Using e-learning to self regulate the learning process of Mathematics for Engineering students.

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Abstract: Mathematics at an undergraduate level is frequently presented to the students in quite a traditional way. When implementing the Bologna education reform in Portuguese universities, the number of contact hours of the courses decreased, therefore increasing the need of a more self-responsible learning by the student. This means that the student has to work by himself (i.e., outside lectures and examples classes) on a regular basis. This implies that the lecturer is supposed to plan the students work, in principle weekly basis. In this paper we intend to describe an experience made at the Department of Mathematics for Science and Technology of the University of Minho in Portugal. Using an e-learning platform specially designed for teaching Mathematics called Maple T. A., we designed, programmed and made available for the students various sets of exercises organized in Question Banks on the course of Calculus. The advantage of this platform is that if properly designed, the questions can be always different and with different methods of solving (because of the use of random variables), the student can do it whenever and wherever he is (he does it via internet) and it feedback is made available to the students as soon as he submits the exercise. At the end of the year and with the aim of being able to evaluate how did the students feel about this experience, the students were given a survey implemented on the e-learning platform. The results of this survey strongly suggest, among other things, that using Maple T.A. helped the students in the study of the course of Calculus, and that it helped to achieve better results on the course.

Key–Words: Mathematics education, Self regulation, Maple T.A., LaTeX, questions banks, random variables.

1 Introduction

Mathematics at an undergraduate level is frequently presented to the students in quite a traditional way. When implementing the Bologna education reform in Portuguese universities, the number of contact hours of the courses decreased, therefore increasing the need of a more self-responsible learning by the student. This means that the student has to work by himself (i.e., outside lectures and examples classes) on a regular basis. This implies that the lecturer is supposed to plan the students work, in principle on a weekly basis.

Within the context of Bologna Process, a new educational paradigm is advocated arguing for the growing importance of new models of teaching and learning and to student-centred programmes and also to self-regulated learning [1].

Learning is seen as an active, cognitive, constructive, significant, mediated and self-regulated process [2]. Therefore, it is a dynamic and open process which requires students to engage in a wide array of tasks and activities which imply, in turn, careful planning, decision-making and self-reflection. Self-regulated learning is "an active, constructive process whereby learners set goals for their learning and then attempt to monitor, regulate, and control their cognition, motivation, and behaviour, guided and constrained by their goals and the contextual features in the environment" [3]. Self-regulation is a three-phase cyclical process: "The forethought phase precedes actual performance and refers to processes that set the stage for action. The performance (volitional) control phase involves processes that occur during learning and affect attention and action. During the self-reflection phase, which occurs after performance, individuals respond to their efforts" [4]. Research has pointed out the key mediating role of evaluation in enhancing the quality of both the process and outcomes of student-centred learning experiences [1], [5], [6]. It challenged some aspects of the theoretical background: (i) lecturer as a key mediating element between knowledge and students in ways conducive to a more active and self-regulated role in the learning process; (ii) interaction as a key element in the process in so far as it is a catalyst of the construction, reconstruction, change, interpretation and making sense of knowledge [1]. This suggests the implementation of distance learning methods. On the other hand, universities are progressively adapting their courses in order to take advantage of the new existing technologies. Web based learning is one of the educational options most used nowadays [7], [8], [9], [10], [11]. Many courses combine the traditional "contact hours" with web based learning methods and techniques. Nowadays it is quite common to use e-learning platforms where study materials for the students are made accessible. However these platforms, appropriate to a wide variety of courses, are not prepared to have the appropriate facilities needed in mathematics to go further in e-learning methods. The web-based system Maple T.A. [12], based on the computer algebraic system Maple [13], is mathematics-oriented so that it overcomes that problem. This article demonstrates how to make an assessment using Maple T.A.. The procedure has many steps which will be described with examples implemented in the courses of Calculus of the first year of engineering degrees in the University of Minho in Portugal. The advantage of this system is that it allows to assess a student in any part of the world, correcting it and immediately giving feedback to the student with all the power of Maple. First of all, one has to pick a up a pencil and a piece of paper and write the types of exercises one intends to assess the students on. This is the crucial step in order to be successful. As always, the design is the most challenging part in order to obtain an assessment that serves both the purposes of teachers and students. The programming part can be done using the Maple T.A. question bank editor together with an editor such as MathML-Control or WebEQ. Another way to do it is to use LaTeX and the LaTeX to Maple T.A. language converter http://latex2ta.mapleserver.com/ [14]. Using the Maple T.A. options enables to generate a test or assessment for a student, that can be done in any place of the world, and gives immediate feedback. This allows the student to organize his study and helps him to develop self learning skills. During the Academic year of 2008/2009, we designed, programmed and made available to the students of the courses of Calculus several Question Banks from which we generated a number of homeworks. At the end of the semester and with the aim of evaluating how did the students feel about this experience, we gave the students a survey implemented on the e-learning platform. The results on this survey, which are presented in Section 6, strongly suggest among other things, that using Maple T.A. helped the students in the study of the course of Calculus, and that it helped to achieve better results on the course. The present work has been done in the framework of Maple T.A. version 2.51. More recent versions of Maple T.A. are also available but some of the features here described might not be exactly the same.

2 Designing questions to feed a Question Bank

In this section we intend to describe the necessary steps to take in order to design the pseudo ideal assessment on a subject of mathematics. Since we intend it to be done via internet wherever the student might be, the design has to be such that we can generate different assessments for all the students. This is achievable as long as we have a big enough bank of questions from where the assessment picks up randomly a subset of them. Also for a given question we can generate different types of exercises using random variables present in Maple T.A. .

The way to explain this procedure will be based on an example. Suppose we intend to assess a student on how to calculate $\int \frac{x^2}{1+x}dx$ or other similar integral.

An assessment that assures that students will get different exercises of similar types as the one presented here, is, for instance, to consider we intend to calculate $\int \frac{x^n}{a+x^m}dx$ [17]. Since Maple T. A. allows us to have random variables, in this case we would say a, n,and m are these random variables that can assume values within a specified interval. Since a, m and n can be within a certain interval, the number of different exercises can be as big as we want it, plus, we get exercises that are solved using different strategies. Say one considers $m \in \{1,2\}$, $n \in \{0,1\}$ and $a \in \{1,2,\ldots,30\}$, MapleTa can generate 130 different exercises. Besides the number of exercises, as we mentioned before, we can also obtain different types of exercises with different methods of resolution. It is easily seen that for $m = 1$, and solving the respective integral, we obtain the following solution:

$$\int \frac{x^n}{x+a}dx = \frac{x^n}{n} - a\frac{x^{n-1}}{n-1} + (-a)^2\frac{x^{n-2}}{n-2} + ... \\ +(-a)^{n-1}x + (-a)^n ln|a+x| + K. \quad (1)$$

If $m = 2$, we have two cases. If n is odd,

$$\int \frac{x^n}{x^2+a}dx = \frac{x^{n-1}}{n-1} + (-a)\frac{x^{n-3}}{n-3} + (-a)^2\frac{x^{n-5}}{n-5} + \\ ... + ((-a)^{(n-3)/2})\frac{x^2}{2} + \frac{(-a)^{(n-1)/2}}{2} ln|a+x^2| + K, \quad (2)$$

and, n is even,

$$\int \frac{x^n}{x^2+a}dx = \frac{x^{n-1}}{n-1} + (-a)\frac{x^{n-3}}{n-3} + (-a)^2\frac{x^{n-5}}{n-5} + \\ +... + ((-a)^{(n-2)/2})x + \frac{(-a)^{n/2}}{\sqrt{a}} arctan(\frac{x}{\sqrt{a}}) + K \quad (3)$$

Let us consider the case where $m = 1, n = 2, a = 1$. Using the correspondent formula above, we obtain,

$$\int \frac{x^2}{x+1}dx = \frac{x^2}{2} - x + ln|x+1| + K \quad (4)$$

Another example could be for $m = 2, n = 1, a = 4$. Using the correspondent formula above, we obtain,

$$\int \frac{x}{x^2+4}dx = \frac{1}{2} ln|x^2+4| + K \quad (5)$$

The design of the assessment is as expected the most difficult as well as the most challenging, since on the one hand we have to design an exercise that is in agreement with the theory taught to the students, and, on the other hand we want as many exercises as possible so students will be assessed properly.

3 Programming the designed questions for a Question Bank

This could be done using some existent text editors, such as Math type or others. Experience told us, this is not the best way since these editors are often not easy to use and change a lot from version to version. We decided to invest in using any text editor and write the questions in LaTeX.

Say we want to programme the exercise described in the previous section. We want to assess the students on $\int \frac{x^n}{a+x^m}dx$. In this case and using for instance the Winedit editor, we would write:

```
\begin{document}
\begin{topic}{INTEGRALS}
\begin{question}{Maple}
\name{Example1}
\qutext{Find $\int\frac{x^{\var{n}}}
{x^{\var{m}}+\var{a}} dx$}
\code{$m=rint(1,2);$n=rint(0,1);
$ a=rint(1,30); $answer =
maple("eval(\int((x^$n)/((x^$m)+$a),x)"));
$Adisplay=maple("printf(MathML:-
ExportPresentation($answer))");}
\maple*{evalb(simplify(($RESPONSE)
-($answer))=0);}
\comment{The correct answer is \var{Adisplay}.}
\end{question}
...
\end{topic}
\end{document}
```

The first two lines are self-explanatory. The third line just says one wants to write a question which uses Maple commands. The fourth line gives a name to the question. The fifth line writes to the screen the question to be assessed in standard LaTeX. The lines 6, 7 and 8 are the core of the programme. There, it is said that m, n and a are random variables within a certain interval. Next a maple command is used to calculate the integral and the value is attributed to the variable answer. To the variable Adisplay is attributed the form of the presentation in the screen for the correct answer. The nineth line verifies if the response given by the student is correct. Finally, the tenth line writes the correct answer on the screen.

4 Compiling and testing the questions for a Question Bank

The next stage of this work is to verify that the code works properly, and in the case it does not, to correct it. The proposed procedure is based on three steps. In the first step we compile the code in , next we convert to Maple T. A. language using [14], obtaining a .qu file, and finally we are able to test it importing this file to a question bank in the Maple T.A. platform.

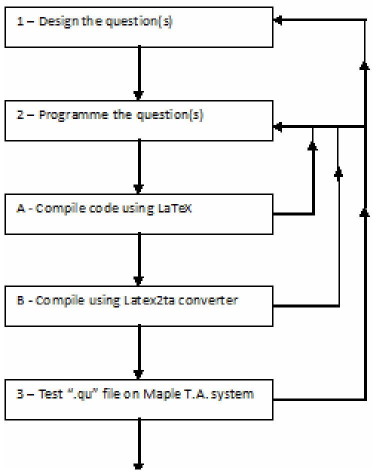

Figure 1: Scheme with procedure proposed to design and programme questions for a Question Bank in Maple T.A.

5 Brief analysis of survey to assess the implementation of Maple T.A.

The procedure described in the previous sections was implemented for the course of Calculus of the first year of an engineering degree in the University of Minho in Portugal. After having a Question Bank ready, three homeworks were given to the students during the semester. Three days were given for the students to complete each homework, and the questions of each homework were of Multiple Choice type. At the end of the semester and with the aim of being able to evaluate how did the students feel about this experience, a survey implemented on the e-learning platform BlackBoard was given to the students. The students were not obliged to answer the survey. The number of students who actually answered this survey was 208. Most of the questions used a Likert Scale for the possible answers given by the students: totally agree(TA), agree (A), do not agree and that they do not disagree (NA/ND), disagree (D), and totally disagree (TD). In this framework TA, A, NA/ND, D and TD correspond respectively to 5, 4, 3, 2 and 1 points. Then, the average value of the answer for each question was calculated.

From all the answers given by the students, the following is emphasized: -the students felt that the homeworks implemented in Maple T.A. helped them to study for Calculus (Average: 4.29);

-the number of homeworks implemented in Maple T.A. was adequate (Average: 3.94);

-the deadlines given to execute these homeworks were adequate (Average: 3.92);

-the content of these homeworks was adequate (Average: 4.07);

-the homeworks helped them to achive a better result (Average: 3.88);

-the available computer facilities at the University were adequate to perform the homeworks (Average: 3.96);

All these results strongly suggest this experience was positive and that one should proceed in this path implementing this in other courses as well as to complete the Question Bank already implemented. Note that the maximum value of the scale is 5, and all these averages are close to 4 or above. Further analysis is still needed from this survey but from the brief analysis presented above one strongly believes that proceeding and expanding this experience to other courses will help the students achieving better results in the courses of Mathematics.

6 Conclusions

- There is a need to rewrite exercises, previously designed with a pencil and piece of paper, when new methodologies and technologies are implemented.

- Randomization of variables on Maple T.A. allows to explore the possibilities of having different types of exercises, as well as a number of exercises as big as one wants.

- The students felt that the homeworks implemented in Maple T.A. helped them to study for Calculus.

- The homeworks implemented using Maple T.A. helped students to achieve a better result.

- The available computer facilities were adequate to perform the homeworks.

- We intend to continue to develop Question Banks of Maple T. A. for other mathematics courses of engineering students, contributing this way to help the self regulation of engineering students in their study for Mathematics courses.

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