ICT IMPLEMENTATION TO THE EDUCATION OF APPLIED MATHEMATICS

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Abstract

The author of the paper deals with the problems of applied mathematics teaching at technical universities. Emphasizing the effectiveness of technical education at universities and applicative character of mathematical disciplines, the paper presents the implementation of ICT as well as technical applications to the teaching of applied mathematics in the context of innovative approach to the teaching.

Key words: applied mathematics, ICT, numerical methods, approximation, MS Excel

1 Introduction

It is evident that within the teaching of mathematics at technical universities it is necessary to develop students‘ abilities to apply the acquired knowledge of mathematics to their study branches. We have in mind not only professional subjects that are being acquired during university studies, but even a period of technical practice. 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. For example through applicative tasks or numerical solution of problems preferably related to engineering practice. 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. The intention of the article is to present some possibilities of ICT implementation to the teaching of Applied Mathematics as well as to bring some views on the teaching of the mentioned subject based on our teaching experience gained within the so called practical classes in computing.

2 Computer –aided teaching of Applied Mathematics

When solving specific tasks at practical classes in Applied Mathematics, appropriate computing equipment is used, at present it is mainly MS Excel. The program Microsoft Excel is often characterized as a very efficient tool with a wide range of utilization. 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. 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. Let us present now a specific example to show some advantages and disadvantages of a computer-aided teaching of Applied Mathematics.

3 Functions Approximation with MS Excel Utilisation

In technical practice, it is often required to approximate the measured values by a function which would as good as possible express 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 cutting depth a_p [mm] on surface roughness profile parameter Rz was recorded according to the table 1, where a variable x represents a cutting depth a_p [mm] and a variable y represents a parameter Rz. 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: *function correlation* $f(x)$.

x	0,3	0,5	0,7	0,8	1	1,5
y	14,32	13,68	13,21	12,53	11,2	10,66

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

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

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:

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

As this sum has to be minimal, we search for the minimum of the function (2). It is the function of two variables, it means that we need to calculate partial derivations $\frac{\partial S}{\partial a_0}, \frac{\partial S}{\partial a_1}$. After a modification we obtain a system of linear equations (SLE)

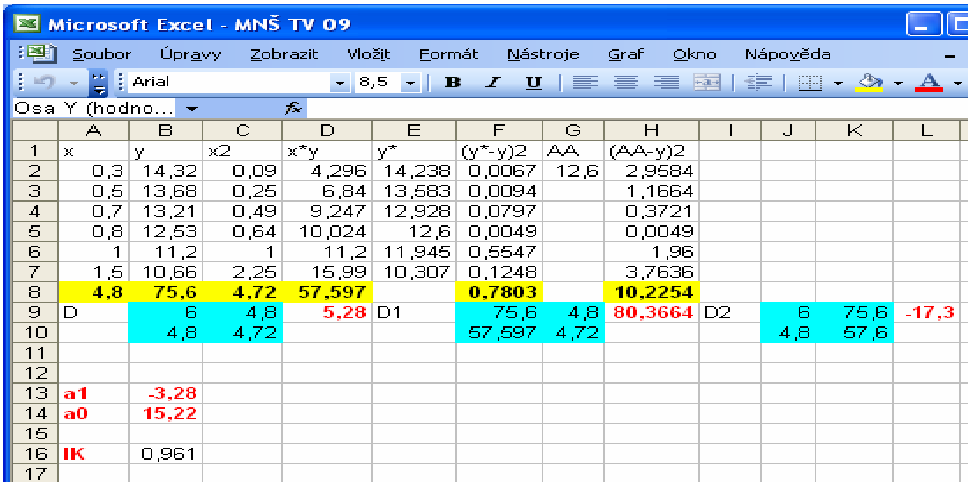
$$\begin{aligned} a_0 \sum_{i=1}^{n} 1 + a_1 \sum_{i=1}^{n} x_i &= \sum_{i=1}^{n} y_i \\ a_0 \sum_{i=1}^{n} x_i + a_1 \sum_{i=1}^{n} x_i^2 &= \sum_{i=1}^{n} x_i y_i \end{aligned} \tag{3}$$

where $\sum_{i=1}^{n} 1 = n$, which is the number of the measured values. Through the solution of the SLE (3) we obtain a polynomial of the first degree $y = a_1 x + a_0$, i.e. a linear dependence.

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). According to (3), we can write down a system of linear equations for our example:

$$\begin{aligned} 6a_0 + 4{,}8a_1 &= 75{,}6 \\ 4{,}8a_0 + 4{,}72a_1 &= 57{,}59 \end{aligned} \qquad (4)$$

Based on the system (4), by the help of Cramer's rule we obtain $a_0 = \frac{D_1}{D}$, $a_1 = \frac{D_2}{D}$. 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
1	x	y	x2	x*y	y*	(y*-y)2	AA	(AA-y)2				
2	0,3	14,32	0,09	4,296	14,238	0,0067	12,6	2,9584				
3	0,5	13,68	0,25	6,84	13,583	0,0094		1,1664				
4	0,7	13,21	0,49	9,247	12,928	0,0797		0,3721				
5	0,8	12,53	0,64	10,024	12,6	0,0049		0,0049				
6	1	11,2	1	11,2	11,945	0,5547		1,96				
7	1,5	10,66	2,25	15,99	10,307	0,1248		3,7636				
8	4,8	75,6	4,72	57,597		0,7803		10,2254				
9	D	6	4,8	5,28	D1	75,6	4,8	80,3664	D2	6	75,6	-17,3
10		4,8	4,72			57,597	4,72			4,8	57,6	
11												
12												
13	a1	-3,28										
14	a0	15,22										
15												
16	IK	0,961										
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, it is necessary to calculate the correlation index I_K. When calculating the correlation index in our example, we added the columns F-H to the table in Excel, where "AA" means arithmetical average of the values y_i. The use of MS Excel program with these calculations assumes that students have already acquired a relative and absolute reference. As we know, for the correlation index it is valid that $I_K \in \langle 0,1 \rangle$ and a higher correlation value expresses a higher accuracy and dependence between a real and approximated function. In our case, in the cell B16 for a linear dependence $y = -3{,}28x + 15{,}22$ the correlation index $I_K = 0{,}961$ is calculated. The calculation of a hyperbolic dependence in Excel is similar because the substitution $u = \frac{1}{x}$ leads us, when searching for a hyperbolic dependence $y = \frac{a_1}{x} + a_0$, to a linear dependence $y = a_1 u + a_0$. For a searched hyperbolic dependence $y = \frac{1,316}{x} + 10,477$ is $I_K = 0,877$ lower. A linear dependence thus approximates the measured values more accurately.

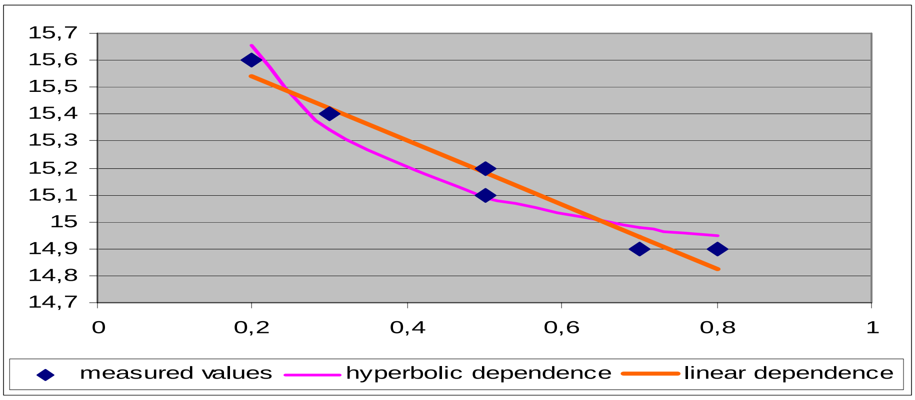


Fig. 3: *Graphical interpretation of linear and hyperbolic dependence of the MLS in Excel.*

4 Conclusion

Based on experience, the following procedure has been approved - a classical explanation, a given task solution, verification if the students cope with the algorithm, utilization of a computing technique with a suitable mathematical software. ICT implementation to the Applied mathematics teaching enables not only to calculate more tasks, but also compare individual methods from the viewpoint of error estimation, promptness, convergence and suitability of the given method. Another undoubted advantage is a graphical interpretation of numerical solution results with a computing support. However, the goal remains that students cope with and master numerical methods to such an extent that they are able to program them independently in any suitable environment of mathematical software.

5 Literature

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