New e-learning objects for the Mathematics courses from Engineering degrees: Design and Implementation of Question Banks in Maple T.A. using LaTeX

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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 (considerably in some cases), 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. In practice 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. We also make a comparison of alternative ways to program the questions of a questions bank. 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 academic 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 obtained from 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.

Keywords— Mathematics education, Self regulation study, Maple T.A., LaTeX, questions banks, random variables

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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-centered 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 behavior, 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-centered 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.

Maple T.A testing evaluation and grading software is an easy-to-use web-based system for creating tests and assignments, automatically assessing student responses and performance. It supports complex, free-form entry of mathematical equations and intelligent evaluation of responses, making it ideal for mathematics courses. It allows a teacher to create its own content using comprehensive content authoring tools. It allows randomization based on different coefficients and different mathematical functions, it identifies as equivalent different algebraic forms of a mathematical expression, it allows automatically assessing student responses and performance answer, it is built to access online when the students are registered.

This article shows how to create/feed a question bank that can be subsequently used 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 assessing a student in any part of the world, grading 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 MathMLControl 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].

In this paper we will present both ways presenting advantages and disadvantages, concluding that the second approach seems to be easier to implement, and therefore a better method.

Then the Maple T.A. options enables us to generate a test or an 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 homework. 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.

I. 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 integrals.

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 use random variables, in this case we would say a, n, and m constants 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 $a \in \{1, 2, ...30\}$, Maple T.A. can generate 120 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:

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

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

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

and, n is even,

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

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

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

Another example could be for $m = 2$; $n = 1$; $a = 4$. Using the correspondent formula above, this would lead to,

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

The design of an assessment is as expected the most difficult as well as the most challenging, since on the one hand we have to design exercises 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 adequately.

II. PROGRAMMING THE DESIGNED QUESTION TO FEED A QUESTION BANK

In this section we explain how to programme a designed question for a Question Bank for Maple T.A. The programming part can be done using the question bank editor of Maple T.A. or for instance in LaTeX subsequently converted into the Maple T.A. language. We compare both methods, then we give our critical appreciation of both methods and finally we present an example using the second approach, since this option seems to be the most appropriate form for a team of lecturers who are familiar with LaTeX.

A. First method: Using the question bank editor of Maple T.A. and a text editor

In order to create a question bank using the question bank editor of Maple T.A. and a text editor, such as MathMLControl or WebEQ, the process is the following:
In the question bank editor of Maple T.A., we click at "*Add a Topic*" and write a topic name for the group of exercises we want to implement. Then, we click at "*Add a question*", we insert a question description and we choose one of the given question types: "*multiple choice*", "*multiple selection*", "*true/false*", "*clickable imagemap*", "*matching*", "*fill in the blanks*", "*maple graded*", "*mathematical formula*", ... We proceed, choosing for example the multiple choice question type. Then, we use the HTML formatting option for the question text and we choose the algorithm option. In order to create the code for the algorithm of the question we can select "*show designer*" and then use the algorithm designer. There we have to complete a form indicating random variables, variables defined by the Maple commands and variables satisfying certain conditions. Then, we click at "*Next*" and we write the question text, the number of possible answers and

we mark the correct answer. At this point one can use the WebEQ editor to write mathematical symbols and copy and pass them to the question text. There is also the possibility to use the equation editor provided by Maple T.A., but the attempt to open this editor and to work with it failed. In addition, we can write some feedback or hints, which will be shown to the student. To finally end this process we click "*Finish*". One can add more questions to the question bank by repeating the steps described previously.

B. Second Method: using LaTeX

The question bank can also be created using LaTeX in the following way. We can create a document with the usual LaTeX commands and the instructions:

\begin{document}
\begin{topic}{}

With this command we build a question group and give a name to it by writing the topic name for the group of exercises inside the empty brackets.

\begin{question}{MultipleChoice}

This command defines the question type. Instead of "*MultipleChoice*" we can choose one of the other options listed in the previous section.

\name{}\qutext{}

Here, inside the empty brackets, appears the name of the first question and the text of the question, respectively. Mathematical symbols can be written using the usual LaTeX commands.

\choice{}\choice{}\choice*{}\choice{}

At this step the different answers for the multiple choice question can be established, where an asterisk indicates the correct answer.

\code{$a = range(); $d =maple("eval()"); }

With this command *(\code{})* one can define the algorithm, on which the question is based, using Maple commands. A variable is represented with a dollar sign in front of it.
In the example given in the line above, "*range()*" generates a random integer and attributes it to variable **a** and "*maple()*" enables to use a Maple command which is then attributed to variable **d**.

\end{question}

This line finished the code for the first question.

\end{topic}

9

This command line finishes the question group.

\end{document}

This line finished the LaTeX document. Note that a document in LaTeX is a file with the extension **.tex**.

If you want to insert more questions to this question group you only have to repeat the part from *\begin{question}* to *\end{question}* and insert it between \end{question} and *\end{topic}*.

After finishing this **.tex** file, it must be converted to a **.qu** file using the LaTeX to Maple T.A. converter that is can be used via the internet address http://LaTeX2ta.mapleserver.com/ (6). There we can select the .tex file to upload to the conversion server. The conversion process usually takes less than one minute. In order to install it in a Maple T.A. class one only has to upload the .qu file at the question bank editor and install it.

C. Critical appreciation of both methods

Comparing the first method using the Maple T.A. question bank editor together with the equation editor with the second method using LaTeX, one can say that the second method reveals to be the better one for the following reasons.

Concerning the first method, where we have to write the mathematical text with mathematical symbols using an editor, it can take more time and it is more complicated to write the text than using LaTeX, because we have to construct each symbol on a separate window using a "clicking process" and copy each time the symbol and paste it to the window in Maple T.A., where you are writing the text. In LaTeX we stay and write the mathematical text in one window and the mathematical text edition is therefore quicker and more practical. In order to construct the question with the question bank editor, you have to pass from one window to another to fill out the question text, to write the algorithm, to write the answers, therefore it is difficult to have an overview of the whole question and of the question group. Whilst using LaTeX you have an overview of the whole question and even of the whole question group, because all commands, building up the question and the question group, occupy the same file which is displayed on one window. The second method provides therefore a clearer arrangement and an organized view of the question contents and programming instructions.

Another advantage of using the second method is that we can rapidly build up a new question by copying the commands of one question and changing then the text and the algorithm. This is not an easy task using the question bank editor, because we must construct the question from the beginning, clicking on buttons, passing through a lot of windows and writing texts. We cannot copy the whole question to profit from what we have written previously. Thus, the process of building up a new question is less prectical and more time consuming.

Concerning the previous facts and analysis we can conclude the following:

- The method using LaTeX is more practical, in particular, it is more appropriate for writing mathematical text and symbols, which appear in the questions.
- The construction of questions and question banks is quicker with LaTeX.
- The second method provides a better overview of the whole question and question groups and a more organized and clearer arrangement of the question contents for the construction process.

Although at a first view the first method appears to be simpler for those who are not familiar with LaTeX, after going through both processes, we recommend the second method which involves the use of LaTeX.

D. An example using 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 sixth is the core of the program. 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 seventh line verifies if the response given by the student is correct. The eighth line writes the correct answer on the screen. On the ninth line we finish the code for the first question. The same procedure can be repeated to program new questions.
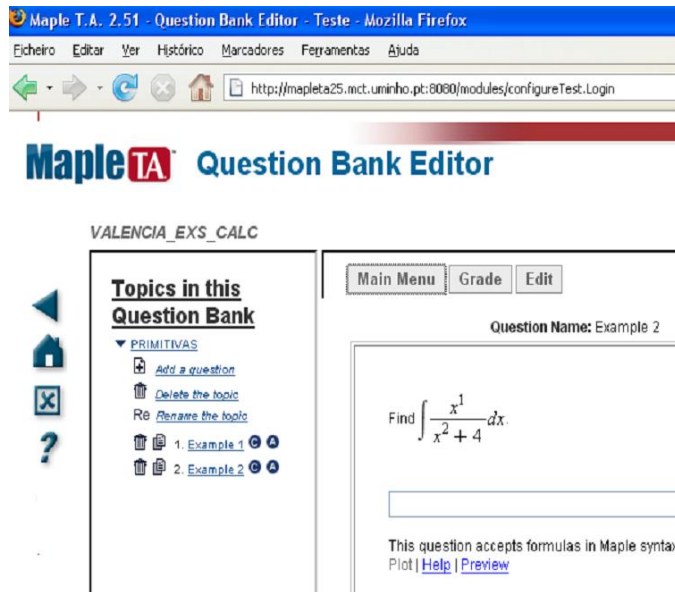

Figure 1: Example of question programmed seen as a student sees it when being assessed on it.

Grade: 0%

$$\text{Find } \int \frac{x^2}{x^1 + 1} dx.$$

INCORRECT

Your Answer: x

Comment: The correct answer is $\frac{1}{2} x^2 - x + \ln(x + 1)$

Figure 2: Screen a student gets when answering x to the example given in equation (4).

Grade: 0%

$$\text{Find } \int \frac{x^1}{x^2 + 4} dx.$$

INCORRECT

Your Answer: x

Comment: The correct answer is $\frac{1}{2} \ln(x^2 + 4)$.

Figure 3: Screen a student gets when answering x to the example given in equation (5).

III. COMPILING AND TESTING 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 LaTeX, 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.

IV. IMPLEMENTING THE DESCRIBED METHOD FOR ENGINEERING STUDENTS ON THE COURSE OF CALCULUS

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 homework assignments were given to the students during the semester. Three days were given for the students to complete each homework assignment, and the questions of each homework assignment 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 Black Board 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 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.
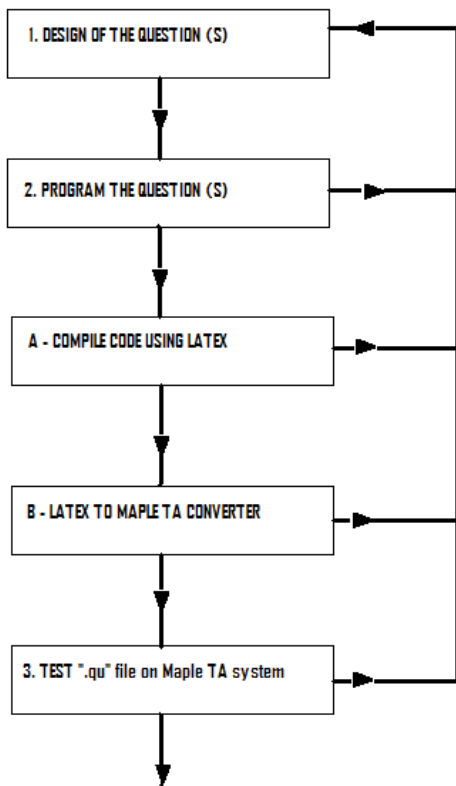
average of their answers was 2.81 with 77 students out of the 206 answering that they don't agree or that they totally disagree.

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 except in one case.

On the other hand the results obtained in the survey concerning the possibility of using Maple T.A in the final exam, indicates that the students so far consider that Maple T.A. is a helpful tool to study a course, but they do not agree, or it is far from consensual, that exams should be done using Maple T.A.. This maybe explained due to the fact that when Maple T.A. marks a question, it considers it as right or wrong. The reasoning or the intermediate steps the student has to answer the question are not totally taken into account. Of course this can be overcome if the questions when designed are subdivided in smaller questions allowing the marking of the assessment to be closer to a normal written exam.

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.

Figure 4: Scheme of the steps involved in the process to design questions for a Maple T.A. question bank.

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 homework assignments implemented in Maple T.A. helped them to study for Calculus (Average: 4.29);

- The number of homework assignments implemented in Maple T.A. was adequate (Average: 3.94);

- The deadlines given to execute these homework assignments were adequate (Average: 3.92);

- The content of these homework assignments was adequate (Average: 4.07);

- The homework assignments helped them to achieve a better result (Average: 3.88);

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

- Students still don't trust the system well enough so that their final exams should be done with this method. When asked directly if their final exams should be done in Maple T.A. the

V. CONCLUSIONS

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 meant that the student has to work by himself (i.e., outside lectures and examples classes) on a regular basis. This also 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-centered programs and also to self-regulated learning.

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 behavior, guided and constrained by their goals and the contextual features in the environment" [3].

Many 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. 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., based on the computer

algebraic system Maple, is mathematics-oriented so that it overcomes that problem.

Maple T.A testing evaluation and grading software is an easy-to-use web-based system for creating tests and assignments, automatically assessing student responses and performance.

This article demonstrated how to feed a question bank that can be subsequently used 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 main conclusions we can take after following the procedure described in previous sections are:

- Using new methodologies and technologies, there is a need to rewrite exercises, previously designed with a pencil and piece of paper;

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

- The use of LaTeX and the procedure presented here offers us a powerful and indeed easy way to design a homework/test that can assess students in any part of the world, with immediate feedback. Furthermore, all the work of marking papers is no longer an issue for lecturers.

- The students felt that the homework assignments implemented in MapleT.A. helped them to study the course of Calculus.

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

- The informatics means the student or that the University has were adequate to perform the homework.

- The students are not convinced that exams should be implemented using Maple T.A.. The students so far consider that Maple T.A. is a helpful tool to study a course, but they do not agree, or it is far from consensual, that exams should be done using Maple T.A..This maybe explained due to the fact that when Maple T.A. marks a question, it considers it as right or wrong. The reasoning or the intermediate steps the student has to answer the question are not totally taken into account. Of course this can be overcome if the questions when designed are subdivided in smaller questions allowing the marking of the assessment to be closer to a normal written exam.

- Further analysis is still needed from the survey we gave the students, but from the brief analysis presented above, we strongly believe that proceeding and expanding this experience to other subjects will help the students achieve better results in the subjects of Mathematics.

- All that is presented in this paper is just the starting point of a project led by researchers of CMAT (Center of Mathematics) of University of Minho in Portugal, together with researchers from the Institute of Education and Psychology from the same University, that has the aim of constructing a whole set of e-learning objects in order to enhance performance in the mathematics subjects of Engineering students at the University of Minho. Our aim is also to cooperate with other Portuguese Language speaking countries CPLP [18] (Portugal, Brazil, Angola, Mozambique, Cape Verde, Guiné Bissau, São Tomé and Principe and Timor Lorosae) in order to build a huge question bank that can be used by all.

REFERENCES

[1] A. M. Veiga Simão e M. A, Flores, O aluno universitário: aprender a auto-regular a aprendizagem sustentada por dispositivos participativos.,Ciências e Letras, 2006, pp. 229-251.

[2] J. Beltran, Desenrrollo y tendencias actuales de la Psicologia de la instruccion, Psicologia de la Instruccion: variables y processos bsicos 1, J. Beltran y C. Genovard (Eds.), 1996, pp. 19-86.

[3] P. R. Pintrich, The role of goal orientation in self-regulated learning, Handbook of selfregulation,2000, pp. 451-502.

[4] D. H. Schunk, P. Ertmer, Self-regulation and academic learning: self-efficacy enhancing interventions, Self-regulation: Theory, research and applications, 2000, pp. 631-649.

[5] C. P. Leão., G. Machado, R. M. S. Pereira, J. Paulo, S. F. C. F Teixeira, Teaching Differential Equations: Concepts and Applications , International Conference on Engineering Education, New Challenges in Engineering Education and Research in the 21st Century, Budapest Hungary,2008.

[6] A. M. Veiga Simão, A. Flores, P. Flores, GraduatesViews on Their Initial Training: Challenges for Higher Education, 13th International Conference, International Study Association on Lecturer Thinking - ISATT Totems and Taboos: Risk and Relevance in Research on Lecturers and Teaching, Canada , 2007.

[7] R. D. Owston. , The World Wide Web: A Technology to enhance Teaching and Learning, Educational Researcher, 1997.

[8] Maple T.A. Content Center, [Online].
Available: http://www.maplesoft.com/tacontent/.

[9] Maplesoft User Case Studies , [Online].
Available: http://www.maplesoft.com/company/casestudies/.

[10] F. Bagnoli, F. Franci,,A. Starbini, WebTeach: an Integrated Web-based Cooperative Environment for Distance Learning, SEKE'02, Italy , 2002.

[11] M. Seppala, O. Caprotti, S. Xambo, Using Web Technologies to teach Maths, WebAlt Conference and Exhibition, 2006.

[12] Maple T.A 5.0, Automated Online Testing and Assessment, Developer's website, [Online].
Available: http://www.maplesoft.com/products/mapleta/.

[13] Maple 13 The Essential Tool for Mathematics and Modeling, [Online].
Available: www.maplesoft.com/products/maple.

[14] LATEXto Maple T.A. Conversion, Maplesoft, [Online].
Available: http://LaTeX2ta.mapleserver.com/.

[15] O. Caprotti, WebALT! Deliver Mathematics Everywhere, Proceedings of Society for Information Technology and Teacher Education Conference 2006, pp 2164-2168.

[16] A. Heck, Gastel Leendert van, Mathematics on threshold, International Journal of Mathematical Education in Science, 2006.

[17] E. Vaz, T. Malheiro, G. Machado, R. M. S. Pereira, Web Technologies: an allied of Mathematics, Procedings of INTED 2008 – International Technology Education and Development Conference, Valencia, Spain, 2008.
[18] CPLP – Comunidade dos Países de Língua Portuguesa, [Online]. Available: http://www.cplp.org/.

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