

Various Usage of Maple T.A. in Mathematics, Modelling and Simulation

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This paper deals with the various ways of establishing the e-learning system Maple T.A. Maple is an algebraic computer algebra system. T.A. stands for testing and assessment and supports complex, free-form entry of mathematical equations and intelligent evaluation of responses, making it ideal for mathematical courses for different levels or any course that requires mathematics. At the moment the usage focuses on mathematics but looking ahead developing a course dealing with modelling and simulation seems realistic.

1 Introduction

Each year more than 5000 students enrol in bachelor's degree programs at Vienna University of Technology. Most fields of study at this university require good basics in high school mathematics to be able to pass courses in advanced mathematics.

The Institute for Analysis and Scientific Computing considered the idea to organise a refresher course. The aim of this course is to repeat the basics of high school mathematics in 1-2 weeks at the beginning of the semester. The first refresher course occurred in 2008 and was supported by an e-learning system. The reasons why this kind of course was chosen is the possibility to handle a large number of students by using the online system and offering practice and assessment at any time. In addition an ordinary lecture and practice was offered. This combination, so called "blended learning", encourages all different requirements of the individual students.

After considering all options the Maple T.A. appeared to be the best software for supporting the refresher course. This Maplesoft's online testing suite is qualified for mathematical example creation. It gives the students the ability to control their learning progress and success.

The results of this blended learning based refresher course showed good results and exceeded the expectations. It gave the idea for programming examples for higher level mathematics for electrical engineering to use Maple T.A. also in the regular mathematical courses at Vienna University of Technology.

2 Maple T.A.

Maple T.A. is a web-based system for creating assignments and tests. It uses Maple to algorithmically

generate questions and grade student responses. This system offers high potential for mathematical exercise creation. In Maple T.A. it is also easy to administrate and easy to use for students.

In Maple T.A. it is possible to design questions of different types depending on the aim of the example. Despite standard fill-in-the-blank questions there are multiple choice, numeric, multipart or true/false questions. The questions designers strain after the creation of diverse exercise that consolidate theoretical knowledge, teach to calculate accuracy and sharp the logical thinking of the students.

2.1 General

At Vienna University of Technology Maple T.A. was used for the first time in 2008 due to the refresher course. The question designers started to work with 4th version of this software when Maple T.A. was on the very beginning of its development. Starting from the creation of simple examples like addition of 2 numbers and continuing with realisation of more complex high school graduation level questions the mathematical capabilities of the system was examined.

Maple T.A. has a lot of tools for designing of the questions. Additionally to the step-by-step question designer and thousands of build-in math commands, the system has a good editor for formatting the text, adding the images, plots and special characters to questions. The exercises can be written in any language. Hints and feedback can be also designed with intent to provide additional guidance to the students. The most important attributes of the questions designed in Maple T.A. are the randomisation of variables and functions and the ability to grade the question and to get the score directly after the calculation.

Table 1: The Table shows the difference between Maple and Maple T.A. syntax.

Commands	
Maple code	if a<b then a else b end if
Embedded in MTA	<code>\$c = maple("if a<b then a else b end if")</code>
MTA code	<code>\$c:=if(gt(a,b), b, a)</code>

The syntax of Maple T.A. is similar to the syntax of Maple. Most of the Maple commands have adequate commands in Maple T.A. The if-else condition can be taken as the simplest example to compare both software,

see Table 1. There is also the possibility to use the Maple commands and functions directly in Maple T.A. In some special cases the Maple syntax is necessary to create questions. Directly usage of Maple commands in Maple T.A. also allows writing of procedures in web-based system.

2.2 Improvements

The usage of Maple T.A. in the refresher inspires the idea to use the system also in exercises of technical mathematics for electrical engineering. The Maple T.A. system was sufficient for designing high school level mathematical questions. Some problems during the creation of advanced mathematical examples occur. There was no requirement for grading complex examples in a fair way for students, for example partial fraction expansion, vectors or matrices. Some colleagues started developing libraries for creating and grading of advanced examples. The improvement especially supports the entry-wise grading of vectors and matrices. Additionally it enables the randomization of matrices with certain properties like the value of the eigenvalues or a positive/negative definite matrix.

2.3 Moodle Connection

Until this summer a CMS-System requires the creation of the user accounts. A student who enrolls at Vienna University of Technology receives a unique registration number and a password for the University System for the course administration. With this account the student comes to the CMS-Homepage enters the number and password and receives an account for Maple T.A. So a student has to go through 3 different websites to get to Maple T.A. In this summer we will integrate the Maple T.A. into the e-learning platform of the Vienna University of Technology, which is based on Moodle.

This connection is a data interface. If a student registers for the course on the e-learning platform from the Vienna UT the student will be able to get to the examples directly through a link on the course page. There is no need for an account on Maple T.A.

3 Refresher Course

About 39% of the courses at the Vienna University of Technology are mathematical courses. Precisely these courses are the major difficulties for the first-year students. The students are more interested in their study field lectures as in compulsory mathematical courses. They also often have weak and distinct high school basics because of the different mathematical levels in various high schools. Additionally there are many high-school graduates that do not start studying direct after school. After high school graduation the male graduates in Austria have to attend the army or work for civilian service. Also a lot of female students have a break between school and university due to working as Au Pair or travelling.

3.1 Development

The aim of the refresher course, organised by the modelling and simulation department at the Institute for Analysis and Scientific Computing, is to make the start and integration in the university easier for students. The first refresher course took place in 2008. Since then the refresher course is in great demand at the Vienna University of Technology.

The first refresher course was offered just for electrical engineering students. It was organised in the first two weeks of October. At the beginning and the end of the course the student had to take a high school level test. The statistics showed that after taking 2 weeks refresher course the test results raise. The course also became a positive feedback from professor who remarked that the students of the first semester are more concentrated and interested in the lectures of advanced mathematics.

Up to now the number of fields of study where students can attend the refresher course increases from one to seven. Because of the increasing number of students and the high stress the students have to deal with in the first two weeks of their study the idea of offering an additional lectures course in the end of September, before the ordinary lectures starts, occurs. The number of attending students rises. For e.g. in 2012 1198 students participated in the refresher course for mathematics. The course will be offered to the following fields of study in 2013:

- (1) Electrical Engineering
- (2) Mechanical Engineering and Process Engineering
- (3) Mechanical Engineering - Economics
- (4) Technical Physics
- (5) Civil Engineering
- (6) Urban and Regional Planning
- (7) Computer Sciences

It is important to mark that the refresher courses are not obligatory for the students. After passing the course the students get some credit points and have refreshed the knowledge in high school mathematics.

3.2 Structure

Since 2011 the refresher course starts in the last week of September. Because of the number of students increased over the time and the capacity of the lecture rooms at Vienna UT exceeds therefore 2 parallel courses was offered. Most of the students preferred taking this course in September because then they can concentrate just on mathematics and have no other lectures and exercises. The organisation (finding of available tutors and rooms) of September course is also much easier. The September course takes from 9:30 am to 5:30 pm five days in a week. The October course is adapted to the scheduling of each field of study. Subsequent after the lectures the students split into small groups (40 to 70 people) to attend an exercise supervised by a tutor.

The script of the lecture contains the following topics:

- (1) Introduction and Fundamentals
- (2) Elementary Functions
- (3) Differential Calculus
- (4) Integral Calculus
- (5) Vector Algebra
- (6) Complex Numbers
- (7) Combinatorial Theory (partly)

The refresher course is separated in eight modules. In each lecture one or two of the topics are presented. Based on the beginning test the students can also estimate their knowledge and choose just those topics they need to repeat.

3.3 Results

In the figure below the results of the test at the beginning and the final test at the end of the course are shown. Although some students quite the course, on the one hand because they think they do not need it on the other hand because they are unable to cope with the expenditure of time, the figure illustrates a rise of the test results. The reason for the increase can be that some students finally remember what they already learned in school and some really gain new knowledge.

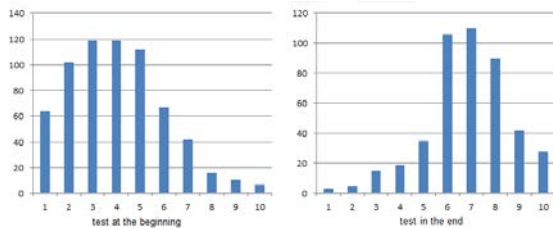


Figure 1: The results of the test at the beginning and in the end of the refresher course. On the horizontal axe are the points and on the vertical axe the amount of stutens who gained that number of points are shown.

4 Basic mathematical course

4.1 Development

Maple T.A. was already established so the idea, to use this system in other lectures too, suggested itself. The department of Modelling and Simulation is also responsible for the exercises concerning basic and advanced mathematics for electrical engineers. This course offers the chance to assemble a blended learning course. In contrast to the refresher course the mathematics in these courses are more complex. Therefore the department had to develop some innovation on Maple T.A. to ensure the usability for higher mathematics, see section 2.2.

4.2 Structure

These courses consist of a lecture two to four times a week. Once a week the students have to prepare examples for presenting in the exercises. A tutor supervises this presentation and asses it. During a semester the students have additional three exams. To make the course they have to pass two of

these tests. To minimize the expenditure of time these exams are done on the online platform. Every week the new examples consistent with the subject matter of the lecture are uploaded to the Maple T.A. system. Therefore the students are able to repeat and practice the examples at any time during the whole semester. Especially the students log in to the Maple T.A. for exercising the examples relevant for the tests. The mark for the courses is composed of the amount of prepared examples, their presentations and the needed positive tests.

4.3 Results

In the following picture the results of the three tests in the first semester of the students of electrical engineering are shown. The first test is not as good as the other ones because the histogram contains also students who had not attended the refresher course but also started with starting not direct after school. These results confirm the suspicion that the additional offer of the Maple T.A. systems supports the students to practice regularly during the whole semester.

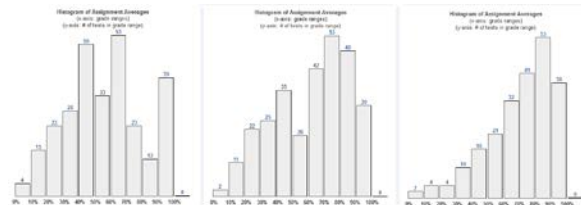


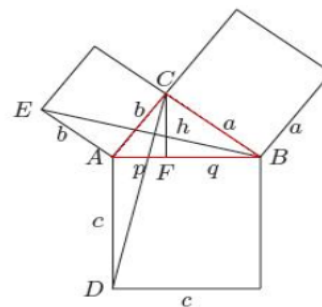
Figure 2: The results of the three tests during the first semester of electrical engeeniers.

4.4 Examples

In the following figure a typical question of mathematics 1 for electrical engineers is given. The task is to calculate the different lengths of the triangle by using the theorem from Pythagoras. The given values are randomized generated every time the example opens.

Question:

Given a right triangle ABC . A length of catheti a is equal to $4\sqrt{15}$. The length of hypotenuse segment q is equal to 15.



Find:

- (1) The length of the side b :


$b =$  

Figure 3: Typical example of the course Mathematics 1 where the students have to deal with Phytagoras theorem.

In the course for Mathematics 2 the examples are more complex. In the figure 4 below the student have to choose the right tangential field which belongs to the given equation.

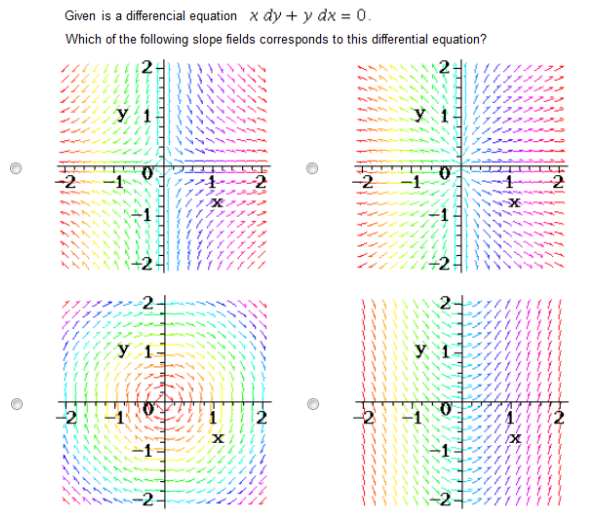


Figure 4: The student has to pick the fitting tangential field. This example belongs to the second semester of electrical engineers.

5 Exams

The exams, regarding the lecture of mathematics 1 and 2 for electrical engineering, were written. It was the task of the examiner to correct all this exams. Most of the time the examiner is the Professor and it takes very long to correct them by hand because every semester 300 students starts studying electrical engineering.

In February 2012 we offered an optional exam on Maple T.A. In addition the students who take that exam have an oral exam at the professor too. The Professor loses no time with correcting tests but has the possibility to determine the comprehension of the theoretical background. The calculation skills are tested by Maple T.A. and the understanding can be examined in an oral exam.

Since October 2012 the rules of examination of the mathematical courses for electrical engineers changed. The exam now consists of a written and an oral part. The students who attended that course this year have the possibility to do the written exam by hand or on the e-learning platform. If they pass the written part they get an appointment at the professor.

The advantages of the Maple T.A. exams are also for students and for examiners. On the one hand time saving for the examiner is very important but also the randomisation of the examples provides cheating during the test. On the other hand the students can practice all the examples on the systems and maybe partly know the examples but also receives the results of the exam right after finishing. So they don't have to wait until they are corrected. Also an inspection is not necessary anymore because the students can look at the done exam at any time by login in Maple T.A.

6 Simulation Course

All the innovations on the system done by researchers of the Vienna UT and the changing possibilities due to the improvements done by the developers of Maple T.A. the idea of creating a course dealing with modelling and simulation occurs. The department "Modelling and Simulation" already developed a server solution, called MMT, for presenting and experimenting with simulation examples. With the combination of the MMT server and the e-learning platform of the Vienna UT also tests are executed.

The configurations of the tests in Maple T.A. are more extensive. The concept foresees a combination of the Maple T.A. and the MMT system or the integration of the simulation examples into Maple T.A. Up to now we have not found the best solution. We are going to check how test on MMT via Maple T.A. could work. And we are trying to develop easy simulation examples.

7 Conclusion

In the last five years the changes concerning the usability of Maple T.A. and the complexity of the examples improved. The additional offer is used more and more by the students.

The primary target, to recondition the mathematical knowledge of the students through the refresher course and the further additional supply in the basic and advanced mathematical courses, supports the learning process and coordination of the students. To use this system in every reasonable way, the practicability of creating a simulation course on Maple T.A. will be reviewed.

Literature

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