

# What software to use in the teaching of the mathematical subjects?

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## Abstract

We can consider two basic views, when using mathematical software in the teaching of the mathematical subjects.

First: How to learn to use specific software for the specific tasks, e. g., software Statistica for the subjects of Applied statistics, probability and mathematical statistics, or financial mathematics.

Second: How to learn to use the software that is available to us to solve specific mathematical problems from different areas of mathematics and applied mathematics.

My article describes the practical use of the software in the teaching of the mathematical subjects and my experience with its use by the students and the pedagogues.

In our computer laboratory our students use the following software: MS Office (MS Excel), LibreOffice (LO Calc), MATLAB 2010b, Octave, wxMaxima, and LaTeX.

We use this software in the following mathematical subjects: Operational Analysis, Linear and Quadratic Programming, Numerical Mathematics, Applied Statistics, Queuing Theory and Fundamentals of the LaTeX.

Eight years of experience with the usage of these programs have shown us, how we can improve the teaching process of the mathematical subjects at the technical universities with freely available software.

## 1 Introduction

It is very difficult to decide what kind of software is the most suitable to use for teaching the mathematical subjects at technical universities. The best software should be applicable not only for specific tasks but also students should be able to use it on various subjects. It is important for students to have an easy access to get this software for studying at home instead of limited usage of this software for the computers in PC laboratories. We should realize that students frequently use specific types

of software at secondary schools therefore usage of the same or similar software could make easier transition to universities. Considering the fact that there is usually no time or space for teaching the students the usage of specific software while studying mathematical subjects.

I describe in this article, eight years of my experiences of using the software for teaching the subjects at Department of Mathematics and Informatics of Faculty of Electrical Engineering and Informatics and also Department of aerodynamics and simulations, Faculty of Aeronautics, Technical University in Košice. I will evaluate the usage of some applications in various subjects and try to inform about other options and possibilities to use easily accessible software.

## **2 Software used at mathematics at Technical University**

This chapter will be about software that we used and still are using at teaching mathematical subjects at our faculty, Faculty of Aeronautics, respectively. In which subjects was software applicable? What kind of response we received while using it? Finally I will try to explain how to choose the software for teaching mathematical subjects considering experience and possibilities which are available at our faculty and university.

### **2.1 What kind of software**

At the beginning we created a PC laboratory with limited possibilities. Eventually there were more laboratories created and the recent hardware gives us a chance to use variety of software.

There are recently four active laboratories at DMTI and DAaS, all of them provide relatively modern computers with high speed graphic cards, processors and memories. The software installed on computers are:

- (a) MS Office (MS Excel),
- (b) LibreOffice (LO Calc),
- (c) MATLAB 2010b + toolboxes,
- (d) Octave,
- (e) wxMaxima,
- (f) LaTeX.

We prepare infrastructure for usage of computers in laboratories on parallel calculating (including Matlab) and also usage of graphic cards for math calculating and simulation in two laboratories.

The question is, why have we chosen this software and what is the importance of usage of this software teaching mathematical subjects at our faculty. MS Excel from MS Office package and LO Calc from Libre Office package were chosen because classic spreadsheet are part of education at many secondary schools and students are familiar with basic usage of this software. MS Office is very common package widely used at schools because it is financially available. We have also chosen alternative option Libre Office (initially we used Open Office). We have chosen Matlab because

it is frequently used in engineering areas. Future engineers should require basic knowledge while using it. Octave is an alternative option of Matlab. The students can use this program on their own computers even after they finish the university. Program wxMaxima is also an alternative option of Maple or Mathematica program. Program LaTeX was chosen as an easily accessible typographic program for writing mathematical and engineering works. Installation of this program is available in operating systems Windows or Linux which is important. The project of Dr. Jan Busa deals with usage of open source software at universities. It is available on website of Dr. Jan Busa sn.: Project KEGA - 3/2158/04 - New teaching technologies. – Usage of OPEN SOURCE software in teachings at universities.

## **2.2 In which subjects can be software used**

At the beginning we were limited by using computers only in subjects such as Numerical Mathematics, occasionally Probability and Mathematical Statistics. The reason why we only used it in those subjects is the number of students who attended specific courses in the capacity of PC laboratory.

Since I was teaching small specialized groups of students in one PC laboratory I was able to use PC on various subjects. We recently use it in these subjects: Operational Analysis, Linear and Quadratic Programming, Numerical Mathematics, Applied Statistics, Queuing Theory and Fundamentals of the LaTeX. I also use PC software in these subject at Faculty of Aeronautics: Selected chapters from Mathematics, Applied Mathematics and Numerical Mathematics. These subjects mostly consist of numerical mathematics, probability and mathematical statistics and mathematical optimization.

## **2.3 How to use the software**

We initially used program package of Matlab 6.0 (7.0), at that time at our faculty, while using computers teaching numerical mathematics, probability and mathematical statistics. It was a subject of the 2nd year bachelor students. Majority of students didn't have any experience using the Matlab program and they also didn't have an access to this commercial software. We spent a certain amount of time explaining the basics of the Matlab program at the beginning of semester and during the class. The time frame we were supposed to use on specific subject was shortened by explaining the Matlab's basics usage. The whole situation caused time pressure and the overall students results were not significantly improved. Students were not able to use computers because of limited capacity of PC laboratories. The lack of traditional calculator knowledge or lack of effectively organizing estimation without using the computers resulted in numerous problems. Therefore the usage of computers with these subjects was stopped. The computers are recently only used on teacher's request.

During that period of time I have started teaching small groups of students. I have tried to find out how can we use computers in these above mentioned subjects in effective way. I knew I didn't have any extra time to explain the Matlab program in all suitable subjects. I have decided to do a short student survey. I wanted to know what kind of software they are familiar with, what kind of software they use and whether they have any experience with programming. I have chosen the software to be installed on computers in laboratory based on student's survey. I also created rules how to use it. I explained to students that computer's software is an intelligent calculator and I won't be able to monitor PC outcomes. I can only check the staff that is on graph (spreadsheet) in notebook, credit

test or final exam. Since the information in computers didn't influence their final evaluation I made another rule that they can use any available computer software installed in laboratory.

The rules about software usage effected student's choice of math exercises for class, credit test and final exam. I also expected there won't be so many numerical mistakes in regards to students calculations.

### 3 Achievements

During eight years period of time, I observed the usage of the software teaching these mathematical subjects:

- (1) how is software used in students calculations,
- (2) what mistakes disappeared and what mistakes appeared,
- (3) how successful will be taking these subjects,
- (4) what kind of student's reaction and respond we got after using this kind of teaching.

I will give you the detailed answers to specific tasks from teaching those subjects from 2.2 section.

I used those principles of using the software for the first time in subject of Operational analysis. I explained to students what kind of software is available in computers and I asked them which software they are familiar with. Most of the students were familiar with MS Excel, one of them used Matlab and one of them wasn't familiar with any software. Later on most of the students were using MS Excel (from secondary school) but some of them were also using Matlab or Octave.

#### 3.1 Operational analysis, Linear and Quadratic programming

Students were basically using software at subjects as Linear programming problem (simplex method, dual simplex method), Integer linear programming (Gomory's algorithm) and tasks of quadratic programming. Quadratic programming problem is subject of the 1st year engineer students. These students are pretty much familiar with using Matlab and Octave software.

I experienced that the most frequent (99 %) program was MS Excel or LO Calc, students were using it during class and during exams. They chose Matlab even though it has function which can solve linear programming problem by simplex method parameter.

Their choice was obvious because they needed simplex spreadsheets from pivoting for their outcomes. They have to decide which pivot to choose for solving individual task or specific tasks of linear programming. They used MS Excel (LO Calc). These programs easily formed readable sheets with applied pivoting. Look at the picture 1, the solved sample:

$$\begin{array}{rcl}
 x_1 + 2x_2 - x_3 - 2x_4 + x_5 - x_6 & \longrightarrow & \min \\
 x_1 + x_2 - x_3 + x_4 + x_5 & = & 4 \\
 x_1 - x_2 + 2x_3 - x_4 + x_6 & = & 3 \\
 x_{1-6} & \geq & 0
 \end{array}$$

A17										$f_{3x}$
	A	B	C	D	E	F	G	H	I	J
1										
2		B	x_0	x_1	x_2	x_3	x_4	x_5	x_6	
3		--	0	1	2	-1	-2	1	-1	0 - I + II
4		x_5	4	1	1	-1	1	1	0	
5		x_6	3	1	-1	2	-1	0	1	
6		--	-1	1	0	2	-4	0	0	0 + 4P1
7		x_5	4	1	1	-1	1	1	0	P1
8		x_6	3	1	-1	2	-1	0	1	II + P1
9		--	15	5	4	-2	0	4	0	0 + 2P2
10		x_4	4	1	1	-1	1	1	0	I + P2
11		x_6	7	2	0	1	0	1	1	P2
12		--	29	9	4	0	0	6	2	
13		x_4	11	3	1	0	1	2	1	
14		x_3	7	2	0	1	0	1	1	
15										

Figure 1: Linear Programming Problem - MS Excel applied

The sheets are displayed within limited space but we can easily see every step of solution from incoming conversion into base and pivot. We can see the difference between the variables as such and the base variables. They used the same approach with the tasks of Inetger linear programming, where they add rows (Gomory cuts) and columns (Gomory variables). They also use it with quadratic programming with simplex sheets.

The students showed less mistakes while using the software. If there were mistakes it was because of basic mistake not only wrongly applied mathematical operation. There were also mistakes caused by inadequate usage of software. Those mistakes are difficult to find.

Process of academic years results is illustrated in Table 1, it shows the subjects of Operational analysis (OA) and Mathematics 3 (Linear programming) (M3).

The results were improved due to students skilfulness of used software. Students were also excited that they can use the software they are familiar with which resulted in lack of mistakes caused by unknown software. WS 2013/2014 subject M3 shows worsen result due to the fact that students were repeated.

### 3.2 Numerical mathematics and Applied statistics

We used completely different software in Numerical mathematics and Applied statistics than in Operational analysis and Quadratic programming problem. Students made different choice in subject but also in actual theme. 90% of students chose Matlab (Octave) in numerical calculations of nonlinear equation. Only 10% of students used spreadsheets of MS Excel (LO Calc). Matlab (Octave) provides easier application of functional instructions, clear illustration of functional graphs, calculations of functional values and precise monitoring of results through included functions for numerical calcula-

Table 1: Results of subjects OA and M3

Subject	Academic year	Average
M3	SS 2009/2010	2,63
M3	SS 2010/2011	2,46
M3	SS 2011/2012	2,22
M3	WS 2012/2013	1,89
M3	WS 2013/2014	2,88
OA	SS 2006/2007	2,63
OA	SS 2007/2008	2,38
OA	SS 2008/2009	2,56
OA	SS 2010/2011	2,21

tions of nonlinear equations. 50% of students used spreadsheets of (MS Excel and LO Calc) and also 50% of students used Matlab (Octave) in numerical integration. Similar choice was with numerical calculations of system of linear equations. Students used Matlab (Octave) to monitor only the results in subject of M1-A1 where was linear algebra. Students chose MS Excel (LO Calc) to monitor in between results. The results are not so significant in these subjects as they were in other subjects, Table 2. It is necessary for students to acquire the basics knowledge and skilfulness of mathematical

Table 2: Results of subjects NM and M1-AI

Subject	Academic year	Average
NM	SS 2007/2008	2,85
NM	SS 2008/2009	2,98
NM	SS 2009/2010	2,95
NM	SS 2010/2011	2,88
NM	SS 2011/2012	2,94
NM	SS 2012/2013	2,88
NM	SS 2013/2014	2,75
M1-AI	WS 2009/2010	2,43
M1-AI	WS 2010/2011	2,61
M1-AI	WS 2011/2012	2,73
M1-AI	WS 2012/2013	2,40
M1-AI	WS 2013/2014	2,57

analysis which wasn't covered by available software.

The results have improved in the subject of Applied statistics. The choice of suitable software also influenced the results. Majority students chose Matlab (Octave), it provides variety of functions and is easily operated. All of the students used MS Excell (LO Calc) and combine with Matlab (Octave) in descriptive statistics. The results are shown in Table 3.

Table 3: Results of subject AS

Subject	Academic year	Average
AS	WS 2008/2009	2,75
AS	SS 2011/2012	2,59
AS	SS 2012/2013	2,40
AS	WS 2013/2014	1,89

The reaction of the students at using software in NM and M1-AI subjects was different. There were the first year students who don't have adequate experience using the software. The first year engineering students of subject of Applied statistics were thrilled to be able to use PC laboratories. Majority of students used at least one of the mentioned programs in varied subjects throughout the study.

The mistakes were mostly systematic not numerical. There were not valid reasoning, no evaluation of verified conditions to solve the problem or wrong set of operations.

### 3.3 Queuing Theory

The second year engineering students showed the best knowledge and skilfulness of the software in this subject. It is difficult to specify the most common program which they used because their approach was individual and almost every student used more than one program. They used Matlab, Octave, MS Excel, LO Calc and also wxMaxima. The positive results are shown in Table 4.

Table 4: Results of subject QT

Subject	Academic year	Average
QT	WS 2008/2009	2,24
QT	WS 2009/2010	2,76
QT	WS 2010/2011	2,75
QT	WS 2011/2012	2,20
QT	WS 2012/2013	1,93
QT	WS 2013/2014	2,36

Students enjoyed the subject in all forms. Students appreciated the opportunity to chose their own programs which made their study easier.

The most common mistakes were from unfinished parts of task, missing some steps of calculation, wrong interpretation of results or wrong set of operations. The numerical problems were nonexistent since students are familiar with software they used.

## 4 Conclusion

We created PC laboratories with numerous installed programs for teaching these subjects at Department of Mathematics and Theoretical Informatics but also at Department of Aerodynamics and Simulations of TUKE. The students are able to decide which software they use in solving the math problems. This type of software should improve the students results but only if they are familiar with available software and are able to effectively use it.

This approach is more successful among the advanced bachelor, engineering and doctorate students at Technical university. The problematic subjects are in the first year bachelor study. The software could be effectively used, if students could apply secondary school knowledge and skilfulness while using this software at university. It would be beneficial to create time frame for introduction of available software.

It is our interest to introduce expanded available software using high speed servers and computers in laboratories. We would like to prepare new studying concepts which will partially include the software usage in teaching some of the subjects. We are preparing the project about students experience and opinions with the software usage in solving some of the problems.

We applied GeoGebra program for linear and whole number programming in the subjects of Operational analysis and Linear programming problem. We are planning to publish the results of this change in the forthcoming future.

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