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The Use of Mathematics Education Project in the Learning of Mathematical Subjects at University Level

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Abstract

The educational context requires a renewal of paradigms. Profound changes in the roles and functions of teachers and students are particularly vital. More active, cooperative and participative methodologies of learning must be privileged, breaking with magisterial education and the mere 'transmission' of knowledge.

Informatics tools can become a major element in the educational context, promoting significant and self-regulated learning for the student, always under the adequate orientation of the teacher.

In this context, the Mathematics Education Project (PmatE) was created in the University of Aveiro, with the main objective of identifying and counteracting the causes of school failure in mathematics in an innovative approach.

However, the PmatE platform has not yet been subjected to the kind of systematic evaluation, especially in higher education, that would allow us to understand in what conditions the goals can be achieved.

Thus, the question underlying this explanatory research is: "What impact does the platform of assisted education developed by PmatE have in the process of learning math subjects at university level?"

A previous analysis (still ongoing) of the data collected through several techniques – inquiry, documental analysis and participant observation – suggests there are interesting and innovative alternatives to the dominant pedagogies in higher education (where teaching assumes almost exclusively a magisterial form), with significant advantages for the construction of knowledge and for the development of the students' capabilities.

Keywords: Computer assisted learning, Higher education, Mathematics education, Self-Regulated learning, Technology

1. Introduction

Nowadays, we live in an ever-changing society. Those changes are reflected, not only, but also, in the educational community. Thus, a renewal of paradigms in the educational context is demanded (Morin, 1999; Schön, 1983), namely in Mathematics.

The modern Information and Communication Technologies (ICT) boosted the information society and, therefore, influenced the social lives. It is not easy to imagine nowadays life without the various services provided by the Internet. A "new learning generation" is around, one that is, actually, “digital native” and makes large use of IC technologies every day for both leisure and communication/social interaction purposes. This emerging situation also has major potential implications in the field of education. Constructivists have argued that instructional technologies can be useful to help learners find their own meaning.

As a consequence, an entirely new learning scenario is emerging. The instructional use of digital devices, applications and services is becoming more and more widespread and new educational approaches, with significant changes in students’ and teachers’ roles, are now envisaged. The role of the teacher has that to be, increasingly more, that of teaching how to think; to endow the student with capabilities that allow him to become actively involved in the construction of the knowledge. Students must assume an ever more autonomous role in the process of learning (Benson, 2003; Biggs, 2003; Solé 2001), in order to become involved and participative citizens in a world in constant change.

The challenge that teachers face today is to motivate students to learn, get them to commit and take an active role in their learning journey (Biggs, 1999; Entwistle, 1988; Felder & Brent, 2005; Solé, 2001).

In this context, the Mathematics Education Project (PmatE – Projecto Matemática Ensino) has developed, since 1989, several strategies to increase the interest and improve the success of students in Mathematics. PmatE developed a platform of computer aided education (PCA), currently available only in the Internet, for students of all ages since primary school. The main goal of this platform is to support teaching, making it possible to: manage the groups involved; elaborate tests; assess students’ performance; analyse results and perform other management tasks. The developed programs are thus a tool to support education, evaluation and learning.

However, this platform has not yet been submitted to a systematic evaluation, especially in higher education, that would allow us to unequivocally conclude whether and in what conditions those goals can be achieved.

From this standpoint, we develop a case study with Food Engineering students. The major goal of the study is to evaluate the impact of the PmatE platform of computer aided education (PCA) in the learning of mathematical subjects at university level. This paper describes how it was conceived as well as the main previous results on the subject.

2. Learning Mathematics and Education Strategies

In response to the changes continuously taking place in our society, it is now imperative to offer math education for everyone instead of restricting it to any social elite. The current curricular orientation aims at “the complete and balanced development of the student as person and promoting his auto-accomplishment as individual and as citizen” (APM, 1998). Urgent changes in the learning and education processes are thus needed, not only in what concerns to contents but also to the methods of education.

It is also important to refer to the vocational and professional aspects of maths education. We live in a society increasingly influenced by science and technology. And maths, beyond being the universal language of scientific and technological development, it is also a fundamental instrument for scientists, engineers, technicians, etc. This subject “provides the training of competent specialists who use mathematical tools, often sophisticated, producing organized knowledge, and that have distinct professional backgrounds from that of the mathematicians” (Ponte et al, 1997, p. 3).

The essential purpose of maths teaching is “to contribute in a positive way to the global educational training of the generality of the citizens” (Ponte, 1997, p. 1). The mere 'transmission' of isolated knowledge, mainly consisting of sets of rules and techniques, which strongly appeals to memorization and mechanization, achieved through the traditional expositive method (where students stay quite passive) is no longer acceptable. Maths is now called to give a fundamental contribution to the student, particularly in learning how to communicate, to interpret, to interrogate, to foresee, to discover and to argue “reasoning about abstract objects and relating them to the physical and social reality” (idem, ibidem). In short, to endow the student with capabilities that may allow him to participate actively and critically in society both as individual and citizen.

Traditionally, maths lessons are divided in two parts: first, the teacher presents some ideas and mathematical techniques and, later, the students work with a set of exercises selected by the teacher. The variations from this standard are related to the time spent by the teacher on each of the two parts: either the teacher occupies most of the time exposing the subjects, or allows the students to stay most of the time solving exercises. We can affirm that the traditional maths education model fits in the exercise paradigm.

This paradigm can be opposed to a problem-solving approach - “It is through intentional mathematical activities, from his living experience, that an individual consolidates, discovers or invents knowledge. It is also this mathematical experience of each student that shapes his vision of mathematics as well as his motivation and disposal to be personally involved in the learning process.” (Silva et al, 1999, p. 71). In students’ mathematical activity, we should give a prominent place to the experience-based learning problems. The resolution of problems inhibits the trend of the students “for the immediate and invites to the reflection on and to the understanding of the problematic situation or to the evaluation of its resolution” (Varandas, Oliveira, & Ponte, n.d., p. 24).

A successful maths lesson is based on valid and involving maths tasks, in a stimulant work environment and propitious to the dialogue. For example, the teacher can launch good questions/challenges providing minimum information; after that, the students, working in small groups, discuss the problem and try to figure out the solution, assuming a central, active and participative role. In the end, and working with the whole class, the teacher coordinates the systematization of the developed work and/or the formalization of inherent mathematical aspects of that work.

The information and communication technologies (ICT) have a fundamental role in this reform of the educational model (Forcier, 1999). The ICT facilitate the teacher's function to accompany each student in a differentiated form and respecting the rhythm and preferences of each one, enhancing the creation of complementary classroom activities and tasks adapted to the specific necessities of the student.

The World Wide Web (WWW) - the most visible source of these technologies - "it is considered a way to develop human capacities, allowing each individual to extend his intellectual and affective horizons" (Carrilho & Cabrita, 2009, p. 165).

In the specific case of maths, "these technologies allow to foresee the education of the mathematics in a deeply innovative mode, strengthening the role of graphical language and of new forms of representation, relativizing the importance of calculation and symbolic manipulation. Moreover, they allow the teacher to give greater attention to the development of capacities of superior order, valuing the possibilities of accomplishment, in the classroom, of activities and projects of exploration, investigation and modelling. This way, ICT allow the development, in the students, of important abilities, as well as of more positive attitudes in respect to mathematics while stimulating a more complete vision of the nature of this science" (Varandas, Oliveira, & Ponte, n.d., p. 1).

This way, students will see a purpose in the study of this science, establishing, thus, a positive relation with mathematics and feeling more motivated to learn.

3. The Mathematics Education Project (PmatE – projecto matemática ensino)

3.1 Introduction

The questions of school failure, and in particular in the subject of mathematics, deserve all our attention today. To know its causes and to find ways of counteracting them is a priority in all levels of education. It was based on this perspective that was born, in the University of Aveiro, the Mathematics Education Project (PmatE), a bold project that, foreseeing the current situation, early started to develop informatics tools as well as contents in various fields of knowledge. The fact of having been born in the Department of Mathematics gave it its name and its main objective - to increase interest and success in Mathematics.

As it was previously mentioned, PmatE has been developing, since 1989, a platform of computer aided education (PCA) that, avoiding repetition of questions, stimulates learning and understanding, in opposition to memorization, of the subjects taught.

The PmatE developed competitions and projects that cover all the degrees of education, including higher education. All the competitions, as well as the corresponding practice tests, from primary to secondary school are completely free and open to every student. In what concerns to higher education students not attending University of Aveiro, the establishment of an agreement with his home institution is needed before participating.

As it was already referred, the project is anchored in a platform of computer aided education (PCA) that can be used after a single registration process (that lasts forever).

3.2 Question Generator Model (QGM)

The main component of the PCA is the Question Generator Model (QGM). It is "a tool based on parameterized expressions which usually allows thousands of different questions to be generated (different formulations of the same model) formally equivalent in terms of pedagogic content" (Pinto et al, 2007, p. 285). These question generating models, from now on simply mentioned as models, are elaborated by mathematics teachers. Its greatest advantage is that all questions have a specific set of parameters – randomly generated – that make it very unlikely to have two exams exactly the same, even though the level of difficulty and type of questions is kept constant. This methodology allows two computers that are placed side by side to present different questions even if subjected to the same model. Each formulation from a model is a set of four propositions, each of which may be false or true. Student must validate the four propositions because it may happen that all of them are true (V) or false (F).

Figures 1 to 3 show three different formulations generated by the same model.

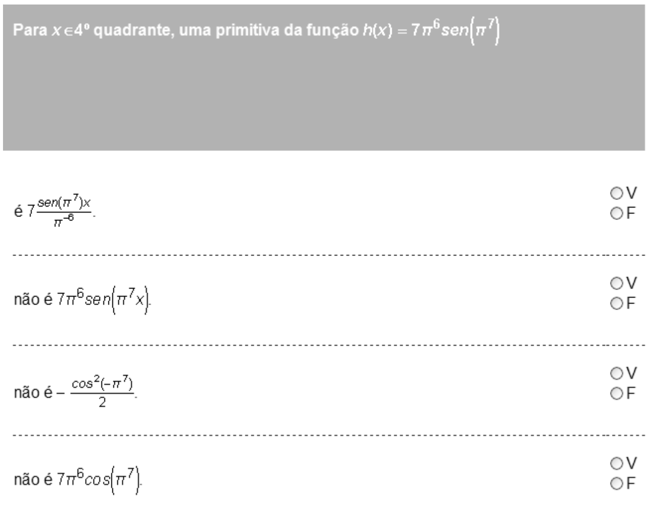

Figure 1. First formulation of the model ID 423

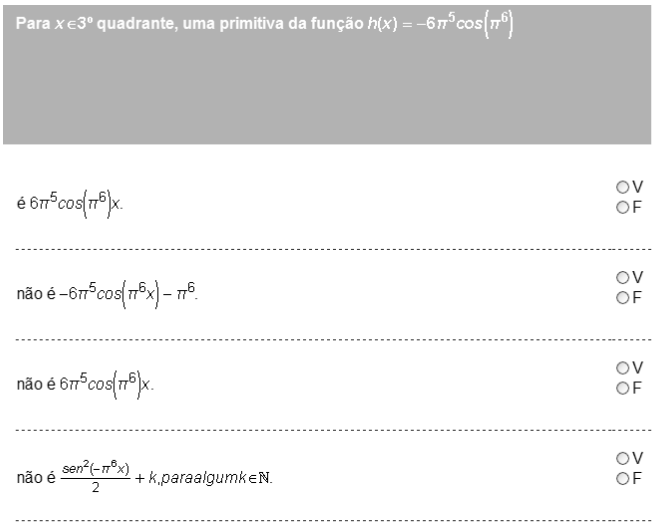

Figure 2. Second formulation of the model ID 423

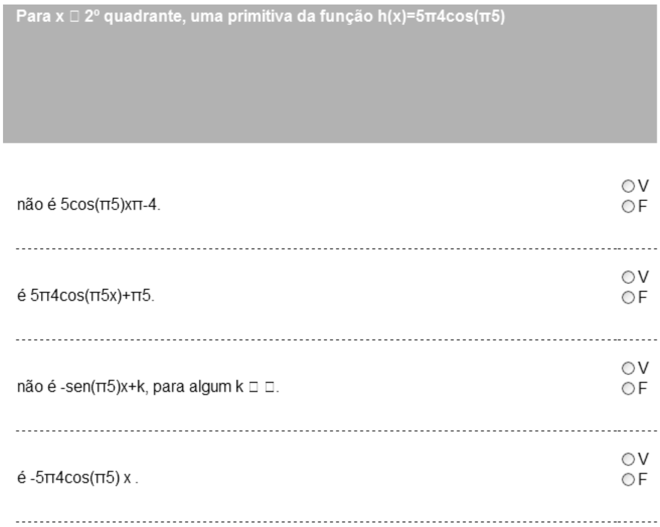

Figure 3. Third formulation of the model ID 423

This is a brief overview of a QGM. Further explanation can be found in Vieira, Carvalho, & Oliveira (2004).

In order to assure international standards of content and evaluation, PmatE followed the thesaurus defined by the American Mathematical Society (AMS) classification. Thus, each model is classified by (Pinto et al, 2007, p. 289):

- Subject – the scientific field where the model's content is designed.
    - Mathematics/ Physics/ Biology/ Digital Systems
- Topic – each subject is divided in topics.
- Sub-topic – a topic is a wide concept so, to have a precise classification, we need to be more specific.

- Main Objective (OP) – dominant cognitive objective of the model.
- Secondary Objective (OS) – within the main objective, a QGM might be so particular that we still need a more specific classification.
- Teaching cycle – this field identifies the teaching cycle or level to which the model refers. 1 refers to the first teaching cycle and 5 refers to university (undergraduate) level.
- Difficulty level – this is a very important item for proper use of the model. Our purpose is to conceive models of different difficulty levels (from 1 to 5) for the same concept. This way, it can be used by good students and by the least interested ones.

If we merge the QGM with an Information System that registers all the right and wrong answers of the users, we will obtain very clear information about students' performance.

3.3 The Tests in PmatE

In the PCA, there are two types of tests - training and evaluation.

In training mode, the student can access several versions (the training testes), except to those reserved to higher education students. The tests presented are organized by education level so that the mathematical concepts can be properly adjusted. Within the scope of higher education, it is the teacher of the group himself who creates the training tests for his group, and only the enrolled students in the group have access to these tests. The tests are presented in a game-looking way, with a chronometer in decreasing counting and several levels to complete. In each level, the player (student) has two tries (or "lives") to correctly answer the questions. If, in a first attempt, the student has one or more wrong questions (of the 4 presented in each level), he has a chance to try to detect the error(s) and correct it (them).

In evaluation mode, the tests are created by the teacher, who builds a specific set of questions for his students. The tests are only accessible to students of the teacher who developed the test. For each test, each student has access to a different formulation of the same questions, while maintaining the concepts that are being evaluated. In this version, students have access to a different test format: they see several questions on the screen among which they can scroll, instead of seeing one single question per screen (levels format), as it happens in the training version.

The main difference between them lies in the fact that, in the first case, the student has to correctly answer the presented questions to see the next screen, while in the second one, the student has access to all questions at once and has the freedom to navigate between them just as it would happen if it was a hand written exam. The system corrects the tests automatically and the evaluation is, generically, quantitative. However, the information made available by the system concerning the performance of the students goes far beyond simple classification. It is also possible to analyse their performance in each of the tested subjects - evaluation by objectives - allowing the teacher to obtain information about how is going on the learning process of different subjects (Anjo et al, 2005).

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Figures 4 and 5 show parts of a formulation of an evaluation test.

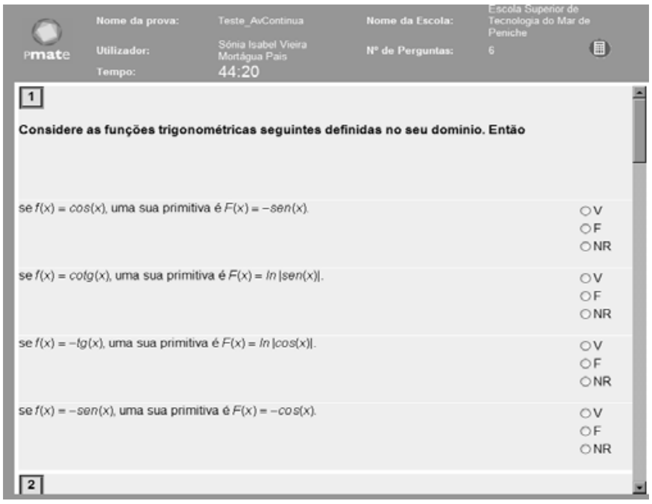

Figure 4. An evaluation test, a

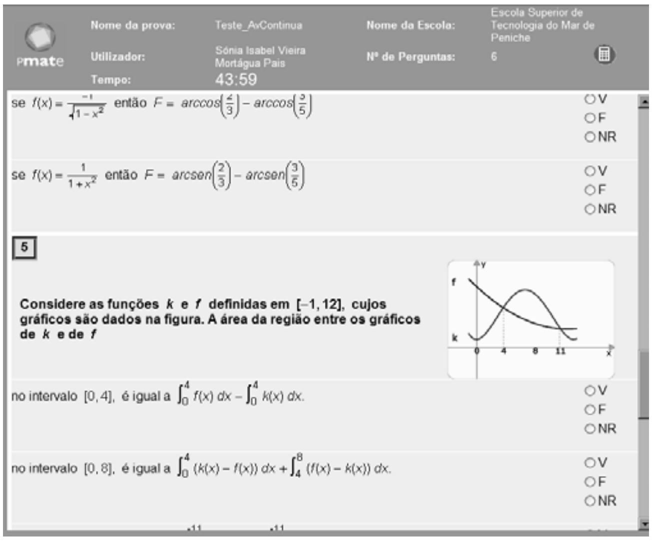

Figure 5. An evaluation test, b

After finishing the test, either in training mode or in evaluation mode, the student has access to the obtained result, being able to verify which questions he failed. However, the platform does not possess the functionality of explaining the student why he has failed because he's expected to look for information (appealing to text books, lessons notes, or other resources), speak with his colleagues and/or the teacher, with the goal of clarifying his doubts and the reason(s) of the error(s). This methodology allows the student to assume a more autonomous and active role in his learning process.

Figure 6 show the results obtained in a test.

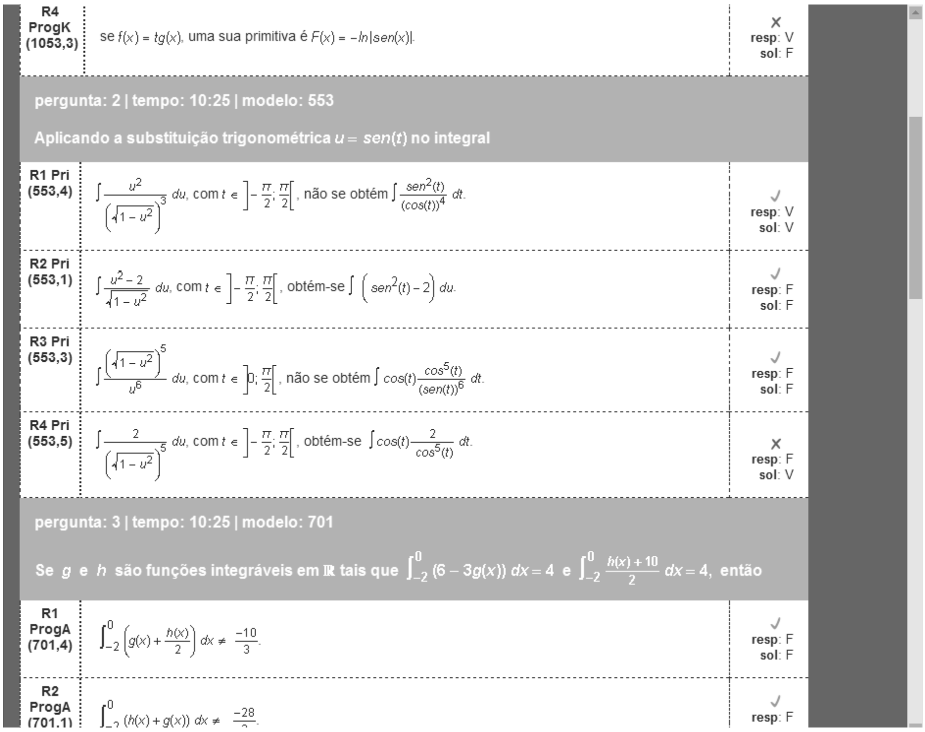

Figure 6. Visualization of the results obtained in a test

4. The Case Study

The question underlying this work is: *What is the impact of the platform of computer aided education (PCA), developed by the PmatE, in the learning of mathematical subjects at University level?*

4.1 Methodological Options and participants

The empirical part of the study admits, as methodological options, a case study with essentially explanatory research intentions (Selltiz et al, 1967). In fact, the objective is to intensively analyse a particular and well-defined situation of some students in a real context, with explanatory intentions motivated by the lack of studies centred in the use of that platform as a support for teaching and for the regulation of the students' learning processes at university level.

For the data collection, we privileged the inquiry techniques, direct observation and documental analysis and the following instruments: an initial and a final questionnaire, assessments tests (in versions: pre-test, post-test1 and post-test2), a battery of tasks of diverse nature, computerized records of the students' performance on PmatE's platform, field notes and interviews.

The study encompassed students enrolled in the curricular unit of Mathematical Analysis I (2008/2009 1st semester), integrated in the plan of studies of Food Engineering of the Superior School of Tourism and Sea Technology (ESTM), of Leiria's Polytechnical Institute.

Given the extension of the program, the study only included the Integral Calculus module.

The teacher responsible for the curricular unit in question was, simultaneously, the researcher.

4.2 Description of the Study

Prior to the beginning of the semester, the teacher designed the curricular unit, including the thematic unit on which the study focused (Integral Calculus module). At the beginning of the semester, a first questionnaire was made to the students. The main objective of this questionnaire was to characterize the students, because knowing their starting point is a fundamental question. It was applied a pre-test that had, essentially, a diagnostic function, but that also served to evaluate the evolution of the students (with the application of the same test at a posterior moment). This pre-test was applied before initiating the approach to the thematic unit in question and allowed to verified, or discard, the necessity to restructure the planning of the unit.

The following step was the didactic approach of the thematic unit in the lessons. In parallel with the lessons, the students explored the platform and worked with it. At the beginning, the students were given a session of clarification about the platform and its use so that they could work with it outside classroom.

It was also intended to verify if the students had the capacity to transfer their skills (learned through the platform, in an autonomous and self-regulated way) to another type of tasks, of the same or of different nature, inside the classroom. As the platform works in an exercise-oriented way, tasks of another nature, like problems or research tasks, were developed by the researcher (in simultaneous teacher of the curricular unit). These tasks were related to real situations either in a daily context or in inserted into the field of training of the students (Food engineering).

In this phase, the data collecting was made through direct observation and documental analysis, supported by the following instruments: field notes, documents produced by students in diverse situations (HW, including a portfolio), and the computerized register of the students' performance (one of the functionalities available in the platform).

At the end of the teaching cycle for this thematic unit, the test that had been applied in the beginning was repeated now.

It was also applied a second questionnaire with the intention of assessing students' opinion about the platform and understanding to what extent they consider it valuable.

Six months after the ending of the curricular unit, the post-test was applied again. The analysis of the results of the three versions of the test will allow assessing the evolution/progress of the students.

5. Statistical Analysis

The PmatE platform allows us to track every interaction between the platform and the users. When we consulted the results of these interactions, we observed that we could split the students in two groups: those who used the PmatE platform (from now on simply mentioned as group 1) and those who didn't (from now on simply mentioned as group 2).

Table 1. Results obtained by students who used the PmatE platform

Group	Student	Pre-test	Post-test1	Post-teste2	HW	Portfolio
1	3	1.75	11		17	15
	4	0	6	4.25	16	13
	5	5	7.75		17	13
	6	2	10	5.5	17	14
	7	3.25	4	4	14	12
	9		12.75	4.5	13	19
	10	4	12.75	4	17	11
	12	3.75	9.25		11	
	13	4	7.25	8	14	
	14	2	7.75		12	10
	15	3	11.5		17	13
	16		7.25	3.75	15	11
	21	5.25	13.25	7.5	15	13
	22		9		17	11
	23	4	8	4.25	15	
	24	2.5	4.5	8.25	13	
	25	4	13.25	6	18	15
	26	2.75	9.5	4.25	13	10
	32	3.75	11.25	8	17	11
	35		6	4.25	18	19
	36	1	5.25	5.75	14	

Table 2. Results obtained by students who didn't used the PmatE platform

Group	Student	Pre-test	Post-test1	Post-teste2	HW	Portfolio
2	1	2.5	4		12	
	2	4		6	16	
	8	4.25	5		15	14
	11		3	2.5	14	
	17	5			15	
	18	4.75			14	
	19	7	8.5	4.5	16	15
	20	2	4.75	4.75	17	
	27	2.75	5	7.75	16	
	28	3	3.5	3.75	15	
	29	3.75			6	
	30	4	8.25		11	
	31	4.25	7.25	8.25	16	
	33	4.25	6.5	4.5	17	
	34	1.25	6	2	12	10
	37	2	5.5		13	10
	38	2.25			14	
	39	2.5	5		15	

Tables 1 and 2 show the outcomes obtained by students at different moments of assessment, the average outcomes obtained in the documents produced by them in diverse situations (HW) and the outcomes obtained in the portfolio.

Comparison of mean values, analysis of variance and t-tests were conducted to determine whether the mean differences, between the two groups of students, were significant and to understand the effects of the platform on the outcomes obtained.

5.1 Applicability Conditions

To perform the statistical analysis referred above, it was necessary to verify the two conditions of applicability: distribution normality and homogeneity of variance.

5.1.1 Tests of Normality

The application of the Kolmogorov-Smirnov Test (K-S) allowed us to realize that all distributions are normal. The following table shows a summary of the K-S results.

Table 3. Summary of the K-S results

Moments Group	Pre-test	Post-test1	Post-teste2	HW
1	n=17 p=0.05 Dcalc=0.16 Dread=0.31 Normal Distribution	n=21 p=0.05 Dcalc=0.10 Dread=0.28 Normal Distribution	n=15 p=0.05 Dcalc=0.25 Dread=0.33 Normal Distribution	n=21 p=0.05 Dcalc=0.23 Dread=0.28 Normal Distribution
2	n=17 p=0.05 Dcalc=0.12 Dread=0.31 Normal Distribution	n=13 p=0.05 Dcalc=0.16 Dread=0.36 Normal Distribution	n=9 p=0.05 Dcalc=0.19 Dread=0.43 Normal Distribution	n=18 p=0.05 Dcalc=0.20 Dread=0.30 Normal Distribution

5.1.2 Tests of Homogeneity of Variances

Table 4 presents the main results of the application of the F-test. As it is shown in the table, variances between the results obtained by the two groups of students, at different moments of assessment, appear to be homogeneous, though for different levels of significance.

Table 4. Summary of the F-test results

Pre-test	Post-test1	Post-teste2	HW
g.l.=(16.16) p=0.05 Fcalc=1.038 Fread=2.34	g.l.=(20.12) p=0.01 Fcalc=2.915 Fread=3.86	g.l.=(14.8) p=0.05 Fcalc=0.615 Fread=3.24	g.l.=(20.17) p=0.05 Fcalc=0.609 Fread=2.23
Homogeneity	**Homogeneity**	**Homogeneity**	**Homogeneity**

5.2 Arithmetic Mean

First of all, we calculate the mean, the standard deviation and the percentage of the standard deviation from the mean. Then, we apply the one-sample t-Test. The results obtained are given in table 5.

Table 5. Mean, standard deviation, percentage of the standard deviation from the mean and results of t-Test

Group	Test	n	Mean	St Deviation	% (s/m)	t_{calc}	$t_{read}(.05;n-1)$
1	Pre-	17	3.1	1.39	44.84	9.05	2.120
	Post1-	21	8.9	2.90	32.58	14.09	2.086
	Post2-	15	5.5	1.67	30.36	12.69	2.145
	HW	21	15.2	2.07	13.62	33.71	2.086
	Portfolio	16	13.1	2.78	21.22	18.90	2.131
2	Pre-	17	3.5	1.42	40.57	10.17	2.120
	Post1-	13	5.5	1.70	30.91	11.80	2.179
	Post2-	9	4.9	2.13	43.47	6.88	2.306
	HW	18	14.1	2.65	18.79	22.55	2.110
	Portfolio	4	12.3	2.63	21.38	9.32	3.182

5.2.1 Significance of Mean

Observing table 5, it is easy to verify that the average of outcomes obtained by the two groups of students reveals statistically significance at all assessment times. Actually, since the test statistic is, for all cases, higher than the critical value for *t* (falling in the rejection region at significance level .05), we can say the averages are statistically significant in all cases.

For both groups, the average increases from pre-test to post-test1, and decreases in post-test2, as can be seen in figure 7.

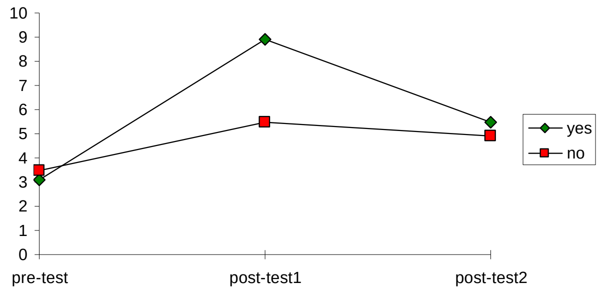

Figure 7. Means of several tests, for both groups of students

On the other hand, concerning pre-test, group 2 has an average value slightly higher than group 1, while at the other two moments of assessment, group 1 has higher average values. The most significant difference between the means obtained by the two groups is verified in post-test1.

Also, in regard to HW and the portfolio, the outcomes presented by group 1 are slightly higher than those presented by group 2, as shown in figure 8.

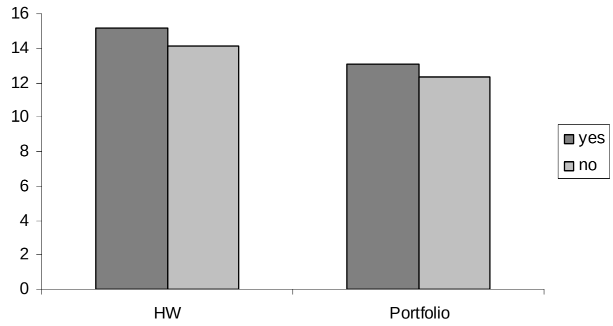

Figure 8. Means of HW and portfolio, for both groups of students

5.2.1 Significance of the Difference between mean values

In order to determine if:

- the difference in results obtained at diverse moments of application of the test is significant;
- the difference in results on the attitudes of the two groups is significant;
- interaction is significant,

analysis of variance were made, for independent groups, involving the following factors: G (group), M (moments of application of the test) and A (attitudes).

To determine the degree of significance of F-calc, we used the classification proposed by D'Hainaut (1997):

- **VS** (very significant), if the test statistic value is equal or higher than F critical value at *p-value* .01;
- **S** (significant), if the test statistic value is equal or higher than F critical value at *p-value* .05;
- **NS** (not significant), if the test statistic value is lower than F critical value at *p-value* .05

Table 6 shows the results of analysis of variance, one-way.

This analysis of variance indicates that the differences between the means obtained by both group 1 and group 2, at different moments of application of the test, are very significant.

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Table 6. One-way ANOVA outcomes

Group	Source Variation	Sum Squares	D. F.	Mean Square	F	Critical Value (p=.05)	Critical Value (p=.01)	Significance
1	Between groups	329.48	2	164.74	34.53	(d.f.=2;50) 3.19	(d.f.=2;50) 5.08	**VS**
	Within groups	238.54	50	4.77				
	Total	568.02	52					
2	Between groups	32.90	2	16.45	5.73	(d.f.=2;36) 3.28	(d.f.=2;36) 5.29	**VS**
	Within groups	103.28	36	2.87				
	Total	136.18	38					

Table 7 shows the results of analysis of variance, two-way.

The two-way analysis of variance also reveals the factor *Moments* as very significant. The effect of Attitudes is also very significant, as well as the interaction between this two effects.

Table 7. Two-way ANOVA outcomes

Source Variation	Sum Squares	D. F.	Mean Square	F	Critical Value (p=.05)	Critical Value (p=.01)	Significance
Attitudes	29.37	1	29.37	7.39	(d.f.=1;86) 3.97	(d.f.=1;86) 6.9	**VS**
Moments	258.71	2	129.36	32.55	(d.f.=2;86) 3.12	(d.f.=2;86) 4.9	**VS**
Interaction	62.38	2	31.19	7.85	(d.f.=2;86) 3.12	(d.f.=2;86) 4.9	**VS**
Error	341.82	86	3.975				
Total	692.28	91					

5. Conclusion

Poor grades in mathematics seem to be widely accepted as a fact in our educational system. What is even more disappointing is that such a fact is confirmed by international statistics reports. It is important to face this reality and take a proactive approach towards the problem, to reduce its effect.

Information and communication technologies (ICT) have a fundamental role to reform the educational model. Informatics tools, mainly those allowing remote use, can become a major element in the educational context.

The previous analysis of the data collected suggests that there are interesting alternatives to the dominant pedagogies in higher education, currently focused in the mere ‘transmission’ of knowledge, introducing an approach in which the student takes an active part on the development of his own capabilities.

Although this project is still ongoing the statistical analysis presented above seems to indicate that the use of PmatE platform proved to be an asset. Students who used PmatE platform reveal a better performance than those who didn't. But we must be careful on interpreting these results due to the small sample size.

We believe that PmatE is an interesting alternative to the dominant pedagogies in higher education even though additional research is needed with a larger sample size, to reinforce these conclusions.

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