Technological enhanced mathematics curriculum in teacher education: an exploratory study[1]

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Abstract

Along with the challenges that the Bologna Process has brought to Higher Education in Portugal there is a growing concern about science education, technology and mathematics expressed by policy makers and with less satisfactory results in some international reports, there are big changes happening. The introduction of a new mathematics curriculum for basic education is reflected in teacher training, either by the particular definition of a new kind of student or the need for new methods of teaching and learning of mathematics.

It is argued that the curriculum should provide a sufficiently strong mathematical background and flexibility so that pre-service teachers can handle and create conditions for students to learn mathematics based on the three problems facing the mathematical training, to identify content relevant to the mathematical education, to understand how knowledge should be learned and what we need to teach mathematical concepts to children.

Theories such as advanced mathematical thinking, self-regulated learning, as well as an increased use of technology in the classroom based on methodologies studied in the context of STEM (Science, Technology, Engineering and Mathematics) education support this papers as a starting point for a broader investigation.

It is necessary to assess the changes to the mathematics curriculum in pre-service teacher training, in terms of content, methodologies and pedagogy, this paper presents the rationale and structural changes to the curriculum in a basic education course at a College of Education in Portugal by a technological enhanced learning environment. And focuses on a preliminary study of the use of Moodle as tutoring environment using forums, demonstration videos and problem solving.

Preliminary results indicate statistically significant differences for students who use the new curriculum with technology and those without this support in Geometry.

Keywords Higher Education, Mathematics curriculum, Moodle, Self-regulated learning, STEM education, teacher education, Technological Enhanced Learning Environment.

Introduction

With the changes in the existing curricula of teacher education under the Bologna process (the process of restructuring higher education) it is necessary to assess the need for change in mathematics education models. Contextualized in the recent policy to promote scientific education (especially in Mathematics, Science and Technology) where initiatives stand out as the Technological Plan for Education and School 2.0, from various government and private initiatives.

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The opportunity to change the mathematics curriculum for teachers comes at a time it joins a combination of several factors: amendments to study plans in higher education; the growing concern with the teaching of mathematics in particular from the poor results of international studies like PISA (OECD); a significant change in the math curriculum in elementary education; the focus of governmental bringing technology to schools, especially through computers, interactive whiteboards and broadband internet.

The question of mathematical preparation of future teachers has been investigated with a view to training and teaching on education and not have as much importance as the subject of study for conceptual knowledge of these professionals. Studies on this topic have shown signs of concern, because this kind of mathematical knowledge is not present in many teachers (Veloso, 2004).

Considering all these factors we designed a mathematics curriculum for Basic Education course at an institution of higher education in Portugal who want to combine three levels of intervention: A solid mathematical foundation for all pre-service teachers; A comprehensive training for teaching mathematics connection between knowing and teaching mathematics; Promoting the technological skills of pre-service teachers in technology enhanced learning environment.

This paper focuses on the third level of intervention present some preliminary data on the use of Moodle in teaching mathematics to pre-service teachers.

Background

In the current context of higher education in Portugal there was a (r)evolution in terms of structure, especially with regard to training of teachers and educators.

Since the beginning of the Colleges of Education (Polytechnic School) in the '80s, and the publication of the Law of the Education System that regulates the Portuguese Education System, teacher training was separated into three major areas, three types of degree course covering all areas of education from Nursery school, Kindergarden school, Primary School to the Elementary School. In 2004 the need arises on the restructuring of teacher education in light of the Bologna Process that advocates separation in two teaching cycles, a cycle of *broadband* general knowledge and a second cycle of speciality (Ponte, 2004).

The College of Education where the study was conducted has made a substantial bet on the use of technological tools, including the use of Moodle to support the disciplines in the various courses.

What mathematics should be taught to pre-service teachers

The aim of this investigation is to understand the extent to which this methodology encourages pre-service teachers in-depth knowledge of mathematics especially from the point of view of Advanced Mathematical Thinking (AMT) in the last twenty years has developed as well as new trends theories of mathematics education expressed by Sriraman and English (2010).

Tall (1981, 2002) connected the AMT in the formal mathematical concept definition and concept image that has been studied by Domingos (2003) in characterizing the academic performance of students at the beginning of higher education.

Edwards, Dubinsky and McDonald (2005) focus on the definition of the phenomenon that seems to occur during the mathematical experience of students as they begin to relate to abstract concepts and deductive statements, recognizing that the mental structures that ensured academic success has not resulted thereby linking the concept of AMT in this transition period.

Another aim is to bridge the gap between the self-regulated learning (Wolters, 2010) and the development of learning skills, linking aspects of mathematics teaching and learning to use technological tools in the follow-up study conducted by Carneiro, Steffens and Lefrere (2007) at European level.

Using technology to teach mathematics

The curriculum has been developed taking into account the argument that the pre-service teachers need to have a better understanding of mathematical concepts because it helps them gain a greater understanding of the connections between various areas of mathematics.

Hence the focus on theoretical issues and data in mathematical proofs and demonstrations of various properties. The structure of the curriculum was set up as follows:

	CH1	FH2	ECTS3	Content
Mathematics I	60	160	6	Logic; Set Theory; Arithmetic
Geometry Topics	60	160	6	Euclidean geometry; Transformations; Vectors
Mathematics II	60	150	6	Number Theory; Algebra; Algebraic structure
Mathematics III	40	150	6	Statistics; Probability
Didactics of Mathematics	60	130	5	Didactics; Curriculum
	280	750	29	

1. Contact hours; 2. Full hours; 3. European Credit Transfer and Accumulation System

Table 1: Mathematical content addressed throughout the course.

The structure of all the disciplines of mathematics in the course is identical: 30% of the workload is 70% is theoretical and practical/laboratory. In addition the second group in both courses had also teaching hours with virtual support on the course page in Moodle.

This support is structured around three main lines: *tutorial* (explanation of theories, problems and exercises using video conferencing, short videos explaining the exercise or interactive applets) usually organized via forum; including subsequent *assignments* via discussion forums and *quizzes* (training) for the student to independently check their progress in learning a particular topic or concept.

With this addition of the online support structure, a number of technological tools to support learning based on issues raised by Oldknow, Taylor and Tetlow (2010) in the context of mathematics education. We used a small instructional videos in Mathematics I, in particular on truth tables in Propositional Logic and animations on Set Theory.

In the discipline of Geometry Topics we introduced small interactive applets to demonstrate the properties of geometric figures and solids and the students were introduced in dynamic geometry environments with GeoGebra.

Methodology

This exploratory study aims to identify two key points: the academic performance of students studied and the interactions made in the Moodle platform based on data collected, first by their final grades (study 1) and other data collected by the access to Moodle during the course (study 2).

In Study 1 descriptive statistics were performed in order to organize the data collected and allow to assess differences between the final scores of the groups.

In study 2 there was a very elemental analysis based on hits students in courses in Moodle and graphics collected with the SNAPP software version 1.5 (Bakharia & Dawson, 2009) of social network analysis.

Study 1

Study participants were students who attended the Mathematics I at 1st year and Geometry Topics in the 2nd year immediately before and after the introduction of the new curriculum and the use of Moodle.

The descriptive statistics are shown in Table 2.

	With Moodle	N	Max	Min	$\overline{x}$	SD	σ	% of approval
Mathematics I	No	42	18	1	9.1	3.9	15.2	50
	Yes	45	14	1	8.8	2.8	7.4	47
Geometry Topics	No	38	18	1	8.4	4.9	23.4	39
	Yes	50	19	3	12.7	4.5	19.8	70

Table 2: Descriptive statistics calculated with R software

Study 2

The interactions made during the forums were also analyzed by SNAPP software by obtaining the graphs presented in Figure 1.

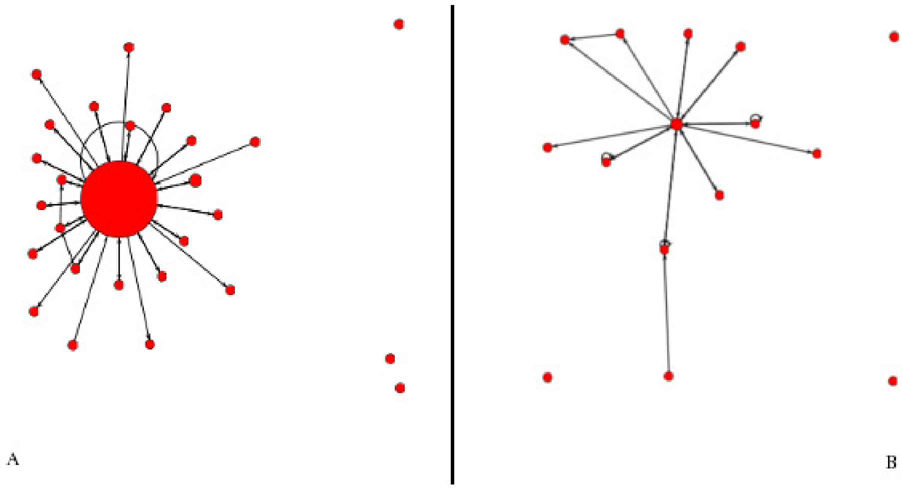

Figure 1: Map of interaction in the foruns of questions (A - Mathematics I and B- Geometry Topics)

The frequency of the course page in Moodle, either in hits (preview documents, personal messages, posts in forums and answers to quizzes), contributions (submission of assignments, quizzes and forums) and interactions in the forums are shown in Table 3.

	N	Page hits	Contributions	Student in forum	Posts in forum
Mathematics I	45	18,295	3,824	26	166
Geometry Topics	50	20,623	4,178	14	57

Table 3: Students hits on course page on Moodle and forum participation

Discussion

In study 1 the results of descriptive statistics of students' educational achievements of Mathematics I suggest no major changes to the introduction of Moodle and the technological tools, there is even a marginal decrease of 3% in approvals, but the variance of the values suggest a greater dispersion of results. In data collected in Geometry Topics differences are evident with the introduction of technological tools and with Moodle, since the average is positive to the difference in percentage of approvals with a difference of slightly more than 30%.

Analyzing the data presented in Table 2 points to the decrease in average ratings and the percentage of approvals between the group that did not use Moodle thus indicating an alert to the factors of this curricular change. On the other hand, the group that used Moodle significantly increased their average grade (from 8.8 to 12.7 on a scale of 0 to 20), obtaining the first positive average ratings and the percentage of approvals rose by 23%.

Data collected in study 2 from the use of Moodle points to the decrease of interactions (in numerical terms) of questions in the forum, which contradicts somewhat the relationship between the other values and analysis of interaction maps (Figure 1).

Both interactions are teacher-centered but these data may therefore require further progress in the direction of the conclusions of Domingos (2003) in which formation of new mathematical concepts are formed from a chain of events that necessarily pass through the implementation of procedures to evolve, increasing their sophistication and while the more advanced understanding, in line with the works of Tall (2002) with the AMT. Thus technological tools can serve as a complement to the AMT, including symbolic manipulation but with explicit conceptual purposes in order to explore concepts in a meaningful way.

The technological environment can serve to explore ideas as in the case of geometry with the use of GeoGebra, opening the field to the student to conceptualize mathematical ideas. This gap points to a close description of the findings of Edwards, Dubinsky and McDonald (2005) in which the AMT occurs only under certain specific conditions, we as teachers need to provide them with these conditions.

SRL models can be developed, taking into account that provide a viable theoretical basis for educational intervention in order to understand how the student takes an active and reflective in their own learning, and in this particular instance in learning mathematics significantly. There were more posts in Figure 1A. possibly because they are first-year students, and be the first to have contact with the technological tools, they felt the need to request more aid. 1B in the graph is no longer so obvious the teacher's role as centralizing information noting more interactions between students themselves, even in a very simple way but this may indicate some elements in the skills of cooperation in line with the SRL that requires more analysis.

The increasing number of hits and contributions points exactly two in this direction, because a larger field of technological tools, allows students to be more autonomous in performing the required tasks, including exercises and problems that are on the course page in Moodle.

Concluding thoughts

The increasing use of technological tools and the steady expansion of the Internet provide a set of technological tools increasingly accessible to all school levels and all age groups.

The pre-service teachers can not be alienated from the meaning of this (r)evolution, much less in the areas of STEM education.

Data from this preliminary study are interesting but need further clarification that a statistical approach can not achieve, it is necessary to understand the preparation (and initial shock) of students in 1st year potentiate their performance in the discipline of the 2nd year, or was simply because it is a discipline more practical and more visually interesting.

It seems not, since the former group (that did not use the technological tools or Moodle) has decreased marginally from the average ratings from the 1st to the 2nd year.

These data suggest a more thorough investigation of the factors that influenced this increase since the only change has been a curriculum change (teachers remained the same) is also necessary to check the group later if the results remain or if the results of the study group are a special case.

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