AN E-LEARNING STUDY: USING MAPLE T.A. TO IMPROVE THE MATHEMATIC SKILLS OF STUDENTS

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Abstract

New students at universities have a widely varying knowledge of mathematics. In this paper we present a blended-learning approach using Maple T.A. to refresh the mathematical knowledge of the new students on the one side, and to teach them enough elementary mathematical skills to be able to follow the elementary applied lectures of different curricula on the other side. The Maple T.A. e-learning platform was used, since it allows for free learning as well as for randomized, supervised tests. In this way the students can specifically train these fields, in which they lack skills, and their progress can be monitored. Although the examples in Maple T.A. can be highly randomized, they can be constructed with this software to guarantee for simple solutions. School students were used to test the software platform beforehand and their feedback was incorporated in the course. After the refreshment course the effectiveness of this approach was evaluated statistically and it was shown, that the knowledge of the students increased significantly.

Keywords: E-learning, Blended Learning, Mathematic Education.

Presenting Author's biography

Vilma Urbonaite. She finished Vepriai secondary school and Ukmerge music school in Lituania. Afterwards, she began bachelorstudy in financial and actuarial mathematics at the University of Vilnius. After two years, she came to Vienna as exchange student and started the bachelor study in statistics and mathematics in economics at Vienna University of Technology. Her field of interest on the one hand is mathematical modeling with differential equations and on the other hand she works on the development of the e-Learning system Maple T.A..

1 Introduction

When new students come to universities in Austria they have a very widely spread knowledge of mathematics. This is due to several reasons: firstly there exists a very highly differentiated school system in Austria, where school students can choose between a wide range of specialized schools. To give a few examples, there are secondary schools specialized in natural sciences, in languages or in music. Then there are professional schools, where students are trained in mechanical or electrical engineering, in economics or in informatics, and many other fields. No matter where the students got their secondary school degree from, they are allowed to start at any university in any curriculum. Only very few curricula have entrance exams, so the future students can choose their field of study essentially freely. Secondly the male students are doing their military service right after school, so many of them are out of training when starting their university career. Thirdly there are also some students who worked or studied something different before they begin their engineering education. And fourthly there are also some students from other countries, in the curricula examined in this paper about 10 percent. Overall the first semester students in the engineering sciences at the Vienna University of Technology are a very heterogeneous group, and they show very different levels of skills in mathematics.

In this paper we present refreshing courses held at the Vienna University of Technology for students of mechanical and electrical engineering in the winter term 2009/2010. These courses were aimed to repeat, advance and consolidate the mathematical tools, which are essential for the understanding of the elementary applied lectures, like electrical engineering one or mechanics one. We used a blended learning approach, consisting of frontal lecture elements, exercises in small groups, and free learning. The basis was the course of the previous year, c.f. [1,2], which was greatly enhanced and extended to students of electrical engineering.

The structure of the paper is as follows: firstly we will describe the structure of the courses. This also includes how the courses were built. Secondly we describe the abilities, the advantages, and the disadvantages of the Maple T.A. software and give examples. And finally we give the statistics, which show the success of our method, and draw some conclusions.

2 Structure of the courses

In figure 1 we give a timeline of the courses, and then we will explain the different phases in detail. The courses were prepared over summer and then they started two weeks before the semester with a setup phase. In the first two weeks of the semester the frontal lectures and the exercises were held, and finally there was the exam followed by an evaluation.

2.1 Preparation phase

The courses were built with the experience of the previous year. Three school classes of the twelfth grade were invited to test the examples beforehand, and their feedback was incorporated in the design of the training exercises. Almost all the programming of the Maple T.A. platform was done in this time. Also the layout of the course in the TUWEL, the TU Wien (Vienna) E-Learning system, which is a Moodle platform, was done in this time. And of course the lecture notes of the frontal lectures were prepared at this time. These lecture notes were designed in such a way, that they were also suited for learning by the students themselves, without any help of others. And also the log-in and the registration interfaces were programmed at this point. The school students were especially asked to absolve the anonymous knowledge test, which with which the students at the university could then asses their knowledge by themselves. This leads directly to the second phase.

2.2 Course phase

The course phase started two weeks before the semester, at which the anonymous self-assessment test

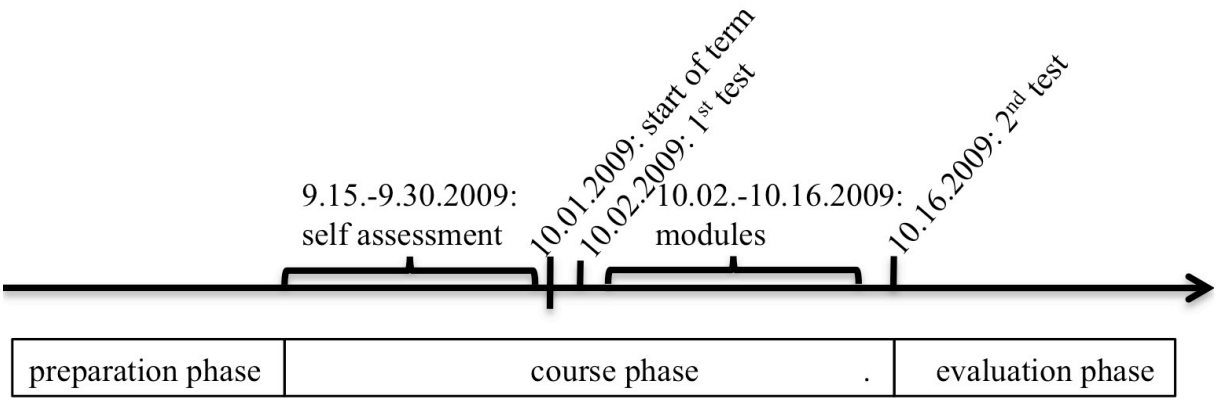

Fig. 1 The timeline of the courses

went online and could be taken by the students. They were allowed to take this test an infinite number of times. The test consisted of examples out of all the fields of study, which the courses would cover. The idea behind this test was, that the students should learn which topics they already knew and in which topics they lack skill. In this way they could decide which modules they wanted to attend afterwards. Although this test took place before the start of the semester it was well appreciated, over 200 students from approximately 500 beginners in total took the test.

On the first of October the semester started and the students were given an overview of the courses. Of course the refreshing courses were scheduled in such way that they didn't collide with other lectures. On the second of October the students where asked again to take a knowledge test. This test lasted one hour, and it wasn't mandatory. The results of this knowledge test were logged with the Maple T.A. system. The idea why they should take this test was again self-assessment. Over 160 students took this test.

In following two weeks the modules were held, each module was offered at two different times, allowing the students to choose which modules to attend or even to repeat. There were eight well-defined modules: fractions and exponents, terms, elementary functions one, elementary functions two, differentiating, integrating, vector calculus, and finally complex numbers. These contents were chosen in accordance with the professors of the applied lectures of the first semester. Each of the modules represents a central aspect of mathematics in school, which are necessary to be able to follow the applied lectures. The eight modules consisted each of 60 minutes frontal lectures and up to 90 minutes exercises in small groups, with maximum of 30 participants in each group. The exercises were done in a mixed way, calculating examples at the blackboard and students trying to solve examples, either in Maple T.A. or in the blackboard, under supervision of a tutor. For every module between 12 and 30 examples were implemented in Maple T.A., and the examples were grouped together to exercise units. These examples were available for the students freely. The students could train them as often as they wanted. Through the e-learning platform they got immediate feedback, hints and even the correct solution if needed.

2.3 Evaluation phase

After all the modules the students were asked to take the same knowledge test again. Although the examples where the same, the numbers in them where different. In this way the increase of their knowledge could be measured, their studying advance could be measured, and the courses could be evaluated. The students were also asked to fill out a feedback form at the end of the semester. Over 240 students took the final test. This is remarkable in so far, as the students didn't get any credits for the test, which could be used for the fulfillment of their respective curricular. So these courses were completely voluntary.

3 Maple T.A.

We are now going to discuss the Maple T.A. platform and its abilities in more detail. Here we will explain how the platform works in general, and we will discuss the feasibility of examples. More technical information concerning the programming will be reported elsewhere [3].

3.1 Structure and abilities

Maple T.A. is software running on a server. The main idea is that Maple T.A. provides an interface to generate and answer randomized questions, while in the background Maple is running to provide the computational power. The whole software can be administered and accessed via a web interface. After the installation different kinds of accounts can be created. In our case the software was adopted, so that the students could use their generic TU-Vienna accounts to log-in. Maple T.A. features a class system, so the students could theoretically be members of different classes, which are courses. Examples generated by the instructors can be shared between the classes.

Content can be crated by a step-to-step basis with the help of an editing mask. There a variety of predesigned question types available, like multiple choice, clickable graphs, or free mathematical syntax. Maple T.A. takes the free syntax and translates it, more or less skillfully, into Maple syntax. In this way it is possible to check results for mathematical equivalency. Hints and feedback can be provided for the questions, like giving hint if the answer is wrong, and then the students can try again. Or the students can click on hints, if they don't know how to start an example. The questions can be put together to different assignments, like practice, homework, or proctored tests. An equation editor simplifies the input, and students can preview their input. The use of randomized variables allows for the generation of many different examples by one template. The selection of the random variables can be limited, e.g. exclude the zero as a choice for a random integer between -3 and 5. In this way it is possible to generate randomized examples where the trouble to solve the example is limited. These random variables can also be used in plots, so it is e.g. possible to ask a student to give the function plotted in a graph, c.f. below.

And finally Maple T.A. can be used for electronic testing. One option would be to give a time-window and the students can then make their test from home. Another example would be, that the students need to come to a testing computer-room, where they need to identify themselves, and then they can start their test. They have then a limited amount of time. Maple T.A. grades the tests as soon as they are finished. One can

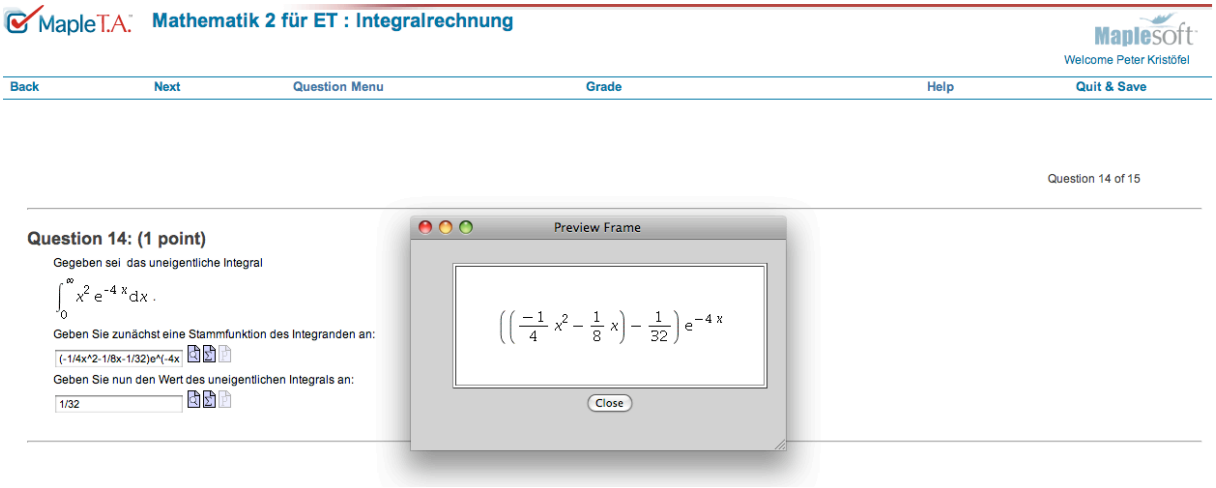

Fig. 2 An integration Maple T.A. example

then also view different kind of statistics from the tests.

3.2 Examples

The first example is integration. The students where asked to calculate an integral of

$$\int_a^{+\infty} x^2 e^{bx} dx = \qquad (1)$$

, where *a* could be -1, 0 or 1, and *b* could be an integer between -5 and -1. And then the evaluation of the integral in the borders was asked.

The answer obviously can be calculated by a twofold partial integration [5] and a subsequent evaluation to get the numerical value. In figure 2 you can see the example together with the Maple T.A. input menu. The parameters in this case where *a*=0, and *b*=-4. Also shown is the preview of the solution.

For the grading the derivation of the solution of the student is computed and compared with the integrand for mathematical equivalency. In this way also integration constants could be entered and the solution would still be right. Any letter could be used for the integration constant, since the derivative is then taken with respect to x. It is true that the students could be entering any term not including x in this way, but if they recognize this to be right, they know enough of integration any way. You can see the scoring of the example in figure 3.

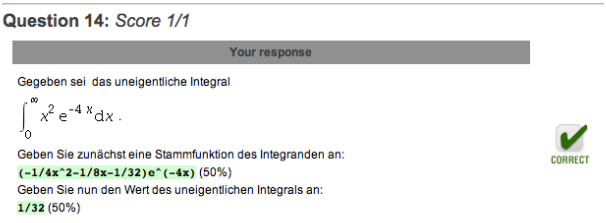

Fig. 3 Grading of the integration example

The second example is a graphical one, where students were asked to give the function plotted in a graph. Plotted were functions of the form

$$f(x) = \sin(a\pi x) + b \qquad (2)$$

or

$$f(x) = \cos(a\pi x) + b \qquad (3)$$

, where *a* was an integer between -5 and 5, excluding the 0, and *b* was an integer between -5 and 5. The students then had to enter the function with the help, that *cos* or *sin* functions are plotted. Another version of this problem was with an additional multiplicative term in front of the *cos* or *sin*, respectively.

3.3 Advantages and disadvantages

The use of random variables is a huge advantage, since students can't simply copy one example. And the students can always train with fresh examples in this way. Also that in exams the sequence of the questions can be randomized is advantageous. As an additional feature one can then make statistics of the outcomes of tests. And, of course, that the tests are corrected instantly reduces the amount of human working power needed.

But this leads directly to the disadvantages: it is a huge effort to implement a sufficient number of examples. Sometimes the construction of the examples in such a way, that the solution is a 'nice' number is quite sophisticated. Of course, once the question banks are generated, they can be used for years to come, and only minor adaptations are needed. Another disadvantage is that not all steps of the calculation are monitored. While in a written exam an instructor could follow all the steps of the calculation, in Maple T.A. a simple miscalculation can lead to a completely wrong answer with zero grading. This can be counteracted, to some extent, by formulating the question appropriately. But if you ask for all the steps you will guide the students to the right answer, since

they would not need to think about what step they should make next. Also the syntax can sometimes be cumbersome, so we introduced new classes, e.g. that students could enter a line or a column vector and the answer is still right. And finally Maple T.A. does not work well with all web-browsers.

Additionally one has to realize, that while human resources could be saved after the initial setup phase, Maple T.A. is commercial software, so you have to pay the license fees. And you need to invest quite some money into the hardware, to make it possible for many hundreds of students to access the software at the same time, and to make it redundant. A loss of data during an exam would be unacceptable.

4 Results

We finally come to the statistical evaluation of the success of these courses. For this we compared the results of the first knowledge test and the second knowledge test. We give here the accumulated values for both, the students of electrical engineering and the students of mechanical engineering. In figure 4 we clearly see that the knowledge of the students increased, on the average about 20%. It was also observed that both, the individual performance and the average performance, increased.

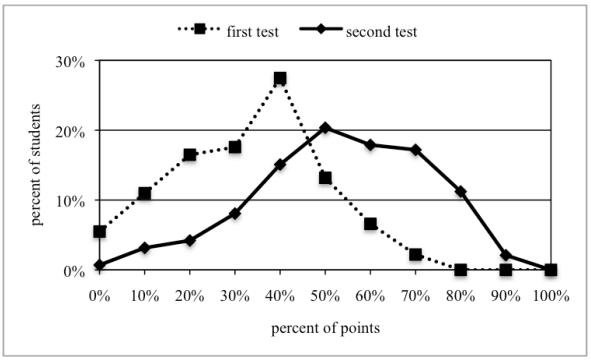

Fig. 4 Test results

The evaluation by the students was done at the end of the semester. The high number of returned evaluation sheets and their content show, that the courses helped the new students to overcome the difficulties at the beginning of their studies. Fewer students were overburdened, and fewer students in percent changed their study compared with the year before. Especially the self-controlling and the resulting learning value was appreciated. Here some quotes: “A great offering!”, “You helped very many students with the introduction to their study!”, “Surely an improvement compared to the years before!”.

5 Conclusions

In this paper we have shown, that blended learning, when done in the right way, uses all competencies and possibilities optimally, and increases the teaching and the learning success. The novelty of our approach was the self-assessment at the beginning of the courses and the modular structure. Free learning was possible by the use of Maple T.A.. Although there are many difficulties to overcome, this approach can be used to optimize the always-scarce resources of universities, both, for the benefit of teachers and for the benefit of students.

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