E-ASSESSMENTS AND E-EXAMS FOR GEOMATICS STUDIES

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ABSTRACT:

We report about our project to introduce web-based automated assessments for engineering studies at the HafenCity University in Hamburg. The assessments are used for free practice and for eExams in the near future in the first-year math lectures of the geomatics studies in Hamburg. We use the out-of-the-box system MapleTA which enables us to put mathematical questions with randomized numbers as well as randomized symbolic parameters. The system uses an inbuilt computer algebra system to grade the answers automatically. Unlike other assessment systems, MapleTA can therefore test answers on semantic correctness , e.g. $1 + \tan(x)^2$ and $1/\cos(x)^2$ will both be recognized as proper first derivative of the $\tan(x)$-function.

1 INTRODUCTION

In many places university teachers of engineering sciences observe similar facts about freshman.

- Engineering students should be intrinsically motivated to learn math. But they are not!
- Teachers face the problem to bore the good students and to overburden the others.
- Many students lack fundamental skills, like reading and understanding complex texts.
- There are deficits in mathematics stemming from the 7th or 8th grade. Starting with improper dealing of fractions, resulting in misconceptions on proper manipulations of terms.
- Many freshman are fixated on notations and methods they learned in school. E.g. "x stands for unknown" or using always the method of "completing squares" for solving quadratic equations.

The first and second point is interesting: Success in learning is strongly connected to motivation. If Spitzer (Spitzer, 2006) claims, "The brain is learning all the time," we could ask, "Why not math?".

This paper deals with an attempt to solve some of these problems. Obviously one solution could be the *hard one*: throw them out. Unfortunately, this does not meet our demands for more and better educated engineers. Selection is a concept for an oversupply of well educated candidates for engineering studies. This is not the case, especially for geomatics studies.

We observe a deviation between the development of curricula of schools and the needs of an academic education. And the situation will probably go worse. Christa Polaczek analyzed the curricula of the Bundesländer and found e.g. that equations containing fractions or logarithms are not explicitly mentioned in more than the half of the curricula (Polaczek, 2006). Consequently, other authors report about the decline of the mathematical "preknowledge" of first-year students and a strong relation to the final success in their study (Schwenk and Berger, 2006), (Polaczek, 2007).

1.1 Mathematical Assessments & Practice for Engineering Studies: Map@HCU

Our answer is a strong employment of computational mathematics combined with an extra tutorial conducted by a school teacher. The teacher has experiences in teaching the final grades of a German secondary school and is therefore well prepared for the needs of our freshmen.

After a diagnostic test in the beginning of the semester, we realized that nearly all of the the students needed a lot of practice and additional exercises. Unfortunately, we have only very little capacity to design and grade such exercises. The solution to this problem was to use a web based eAssessment system with automatic grading. Using this system makes it easier to introduce the concept of *formative assessment* (vs. *summative*) which states that the results of the accompanying assessments give an immediate feedback to the lecture. Not only the students get better but also the teacher! (Compare (Heck, 2004) and e.g. (http://en.wikipedia.org/wiki/Formative_assessment))

Another reason for a bad success rate in engineering sciences are wrong expectations of future students. Our plan is to offer self-tests for pupils and teachers. The aim is to make clear what we think students should know starting an engineering study. Right now, we test our eAssessments at a single school.

In the near future, we plan to use the eAssessment system not only for free self-study practice and homeworks but also for a replacement of the written examinations.

Because of the key role of the eAssessment system in our concept, we will discuss the possibilities and our choice in the next section.

2 E-ASSESSMENT SYSTEMS

In the beginning we looked for a web based system that could simply offer and grade mathematical questions with *infinite patience*. Therefore it needs the capability for in- and output of mathematical formulas, the dynamic generation of plots and the generation of random expressions and numbers. Most eLearning platforms (e.g. Blackboard, Moodle, StudIP etc.) offer some eAssessment features but can only deal with numbers or static expressions. These systems can do a syntactical checking but understanding mathematical input (semantic checking) is far beyond the scope of such systems. The problem is that even a simple mathematical question can have an infinite amount of different correct answers.

2.1 Available Systems and Possibilities

Several solutions to these problems are available. The idea is to use a computer algebra system for the (possibly randomized) generation and grading of the questions.

Without intending to be exhaustive we quote only a few systems.

- An interesting project is *Active Math* (http://www.activemath.org/). The team around Erica Melis offers a complete math eLearning environment using elements of artificial intelligence including algebra systems. For our purpose the system is too complex and needs too much support but is still an interesting candidate.

- The project *Alice Interactive Mathematics* (AIM) (http://caroll.ugent.be:8080/index.html) is a web-based system designed to administer graded tests with mathematical content supported by the computer algebra system Maple. This Open Source Project (OSP) seems to be a little outdated at the moment but should be kept in mind.

- Another very promising OSP is the LON-CAPA system (http://www.lon-capa.org/), especially designed to offer eLearning courses and eAssessments with content from natural sciences and mathematics. The advantage is a huge and free available amount of repositories and a big user group.

Although each of the mentioned OSP eAssessment systems contain very interesting features, we decided to use the commercial MapleTA. The installation is relatively simple and the maintenance can be done completely via web. Additionally, we can use the full power of the underlying current Maple computer algebra system.

2.2 Maple TA

MapleTA is designed by Maplesoft Inc. in cooperation with Brownstone Research Group Inc. (http://www.maplesoft.com), (http://www.wimba.com). It combines a classical eAssessment system with typical question types as *Multiple Choice*, *Fill in the Blanks*, *Drag and Drop* and *Essay* with so called *Maple Graded Questions* which use the ability of Maple to check formula input for correctness. E.g. we could ask for the nth derivative of $\cos(x)$. Answers like

$$\cos(x + \frac{n\pi}{2})$$

or

$$\cos(x)\cos(\frac{n\pi}{2}) - \sin(x)\sin(\frac{n\pi}{2})$$

would both be detected correct. For details compare (Heck, 2004).

Additionally, questions can contain symbolic or numerical parameters,called *algorithmic variables*, which can be chosen randomly. Combining these parameters into mathematical terms yields dynamic expressions which can be plotted using Maple's plot facilities. Using this feature one can build question templates

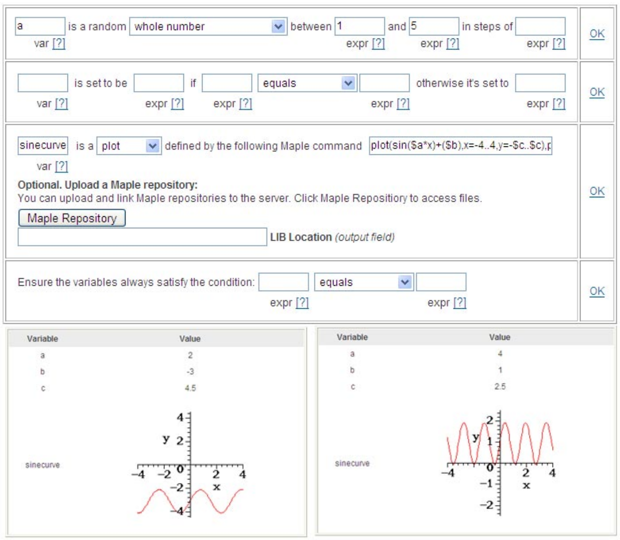

Figure 1: Designing Algorithmic Variables

which look different each time they are called. In Figure 1 the designer for algorithmic variables and the resulting dynamic graphs are shown.

The questions are stored in so called *question banks* and possibly be shared with other instructors. The questions can be developed in a full graphic *question bank editor*. Alternatively a script language similar to HTML can be used or a special LaTeXstyle which must be converted by Maplesoft. Compare Figure 2.

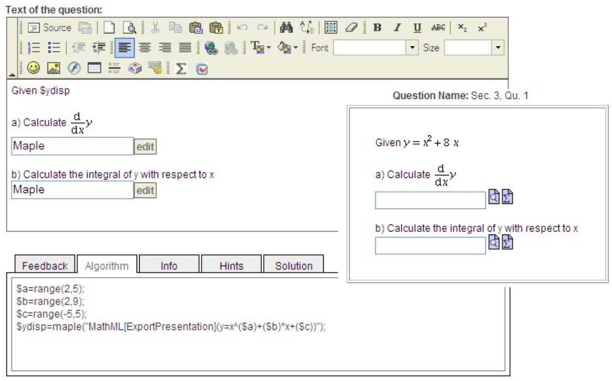

Figure 2: Editors's view

The particular assignment is then built using the *assignment editor*. One can choose question banks, assign weights (points) to the questions, order them randomly or even in a static order, choose the type of the assignment (e.g. self-study practice, homework, exam etc.), the time of availability and many other options.

The assignments can be done e.g. as homework using a standard browser or as exams in a controlled computer environment. So called *proctors* can check the authorization of the examinees and log them into the system.

The student's input can be immediately graded so that the student gets immediate response. Compare Figure 3. Note, that there is not only the correct answer but also several hints and comments to learn how the right answer could be achieved.

The results are stored in the so called *gradebooks*. They can be used for individual reports on students or for statistical purposes of groups or classes. Compare Figure 4.

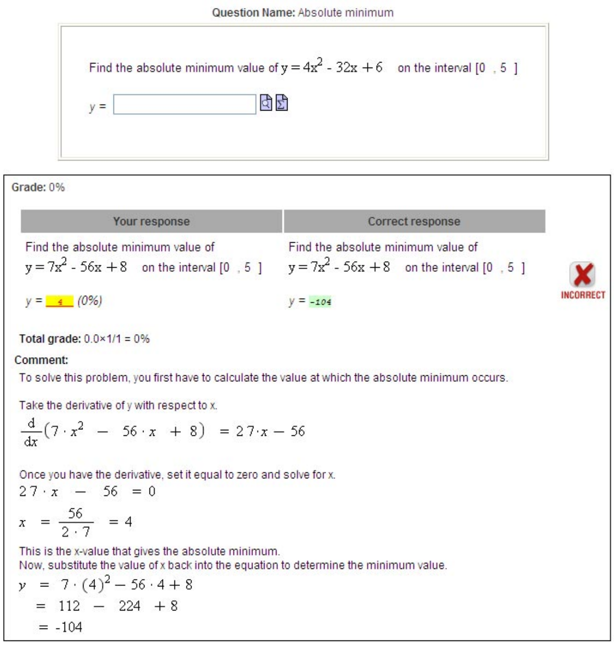

Figure 3: Response to a wrong Answer

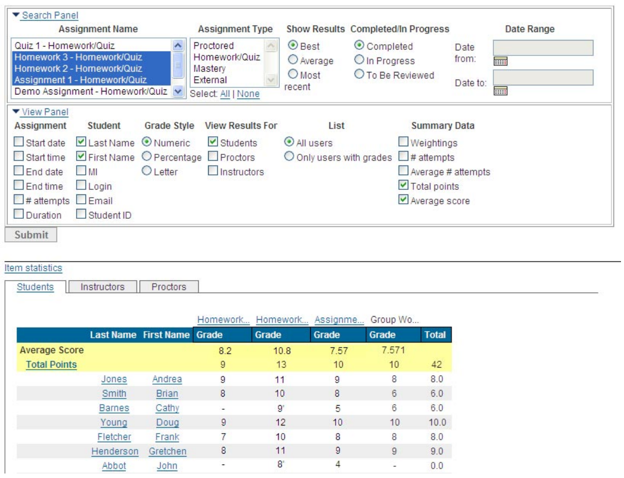

Figure 4: Instructor's View on the Gradebook

To access the system individual accounts must be arranged. Alternatively, an LDAP can be used or groups of users can be imported by an administrator using a simple roster.

3 SUMMARY

We discussed the problems of first-year students and tried to identify some of the reasons in schools and universities. We think that the introduction of eAssessment systems could help to overcome some of the problems in several ways. Diagnostic tests, self-studying practice with infinite patience and accompanying exercises are important elements at our university. But it is also important to get in touch with schools to find a common language, show the demands of engineering studies and last but not least motivate the young pupils to engage in mathematics, natural sciences and technology.

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