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# MATHEMATICS AT VŠB – TECHNICAL UNIVERSITY OF OSTRAVA YESTERDAY AND TODAY

## 30.1 INTRODUCTION

"The queen and servant of science" - this is how mathematics was written about in the popular and daily press in the not-too-distant past, if math was ever mentioned. At the same time, only those who were competent from the point of view of profession or education wrote about mathematics. The need to be educated in mathematics was taken as the fact about which there was not any discussion. Similarly, it was natural that applicants for study at technically-oriented higher education institutions received good grades in mathematics in the framework of school-leaving examinations, and the school-leaving examinations also included physics and descriptive geometry. In international comparison, educational attainments of secondary school students corresponded to this.

In recent decades, the situation has however changed dramatically. Mathematics is written about in the daily press frequently, everybody feels competent. Mathematics is often described as a boring, difficult and stressing subject and, according to a number of writers, useless. The reason for such boom is discussions about the compulsory school-leaving examination in math.

Yes, for hair stylists with the school-leaving examination, for graduates from medical secondary schools, conservatories and many other secondary schools with the school-leaving examination, the school-leaving examination in math is useless. Unfortunately, also these candidates for the school-leaving examination can apply for studying at technical higher education institutions. This by itself would not be so bad. What is bad is the fact that candidates for the school-leaving examination are not forced into supplementing their knowledge according to the requirements of the higher education institution (HEI), but that HEIs adapt their requirements to poor knowledge of the graduates. HEIs are put into a difficult situation.

The network of HEIs is overdesigned and HEIs are thus forced to struggle for students. The system of HEI financing supports doing so. A number of higher education institutions (awarding the degree Ing.) lure applicants by means of statements, such as „The admission procedure has the form of a motivational interview aimed at determining the applicant's

qualifications and motivations for study. In the case of Bachelor's degree study, neither tests, nor examinations are required. The admission procedure from April to October every month in the form of a motivational interview with the study advisor.". This only means implicitly that there is no need to worry about mathematics.

Technical higher education institutions that do not pander thus find themselves in a very difficult situation. For many years they have fought with little interest in technical fields. That is why also those applicants who have not sufficient qualifications for successful study or are not interested in technical fields but who come because they have not been admitted to other higher education institutions are admitted to technical higher education institutions.

## 30.2 EUROPEAN SOCIETY FOR ENGINEERING EDUCATION (SEFI)

In addition to the ministries of education, many non-governmental organizations are concerned with engineering education. One of them is the European Society for Engineering Education (SEFI) seated in Brussels; it was founded in the year 1973. The objective was to improve, on the basis of discussion, engineering education so that it might reflect scientific and technical progress and take into account the needs of industry. SEFI implements diverse activities such as Annual Conferences, Ad hoc seminars/workshops organized by its thematic working groups, organizes specific activities for the Engineering Deans, publishes a series of Scientific publications (European Journal of Engineering Education) and Position Papers, is involved in European projects, cooperates with other major European and international associations and international bodies.

One of working groups of SEFI is the Mathematics Working Group (SEFI-MWG), established in the year 1982. One of aims of SEFI-MWG was to formulate a core curriculum in mathematics for the European engineer. Four working subgroups were created, namely for mathematical analysis, linear algebra, discrete mathematics and probability and statistics.

### 30.2.1. First version of A Core Curriculum for the European Engineer

In the year 1990, the Curriculum consisting of about 220-320 lessons was published; this is, according to the authors, the absolute minimum of basic mathematical knowledges in engineering study at all European universities. Into this number, neither preparatory study, nor optional lectures were included.

The curriculum was based on the basic idea that engineers need not be and maybe should not be experts in mathematics, but they should be able to

- solve and explain standard problems, requiring direct minimal applications of mathematics and statistics,
- understand the literature, containing direct minimal applications of mathematics and statistics,
- understand basic mathematical models of engineering problems (differential equations with boundary and initial conditions, data analysis, simulation) and interpret solutions to these problems.

The curriculum was divided into three levels: pre-requisite knowledge (level zero), basic curriculum (level one) and optional (extension) curriculum (level two).

The curriculum took into account specifics of education in individual countries (different lengths of study, different pre-requisite knowledge, etc.). It should be noted that according to the curriculum, engineering mathematics should be taught by the department of mathematics.

In our opinion, this first core curriculum was affected too much by massive invasion of computers not only to the human life but also to education.

### 30.2.2. A Framework for Mathematics Curricula in Engineering Education

The core curriculum was the basis for further work of the Mathematics Working Group. The curriculum was gradually improved and extended. In the year 2013, SEFI issued A Framework for Mathematics Curricula in Engineering Education [2]. Especially an introductory part Goals and Use of the Curriculum Document was extended. Part General Mathematical Competencies for Engineers explains terms such as mathematical thinking, proofs, solving problems, modelling, handling mathematical symbols and formalism for engineers.

The curriculum itself was extended substantially as well. It was divided into four levels: Core Zero – pre-requisite knowledge, Core – essential level, Electives – optional parts, Specialist Modules – extending parts. Implementation of computers in teaching, which is taken for granted, is emphasized no longer. However, the role of teachers and teaching methods is emphasized.

The curriculum at all levels is elaborated in detail. The whole document has 86 pages (in comparison with 27 pages of the original Core Curriculum).

At present the importance of the Curriculum grows in connection with a substantial increase in student and teacher mobility. If a binding curriculum of core courses existed for all higher education institutions educating engineers, any problems associated with mutual recognition of examinations would not exist. For instance, an excellent student, travelling in the framework of Erasmus to a foreign country, will improve his or her knowledge of the foreign language, but simultaneously he or she will often lose a year of study only because required examinations will not be recognized.

## 30.3 EXTENT OF MATHEMATICS LESSONS

### 30.3.1 Changes in the extent of mathematics lessons at VŠB–Technical University of Ostrava

According to the Curriculum, the number of lessons in mathematics for future engineers should be 220 – 320 as a minimum. Because we have been working at the Department of Mathematics and Descriptive Geometry for more than forty years, we are able to observe changes in the extent of teaching at our university.

Forty years ago, the number of lessons in mathematics was above the recommended limit. Still twenty years ago, in the academic year 1997/98, mathematics was taught by our department at the Faculty of Mining and Geology in 375 lessons. At the Faculty of

Mechanical Engineering, the number was even higher. Since then, however, the number of lessons has been gradually decreased. What are the main reasons?

- In the eighties of the last century, the engineering study was reduced for political reasons from 5 to 4 years. In the education plan, it was necessary to move the teaching of specialized subjects to lower classes especially at the expense of mathematics.
- After revolution in the year 1989, efforts to humanize education emerged. In secondary schools, teaching of humanities is extended at the expense of subjects of natural science. This manifests itself gradually both in the decreased interest of future students of higher education institutions in technical fields of study and in the lower pre-requisite level of knowledge of mathematics [1]. In most cases, students already were not able to master the curriculum in the original extent. For this reason, the content must have been reduced and less difficult tasks must have been solved. Preparatory courses and in the first semester refresher courses are offered to students with a view to repeat and practice the secondary-school knowledges needed for teaching mathematics at higher education institutions.
- In the academic year 2003/04, transition to the teaching plans of structured study took place. The study is divided into Bachelor's degree study – Master's degree study – Doctoral degree study. Bachelors, graduating from the usually three-year Bachelor's degree study, should have at least basic specialized knowledge. Thus the pressure on inclusion of specialized subjects into even the first years of study is generated. Because the number of lessons per week can be increased no longer, this is done especially at the expense of subjects of the theoretical base, and thus mathematics as well. The problem is also solved by transferring one semester of teaching of mathematics to the Master's degree study. This brings certain problems, when students have partially forgotten the curriculum from the first two semesters or when those parts of mathematics are taught that they could already use in their Bachelor's theses.
- In several recent years, also full costing has had negative influence on the extent of teaching. Individual faculties purchase lessons from all-University workplaces and other faculties. The efforts of individual faculties to save on payments to foreign entities are clear. For this, several ways are used. One of them is the possibility of decreasing the number of credits for some course (e.g. Mathematics for Architects at the Faculty of Civil Engineering). Another way is transfer of the subject to be included into optional subjects; then only a few students will select it and gradually the subject will disappear completely from the teaching plans. Thus the teaching of numerical methods was removed. Another method is a change in the name of the subject and the curriculum in order the staff of the faculty could teach it and there might be no need to purchase the teaching. Our department has taught the subject Algorithms and Programming. In the newly accredited study plans, subjects Computer Laboratory, Technical Computations or Technical Informatics, where the fundamentals of Word, Excel and using other specialized programs are taught, appear. The most of the faculty staff are, of course, able to master this and then any purchase from specialized workplaces is not necessary.

### 30.3.2 Current state of teaching of mathematics at individual faculties

At present, our Department of Mathematics and Descriptive Geometry ensures the teaching of mathematics at 5 faculties of VŠB-Technical University of Ostrava (HGF - Faculty of Mining and Geology, FMMI - Faculty of Metallurgy and Materials Engineering, FS - Faculty of Mechanical Engineering, FAST - Faculty of Civil Engineering, FBI - Faculty of Safety Engineering). The Faculty of Electrical Engineering and Computer Science and the Faculty of Economics have their own departments of mathematics. The current total number of lessons in mathematics in the Bachelor's degree study and the Master's degree study is given in Table 30.1

**Table 30.1** Teaching of mathematics

| | Faculty of VŠB-TU Ostrava | | | | |
|---|---|---|---|---|---|
| | HGF | FMMI | FS | FAST | FBI |
| Bc. | 168 | 182 | 224 | 182 | 196 |
| Mgr.*) | 56 | 70 | 56 | 56 | 56 |
| total | 224 | 252 | 280 | 238 | 252 |

*) Mathematics Master's degree is taught only in some selected fields of study.

It can be seen that in the past 20 years, the number of lessons in mathematics ensured by our department has decreased by 25 – 40%. This must have necessarily manifested itself in the content of the basic course on mathematics (30.4).

## 30.4 ACTUAL CURRICULUM ON VŠB – TECHNICAL UNIVERSITY OF OSTRAVA

### 30.4.1 The SEFI Curriculum and VŠB – Technical University of Ostrava

Although it is emphasized in Introduction that the Curriculum covers the absolute minimum of mathematics, not all is included in the curriculum in mathematics at VŠB – Technical University of Ostrava. Limiting factors are the level of pre-requisite knowledge of admitted students (downward tendency) and the number of lessons available (see below).

Furthermore, pre-requisite knowledge of admitted students, which is often very divorced from the expected level zero, causes problems.

As a consequence, merely the essential, most important knowledge without details is taught in linear algebra, analytical geometry and mathematical analysis. Some parts (solution of nonlinear equations, mathematical logic, mathematical induction, linear spaces and their transformations, Fourier series, surface integral, etc.) are not included in teaching at all.

### 30.2.4. Mathematics Curriculum Yesterday and Today on VSB-TU Ostrava

There are differences not only in the Curriculum requirements but also in the content of the curriculum earlier and today. To show an abysmal difference between the curriculum in mathematics almost forty years ago and the present mathematics curriculum, we give the content of the basic course on mathematics at VŠB in the year 1979 [4]. Those parts that are not today included in the content of the course at the majority of the faculties of VŠB – Technical University of Ostrava are indicated in italics.

1. *Logic and sets*
   *a) the language of mathematics;*
   *b) propositional calculus;*
   *c) basic of set theory;*
   *d) basic properties of number sets and functions;*

2. Algebra and geometry
   a) basic matrix operations, determinants, algebraic equations, systems of linear algebraic equations, etc.;
   *b) basis properties of finite dimensional linear spaces and linear mapping;*
   *c) basic properties of linear space with dot (inner) product ;*
   d) analytic geometry of linear and *quadratic* forms in plane and space;

3. Differential calculus
   a) limit, continuity, derivative and differential, real functions of one variable with theory and calculus;
   b) limit, continuity, partial derivative and total differential of functions of several variables with theory and calculus;
   c) behaviour of functions of one and several variables;
   d) *basic properties of real functions defined by implicit form with applications;*

4. Integral calculus
   a) primitive function and Newton integral with methods of calculations;
   b) Riemann definite integral of real function of one real argument;
   c) basic properties of Riemann integral, methods of calculation with applications for functions of one real and several real arguments ;
   d) concepts, basic properties and methods of calculation of line integrals and *surface integrals;*
   e) *basic theorems and methods of vector analysis;*

5. Series
   a) Number series and *convergence criteria;*
   *b) series of functions, in particular power series and Taylor series;*
   *c) Fourier series;*

6. Differential equations
   a) elementary solution methods for ordinary differential equations;
   *b) existence and uniqueness theorem for ordinary differential equations and its systems;*
   *c) properties and solution methods for systems of ordinary differential equations;*
   *d) basic properties and solution methods of boundary value problem for ordinary differential equation;*
   *e) solution methods for partial differential equations, in particular partial differential equations of second order;*
7. *Complex analysis*
   *a) concept and basic properties of analytical functions;*
   *b) conformal mapping methods;*
   *c) integral of a complex function and application Cauchy theorem;*
   *d) concept singular point of complex function, its properties and Laurent series;*
   *e) residue function and its application;*

8. *Integral transformations*
   *a) basic properties, application Laplace transformation and inverse Laplace transformation;*
   *b) basic properties Fourier transformation and Fourier integral with applications;*

9. Probability and statistics
   a) concept random event, sample space and probability definition;
   b) random variable and random vectors, random variable distribution and transformation;
   c) expected value and its properties, *characteristic function of random value and random vectors;*
   d) elements of mathematical statistics;

10. *Numerical methods*

11. *Computer programming*

The last two chapters have been omitted from curriculum. They are taught as an option only for selected fields of study.

## CONCLUSION

The contribution deals with changes in the content and extent of teaching of mathematics at five faculties of VŠB-Technical University of Ostrava. In the past 20 years, the number of lessons in mathematics has decreased by 25 – 40% at individual faculties, which must have been reflected on the content of curriculum. Owing to the smaller number of secondary school graduates, lesser interest in technical universities and the lower level of preparedness of students, the level of preparedness of students for mastering the curriculum decreases especially in the first two semesters.

What remains is to pose a question to ourselves how to get out of this vicious circle. We are afraid that such a question cannot be today answered at our level reliably. Remedy must be established especially on the part of the state administration. Maybe the introduction of a

state school-leaving examination is a harbinger in this regard. The state school-leaving examination will certainly lead to an increase in the level of knowledge of mathematics on the part of applicants for study in higher education institutions. It will make it possible for higher education institutions to be concerned with technical university mathematics, including so needed technical applications for which there is not enough time today.

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## MATHEMATICS YESTERDAY AND TODAY ON VSB-TU OSTRAVA

***Abstract:*** *The authors compare mathematics curricula at VŠB - Technical University of Ostrava in the year 1979 and at present. They compare the extents and the contents of the curriculum, numbers of lessons and above all the preparedness of students for applications in engineering practice. Reality is compared with the requirements of the European Society for Engineering Education (SEFI) in the material A Framework for Mathematics Curricula in Engineering Education.*

***Keywords:*** *SEFI, mathematics curriculum, mathematics education*

## MATEMATIKA VČERA A DNES NA VŠB-TU OSTRAVA

***Abstrakt:*** *Autoři srovnávají osnovy předmětu matematika na VŠB TU Ostrava v roce 1979 a v době současné. Porovnávají rozsah a obsah učiva, hodinové dotace a hlavně připravenost posluchačů pro aplikace v technické praxi. Skutečnost je srovnávána s požadavky Evropské společnosti pro inženýrské vzdělávání v materiálu Základní curriculum z matematiky pro evropského inženýra.*

***Klíčová slova:*** *SEFI, osnovy matematiky, výuka matematiky*

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