APPLIED MATHEMATICS IN THE CONTEXT OF TECHNICAL EDUCATION

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Abstract

At the faculties of technical universities, teaching of mathematics should be aimed at the development of students' abilities to apply their knowledge of mathematics to the technology, mathematical modelling as well as numerical solutions of engineering problems. Within the structuralization of university studies, the subject Applied Mathematics, which has been introduced to the freshmen engineering studies at the Faculty of Manufacturing Technologies in Prešov, supplies a suitable space for it. Emphasizing the effectiveness of technical education at universities and applicative character of mathematical disciplines, the paper presents the implementation of technical applications as well as ICT to the teaching of applied mathematics.

Key words: technical education , technical universities, applied mathematics, mathematical modelling, numerical methods, ICT, MS Excel.

1 Introduction

The structuralization of university studies at faculties of technical universities has brought about changes to Study Plans of both bachelor and engineering studies. This especially refers to subjects based on essentials of natural science, primarily mathematics. At many faculties of technical universities in the SR, within bachelor studies some compulsory mathematical subjects were cancelled and the remaining subjects are taught with a reduced number of classes, thus the introduction of mathematics to the first year of engineering studies can be considered a partial compensation. At the Faculty of Manufacturing Technologies of the Technical University in Košice with the seat in Prešov, a compulsory subject Applied Mathematics has been introduced to the 1st year of engineering studies (2 lecture classes/2 practical classes per week). In winter semester of the academic year 2008/2009 the teaching of this subject to the first graduates of bachelor studies began.

The possibilities of the implementation of technical applications as well as ICT to the teaching of Applied Mathematics are presented in the article with the aim to contribute to the effectiveness of technical education at the faculties of technical universities. We also bring some views on the teaching of the mentioned subject based on our first teaching experience gained within the so called practical classes in computing.

2 Content of Applied Mathematics and ICT Implementation

Based on the information sheet of the subject "Applied Mathematics" we can find out that lectures and practical classes are aimed at students acquiring theoretical and practical knowledge of selected numerical methods and statistics provided that they will be able to use it in algorithms design and application to the solution of specific tasks with PC support. The subject "Applied Mathematics" gives space also to innovative approaches to the teaching by means of ICT implementation as well as new teaching forms. Practical classes exclusively take place in computing classrooms which owing to a complexity of mathematical calculations in technical applications is inevitable and natural. Among basic advantages of a computer-aided teaching of Applied Mathematics we can include increase in students motivation, high graphical and display possibilities of current PCs which enable relations visualization and simulation, but especially a partial or even a complete elimination of a routine work and demanding and time-consuming calculations (mainly regarding numerical methods) [1].

3 MS Excel in Applied Mathematics

When solving specific tasks at practical classes in Applied Mathematics at the Faculty of Manufacturing Technologies, an appropriate computing equipment is used, at present it is mainly MS Excel. Its indisputable advantage is an easy availability or a simpleness of work in MS Excel environment. It is not difficult to work in this environment even for those students who so far have not had any experience with it. Obviously, for our work at practical classes we could choose some other programs of CAS, for example MATLAB. But due to the fact that MATLAB is at the Faculty of Manufacturing Technologies an optional subject of bachelor studies, we could not rely on all students' ability to work with this mathematical program. A considerable part of students would be disadvantaged at practical classes. Their active participation in a teaching-learning process due to their disability to algorithmize a related method in MATLAB would be almost impossible. Therefore ME Excel seemed to be a more suitable choice.

Students' enthusiasm resulting from the possibility of using MS Excel to solve tasks was evident as early as they started solving tasks of introductory topics of Applied Mathematics (functions approximation, numerical methods of nonlinear equations solution, solution of systems of linear and nonlinear equations, numerical calculation of integral, …). Students appreciated the possibility of graphical interpretation and they realized that many time- consuming calculations can be carried out by MS Excel instead of them. It turned out, however, that some students too much relied on computing technique and underestimated their theoretical knowledge. This resulted in difficulties to interpret the results obtained in Excel. This occurred when passing written tests during semester as well as at examinations. Individual topics and included tasks for solving at practical classes were chosen in order to emphasize the utilization of applied mathematics and computing support in technical practice. Let us present now a specific example to show some advantages and disadvantages of a computer-aided teaching of Applied Mathematics.

In technical practice, it is often required to approximate (substitute) the measured values by a function which would as good as possible express a dependence between measured values. The advantage of an approximation by the method of least squares (MLS) is that an approximation polynomial does not necessarily pass through all node points (measured values), and that is a user who can determine a degree of a polynomial. This has a great importance considering a technical practice, where a higher number o values is measured. The following example illustrates our effort to elucidate problems of a technical practice to our students.

When working a material, an influence of some parameters on a resulting roughness of a worked surface appeared. The influence of a current $I[\mathrm{A}]$ on a roughness Ra was recorded according to the table 1, where a variable x represents a current $I[\mathrm{A}]$ and a variable y represents a roughness Ra. Using the method of least squares determine a linear hyperbolic dependence as well as indices of a function correlation $f(x)$ given by the table.

Table 1

x	0,2	0,3	0,5	0,5	0,7	0,8
y	15,6	15,4	15,1	15,2	14,9	14,9

When explaining theoretical essentials of the MLS at practical classes, we start with the derivation of a linear dependence of the MLS. With the functions approximation by the MLS we search for the function $y = f(x)$; i.e. for a linear dependence $y = a_1 x + a_0$ so that a sum of squares of deviations

$$S = \sum_{i=1}^{n} \left(f^*(x_i) - f(x_i) \right)^2 \qquad (1)$$

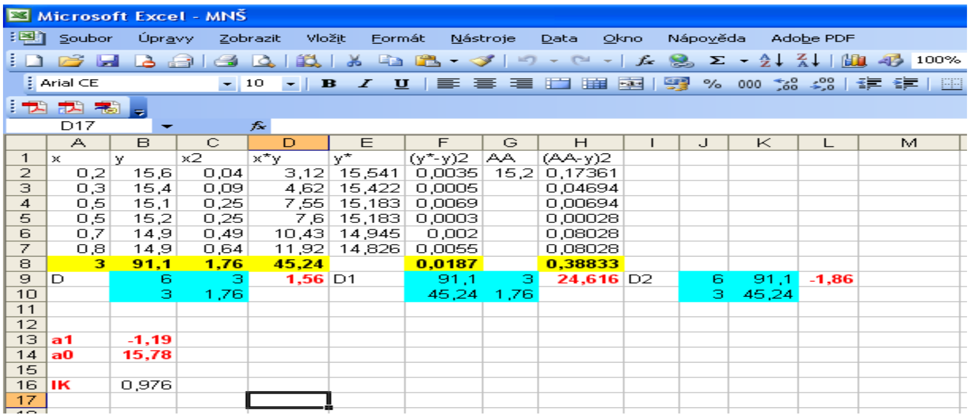
is minimal. At the same time, $f^*(x_i)$ represents a real function, in our case $y_i^* = f^*(x_i) = a_1 x + a_0$; $y_i = f(x_i)$ represents the measured values [3]. According to (1) in a linear dependence for a sum of squares of deviations it is valid:

$$S = \sum_{i=1}^{n} \left(a_1 x_i + a_0 - y_i \right)^2 \qquad (2)$$

As this sum has to be minimal, we search for the minimum of the function (2). When calculating the sums $\sum_{i=1}^{n} x_i$, $\sum_{i=1}^{n} x_i^2$, $\sum_{i=1}^{n} y_i$, $\sum_{i=1}^{n} x_i y_i$ it is suitable to use MS Excel. As it can be seen in fig. 1, for our example these sums are calculated in the line 8 (based on the values of the columns A – E). We can write down a system of linear equations for our example:

$$\begin{aligned} 6a_0 + 3a_1 &= 91{,}1 \\ 3a_0 + 1{,}76a_1 &= 45{,}24 \end{aligned} \qquad (3)$$

Based on the system (5), by the help of Cramer's rule we obtain $a_0 = \dfrac{D_1}{D}$, $a_1 = \dfrac{D_2}{D}$. Also when calculating determinants D, D_1, D_2 we advantageously utilized in Excel inbuilt function DETERMINANT, see fig. 1. For the calculation of coefficients a_0, a_1 in the cells B13 and B14 it is sufficient to write down into these cells related formulas, into B13: =L9/D9, into B14: = H9/D9.



	A	B	C	D	E	F	G	H	I	J	K	L	M
1	x	y	x2	x*y	y*	(y*-y)2	AA	(AA-y)2					
2	0,2	15,6	0,04	3,12	15,541	0,0035	15,2	0,17361					
3	0,3	15,4	0,09	4,62	15,422	0,0005		0,04694					
4	0,5	15,1	0,25	7,55	15,183	0,0069		0,00694					
5	0,5	15,2	0,25	7,6	15,183	0,0003		0,00028					
6	0,7	14,9	0,49	10,43	14,945	0,002		0,08028					
7	0,8	14,9	0,64	11,92	14,826	0,0055		0,08028					
8	3	91,1	1,76	45,24		0,0187		0,38833					
9	D	6	3	1,56	D1	91,1	3	24,616	D2	6	91,1	-1,86	
10		3	1,76			45,24	1,76			3	45,24		
11													
12													
13	a1	-1,19											
14	a0	15,78											
15													
16	IK	0,976											
17													

Fig. 1: *The calculation of coefficients of linear dependence of the MLS in Excel.*

If we want to find out how close to the measured values a related line (a graph of a linear dependence), or a hyperbola (a graph of a hyperbolic dependence) is lying, or, in other words, what the approximation quality is, it is necessary to calculate the correlation index I_K. In our case, in the cell B16 for a linear dependence $y = -1{,}19x + 15{,}78$ the correlation index $I_K = 0{,}976$ is calculated. for a hyperbolic dependence $y = \frac{0{,}188}{x} + 14{,}712$ is $I_K = 0{,}9635$ lower. A linear dependence thus approximates the measured values more accurately.

MS Excel is able to create graphs of various types in a very simple way based on the calculated data. A graphical interpretation of the results enables students to self check if the graph of the searched dependence (function) really is close to the measured values. In order to prevent students from exclusive relying on the strength of a computing technique, at practical classes, but especially in written tests during semester, it is required that they have a good knowledge of theoretical essentials and the algorithm of the given method.

4 Conclusion

Finally, we can state that introduction of technical applications to the teaching of Applied Mathematics has its grounds. Students were motivated to be successful when solving tasks related to the environment of technical practice, topics of diploma theses including. We can also state that the utilization of information technologies in the education process, in particular within the teaching of Applied Mathematics, significantly contributes to making students and teachers work easier and more effective. In computer-aided teaching of the given subject advantages prevail over disadvantages (the latter can be eliminated). Information technologies improve teachers work even in the phase of the teaching process preparation and also during its realization.

5 Literature

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