USING COMPUTER PROGRAMS IN HIGHER EDUCATION – GOOD PRACTICE IN MATHEMATICS

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Summary: To which extent computer programs and pocket calculators should be used in the education process at schools and universities? At which class or stage of study does it make sense to use them? Should students be allowed or, on the contrary, be encouraged to solve exercises, complex problems or even (part of) exams by means of computer programs or pocket calculators? Does the use of pocket calculators make the ability of mental arithmetic worse? We report on our experience in teaching (applied) mathematics both for mathematicians and non-mathematicians using computer algebra systems and spreadsheet calculation programs. Advantages and disadvantages are discussed and some recommendations are given.

Key words: Computer algebra system, spreadsheet calculation, informatization of teaching

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INTRODUCTION

To which extent computer programs and pocket calculators should be used in the education process at schools and universities? At which class or stage of study does it make sense to use them? Should students be allowed or, on the contrary, be encouraged to solve exercises, complex problems or even (part of) exams by means of computer programs or pocket calculators? Does the use of pocket calculators make the ability of mental arithmetic worse (certainly: yes)?

To answer these questions is quite difficult and often depends on the auditory. The teaching process of mathematics for mathematicians will certainly differ from the one for engineers, economists or IT specialists. Moreover, concerning these questions, every lecturer has its own point of view. On the other hand, a lecturer of mathematics at a university cannot simply close his eyes, ignoring the former way of education of his students. So, for instance, German pupils from Saxony have great experience in the use of programmable pocket calculators due to their secondary school education. And graduates will be confronted in enterprises with different, widely used commercial software systems (Excel, R3-SAP and many others). Thus, it seems to be important to prepare students for the "real life" and to encourage them to apply mathematics to "real-life problems" carrying out their calculations in a computer-supported way. Many interesting links about computer based teaching and learning one can find on the Internet (e.g. [1]).

The present paper aims at describing examples of the use of computer programs in teaching (applied) mathematics both for students of mathematics and non-mathematicians (engineers, economists etc.) at the Department of Mathematics, Chemnitz University of Technology (CUT), Germany. We focus on examples with which we have got good

experience, where advantages clearly dominate disadvantages and where the feedback of students and graduates is very positive.

COMPUTER ALGEBRA SYSTEMS

CAS represent powerful collections of mathematical knowledge. This knowledge can be used not only in a "static" way, but in a way which is typical for mathematicians: it can be transformed, adapted and structured. Moreover, one can take advantage of different solution methods and compilation of rules.

The core and main task of a CAS consists in the manipulation of symbolic terms and the processing of rational numbers with arbitrary accuracy. These techniques enable the user of a CAS to transform mathematical models in an exact way as long as possible without using numerical approximation methods. Thus, for instance, for an equation involving parameters the exact solution can be described in terms of these parameters, which allows the user to study its behaviour in more detail. These amazing abilities of symbolic manipulation encourage the user to carry out mathematical experiments or to solve (medium-sized) problems, which presumably would never have been done or solved without a CAS, only using "pencil and paper". The wonderful possibility to check a mathematical hypotheses by nontrivial examples in a fast way using CAS cannot be overestimated.

Modern CAS are able to visualize the results obtained in an excellent manner and are equipped with interfaces to text processing systems. In this way, they are a suitable working environment for mathematicians.

The continuously growing importance and acceptance of CAS can be seen in the fact that e.g. the widely used calculation programs Matlab and MathCad involve an Add-In enabling symbolic calculations with Maple.

The two computer algebra full systems Mathematica and Maple are very powerful means, having a wide range of functions and services, but needing modern personal computers as a basis. They run both under Linux and Microsoft Windows. Unfortunately, the licences for them are very expensive. Even a student's licence amounts approximately to 200 Euro.

A widespread "small" system is Derive, used in Austria for a long time and forming the basis of computer algebra pocket calculators from Texas Instruments. such a type of pocket calculators is used in higher classes of secondary schools in Saxony, a federal state of Germany.

At the Department of Mathematics at CUT, the CAS Maple is preferred. Its latest releases provide an excellent, continuously growing support for the study. The system involves a mathematical dictionary, where facts and definitions can be found. Moreover, in a special menu tutors and assistants for basic problems of linear algebra and analysis are integrated that can be used in an interactive way as Java applets. In the assistant "integration" e.g., in searching for a primitive (antiderivative) the user can propose a special rule of integration that will be carried out later on by the system. If he does not have any idea how to solve the integral, he can ask the system for a hint and, after that, proceed calculating. Thus, it is possible to solve a (complicated) problem step by step without getting the complete solution immediately by the CAS.

The system language is adapted to usual notions of mathematics so that a beginner can easily approach to the system. Our experience arises from the following fields:

- a course of lectures for beginners from different courses of studies; on these lectures the tool is presented in an overview and the potential users are encouraged in the daily use of CAS for solving mathematical problems arising in various lectures and fields
- collection of examples (easy, medium, complicated) in linear algebra, analytical geometry and analysis intended both for students and teachers
- examples of theoretical, applied and real-life problems in mathematics of finance and investment banking
- the use of Maple within lectures "Mathematics for engineers".

Concerning the last topic, it goes without saying that an adequate technical equipment of the lecture rooms is presumed. In any case one needs a connection for a beamer to be able to project calculations, graphics etc. onto the screen. Moreover, a connection to the intranet of the university, where Maple has to be installed, is necessary, giving access to personal data. Alternatively, a USB keychain with lecturer's own data together with a local variant of Maple at the notebook can also be used.

To be more precise, at the Department of Mathematics at CUT the computer algebra system Maple is used in teaching mathematics for engineers as follows:

- Visualizing the subject-matter at the lectures. A great deal of students finds two- and three-dimensional integral calculus quite difficult, especially, it is hard for them to imagine plain and spatial domains of integration. Here the Maple graphic package can help to outline the domains of integration and to obtain information about the limits of integration. Because Maple is able to visualize scalar and vector fields, in vector analysis the notions of gradient, divergence and rotation can be illustrated in a vivid way. Similarly, the circulation of a vector field along a closed curve as well as the vector flux through a surface may be plotted.
- Maple also provides an efficient tool for problems from linear algebra. Thus e.g. the solution of linear systems of equations and the calculation of eigenvalues and eigenvectors can be shown.
- It proved to be useful for students to put small Maple applets into the Internet (e.g. for solving the task of expanding a function into a Fourier series). These applets may be used by students provided that they have maple at their disposal.
- In seminars Maple is used for solving problems step by step, displaying the (partial) results of the exercises.
- Last but not least, Maple livens up the lectures of mathematics being mostly exhausting and dry.

In summary, it can be stated that the use of Maple in the teaching process is successful and approved. The feedback got from students is very positive and encouraging.

MS-EXCEL

MS-Excel is a widely used spreadsheet calculation program. Making an internship at an enterprise or bank or insurance company, but also solving challenging problems from financial mathematics or investment banking, it is nearly impossible to ignore the existence of this system. Thus, being a student of (applied) mathematics or economics, it is extremely important to have good knowledge of this tool. Exactly this circumstance was the origin and reason for creating the modern course of lectures "Financial mathematics with Excel". In this lecture we do not aim at merely giving hints and "magic formulas" how to use the tool, to tell which button has to be clicked on etc. if you want to get a certain result rather the lectures focus on how you can solve complex (and often complicated) applied problems taken from the field of financial mathematics. Far beyond the fundamental operations of arithmetic Excel provides possibilities to do "serious" mathematics using the full spectrum of Add-Ins, e.g. the solver or the package "statistics". Note, that some traps result from the fact that MS-Excel is an American program having US data conventions as standard settings. Another task that cannot be underestimated, especially for beginners, consists in importing and processing data (prices, market information, ...) delivered by the Internet or by commercial financial services in order to analyze and transform them for further calculations.

SUMMARY

A great part of literature as well as offers for continued education on the use of (commercial) software concentrates on the aim to impart to the students how to use a certain program or package of programs and how these programs are structured. Therefore, in most cases illustrating examples are relatively simple and aim at the very beginners (see e.g. [2]). But such a type of examples does not give support a user mainly interested in solving his problems, but not being interested in becoming acquainted with the latest releases. In our opinion it is therefore important to put the problem into the centre of attention and only after that to "resort to the tool box". It is to be welcomed that an ever increasing part of textbooks deal with this aspect (see e.g. [3, 4, 5, 6]).

LITERATURE

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