the lessons in Mathematics successfully and to use it in learning other subjects. Beside that the students at the department of Mechanical engineering do not study important mathematical contents such as: differential equations in higher order curve and surface integrals, complex analyses that would enable to the students to acquire necessary knowledge and teaching methods of the

engineering subjects (mechanics, automatics, thermodynamics,...).Therefore very often we are being criticized by the colleagues in the next academic years that the students are not prepared to attend their subjects. Yet, that critic is not constructive nor of real benefit for the students. There, we can say it is about a discontinuity of the systematic study of the mathematical topics.

PROPOSALS AND PRESENTATION OF THE SOLUTIONS FOR PARTIAL OVERCOMING OF THE PROBLEMS PRESENTED

Our efforts for improving of the quality of teaching mathematics at the department of Mechanical engineering at the Faculty of Technical Sciences Bitola never stopped, but very often those efforts were not even considered and very often they were even completely ignored. At the same time we were adduced that we have to accept the reality of the importance of the necessity of enrolling certain number of students, which was literally related to the financial survival of the Faculty of Technical Sciences Bitola. That was complemented with the unsurpassable reality of the essentially low expected level of the mathematical prior knowledge at the future students, in consequence and their expected resistance towards the usual number of the mathematical subjects and the expected volume of the appropriate contents for engineer studies. Nevertheless, on our pleasure that kind of rhetoric and the attitude to our remarks concerning the number of the classes and the volume of the mathematical contents has undergone a change, partially because of the fact that at the bigger part of the academic staff the awareness was risen about the significance of our remarks and the need for the changes proposed. This has happened mostly because of the greater openness and cooperation of the university with different companies from the state sector and private sector.

Cooperation on different projects, granting scholarships to great number of students as well as the student exchange with the universities abroad has even more emphasized the necessity of quality engineer professionals, which is impossible to be achieved without quality mathematical education. All that has contributed our long-term proposals not to be only taken into consideration, but finally to be accepted in goodwill. In that way we have succeeded all our analyses and views of Mathematics curricula at the Faculties of Mechanical

engineering and also from other Universities in the country and out of the country to be presented in proposals and changes in the curricula of Mathematics.

With the last accreditation made, the changed curricula will be able to be used in the academic year 2022/23. According to this accreditation the total number of the classes is increased from 10 to 18 in three mathematical subjects Mathematics I, II, III which will be taught in weekly fund of classes 3+3.

We strongly believe that these solutions will contribute our students to acquire quality and modern engineer education based on solid mathematical knowledge and skills. In that way the department of Mechanical engineering at the Faculty of Technical Sciences will be able to be proud of the engineers that graduate there.

CONCLUSION

As direct participants in the higher educational system in our country in the last 18 years we could not realize in total our ideas and possibilities in the so called ECT system. Mainly in the previous accreditations we have not been consulted at all about organizing the teaching in subjects in the field of Mathematics ,therefore we cannot agree or accept completely not even one of the previous accreditations as appropriate. Here we can see one of the basic oversights that is being done in our higher educational process independently from us as Mathematics teachers, authors of this paper. This kind of situation has created a line of damaging consequences for the students, teachers and the higher education system in general, as it was presented in the text above. Beside all the problems enlisted that we have been dealing with we have succeeded to keep satisfactory level of the quality in teaching mathematics to our students. That was achieved most often by additional work with the students in the classroom, out of the curriculum with additional homework for individual work and checking of the homework, teaching additional seminars on the contents which were not predicted in the curriculum but which we considered to be necessary. All these activities were conducted by spending enormous part of our free time as well as of the students' free time.

We are hoping that the new accreditation and the appropriately accepted changes will enable us more relaxed approach in realization of teaching

mathematics in terms that now we would have almost double more time spent with the students in the classroom; as well as the changes made in the curriculum will enable even distribution of the number of the students in groups, something which was impossible with the old curriculum. Additionally the added contents will enable to the students in the higher academic years to understand the engineer subjects more easily.

Our efforts in the future will be focused on raising the quality of the mathematical education of our students and also their engagement in our scientific research in the field of the mathematical sciences and their application. We would be especially happy if we achieve the latter because in our experience so far we have very little examples of that unfortunately. Also our aim will be engaging the teachers of mathematical subjects in science research projects of our colleagues, engineers.

We are hoping that with this paper we will contribute for more complete picture of the situation in the mathematical education at one part of the faculties of technical sciences, as well as to cause greater debate among the colleagues in order to improve the quality of the engineers.

BIBLIOGRAPHY

1. Котевска Е., Чаламани С., Соколоски П., Северин-Кузмановска М., *Математика од основно образование до факултет-дали сме ланец или посебни алки?*, Меѓународна конференција за образованието по математика, физика и сродни науки, 27-28 септември, Скопје, ISBN: 978-608-4711-09-4, pp. 287-294, 2019
2. Информатор на Технички факултет Битола, јуни 1996-1998
3. Информатор на Технички факултет Битола, април 2006
4. Информатор на Технички факултет Битола, јуни 2012
5. Информатор на Технички факултет Битола, јуни 2017
6. <file:///C:/Users/Sonja/Downloads/Zbornik%20PAP%20-%20ANG.pdf>
7. https://www.fs.unilj.si/en/educational_process/first_degree_rrp/program_information/?fbclid=IwAR3TUAARGrSxqfA0NA_jsB0rZFTgtp4ZuqouyRz-UnqptlTxpda5DOEiiE
8. <https://www.fsb.unizg.hr/upisi/noviprogram/Nastavni%20program%20L-Web.pdf>

9. https://www.mas.bg.ac.rs/_media/studije/vodic.pdf
10. <http://www.masfak.ni.ac.rs/index.php/sr/2015-03-03-09-42-14/2015-03-03-09-58-58/shins-inz-nj-rs-v>
11. <https://www.mf.ukim.edu.mk/mk/pi>