

## **UNDERGRADUATE PRIMARY TEACHERS' PREPAREDNESS TO USE NATIONAL MATHEMATICAL SOFTWARE IN THE CLASSROOM**

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### **Abstract**

Twenty-five final-year undergraduate students of primary education who were attending a course on mathematics education participated in a research project during the 2009 spring semester. Based on the Technological, Pedagogical and Content Knowledge framework (Mishra & Koehler, 2006) and Cobb, Confrey, diSessa, Lehrer, and Schauble's (2003) experiment design procedure, the course was organised so as to incorporate ICT and special mathematical scenarios in the teaching approaches of undergraduate students. This article presents the course design, the research procedure and the pathways for the integration of educational software and mathematical scenarios into final year undergraduate student teaching practices.

### **Introduction**

Over the past few decades, one of the most important issues related to educational change and educational innovation is the incorporation of Information and Communication Technologies (ICT) (Black & McClintock, 1996; Hoyles, Noss, & Kent, 2004; Jonassen, Peck, & Wilson, 1999). ICT constitute an essential tool for teachers, since it can be used as: a) an educational method to support student learning; b) as a personal tool to prepare material for his/her lessons, to manage a variety of projects electronically and to search for information; c) as a tool to collaborate with other teachers or colleagues (Da Ponte, Oliveira, Oliveira, & Varandas, 2002).

In Greece, the educational changes of 2003 led to the Cross Curricular/Thematic Framework (CCTF), which has been implemented in compulsory education since 2006. One of its general principles is "to prepare pupils to explore new information and communications technologies" (Official Government Gazette, 2003, p. 1). In its effort to

implement this new educational policy the Pedagogical Institute has developed textbooks and Educational Software (ES) for all teaching subjects. The educational software produced is not to be used alone for the teaching of the subject, but is also for consolidation and supplementation and has been designed so as to complement and at the same time make use of the teaching materials for the teaching of the subject in primary education.

Despite significant political will and spending by governments on technical equipment and training, levels of ICT integration in schools for learning and teaching are often low (Chionidou-Moskofoglou, Zibidis, & Doukakis, 2007). As Gill and Dalgarno said:

The drivers behind government and organisational policy relating to ICT integration are many and varied. Reasons cited for encouraging ICT integration include the need to equip students with the skills to participate and thrive in an information society, and the need to create highly skilled and flexible workforces..." (2008, p. 330)

One of the challenges facing teacher educators and moreover university departments is how to ensure that graduate teachers have the necessary combination of skills and pedagogical knowledge that will enable them to both effectively use today's technologies in the classroom, as well as continue to develop and adapt to new technologies that emerge in the future (Gill & Dalgarno, 2008).

Recently, research in educational technology suggests the need for "Technological Pedagogical and Content Knowledge" (TPACK), which is based on Shulman's (1986) idea of "Pedagogical Content Knowledge", so as to incorporate technology in pedagogy (e.g., Angeli & Valanides, 2009; Cavin, 2007; Keating & Evans, 2001; Niess, 2005; Mishra & Koehler, 2006). This interconnectedness among content, pedagogy and technology has important effects on learning as well as on professional development. Mishra and Koehler suggest "...a curricular system that would honour the complex, multi-dimensional relationships by treating all three components in an epistemologically and conceptually integrated manner" and they propose an approach which is called "Learning technology by design" (2006, p. 1020).

Furthermore, according to Gill and Dalgarno (2008), undergraduate students are shaped by the teaching styles they experience and as a result will often employ those teaching tools they were exposed to during their education. Therefore, contemporary technological tools, i.e. course portfolios (for faculty and students), forums, sms, blogs, e-mails and web pages, used for the duration of this research and student training and education, have an added value while enhancing the educational environment.

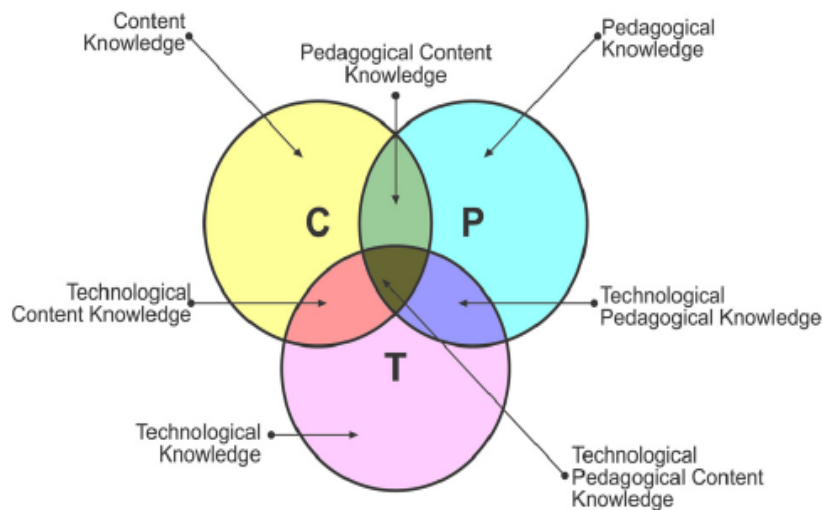
Therefore, from a constructivist viewpoint, educational software integration into 4th year undergraduate student teaching practice is a crucial factor for teachers' future "establishment" and improvement in classroom practices. This is the factor that the researchers of this project have begun to investigate. This paper presents our research and the pathways to this development.

## Brief Literature Review

Content knowledge refers to an understanding of the subject matter relating both to what is so and why it is so, and pedagogical knowledge relates to teaching strategies that are applicable across all content areas (Cavin, 2007). Shulman's PCK (1986) identifies the overlap of these two areas, which is known as pedagogical content knowledge. TPCK is the link between the use of technology as a performance tool and the use of technology within a teaching strategy as a pedagogical tool.

Mishra and Koehler (2006) have represented TPCK through the use of a Venn diagram (Figure 1), where the individual circles represent the knowledge components of content (C), pedagogy (P), and technology (T) and the overlapping area of all three circles represents TPCK.

Figure 1: The overlapping components of technological pedagogical content knowledge



(Source: Mishra & Koehler, 2006, p. 1025)

The relationship between each pair of concepts is then identified as pedagogical content knowledge (PCK), technological content knowledge (TCK), and technological pedagogical knowledge (TPK). Emphasis is placed on the “connections, interactions, affordances, and constraints” (Mishra & Koehler, 2006, p. 1025) between and among the three components. The intersection of the three component circles represents technological pedagogical content knowledge (TPCK). More than just the sum of technology, pedagogy, and content, the significance of the overlapping areas lies in the interaction between the three components, described by Mishra and Koehler as follows:

TPCK is the basis of good teaching with technology and requires an understanding of the representation of concepts using technologies; pedagogical techniques that use technologies in constructive ways to teach content;

knowledge of what makes concepts difficult or easy to learn and how technology can help redress some of the problems that students face; knowledge of students' prior knowledge and theories of epistemology; and knowledge of how technologies can be used to build on existing knowledge and to develop new epistemologies or strengthen old ones. (2006, p. 1029)

As mentioned above, the ultimate goal is for students of the education departments to effectively incorporate the use of technological tools in their teaching practice. Furthermore, the inherent investigatory nature of technology itself allows students to "identify what is different about the new electronic media and what those differences mean in terms of cognition, learning, teaching and related matters" (Kaput, 1992, p. 516). The use of educational software contributes to learning through planning and investigation (Mishra & Koehler, 2006).

Additionally, the use of such communication tools as e-mails, forums and blogs contributes to the synchronous and asynchronous communication between students and tutors while at the same time modifying the role of educator and educated (Price et al., 2005).

Finally, using a management information system, which will assist teaching and facilitate documentation of student progress, can also prove useful in the interaction between tutors and students. According to Carter "...the appropriate use of these tools is to serve human agency as enablers and mediators of the many and different forms and settings in which purposeful interaction may and does occur. . ." (2005, p. 483). Jafari claims that a Course Management Information System (CMIS) is a powerful tool that "...promises a new environment with tools to demonstrate and assess student learning and thus to map teaching and learning outcomes in accordance with each institution's established principles of learning. . ." (2004, p. 40). The CMIS enables information such as performance data, student/ teacher self-reflective data, including assignments, comments and microteaching lessons which can be accessed and stored in the form of electronic portfolios.

## **Research Methods and Approach**

In order to explore the development of TPACK, we have employed design experiments which constitute an effective methodology for studying teacher development in the setting of an education university department (Cobb et al., 2003). The researchers have taken a triangulation multiple-method approach (qualitative and quantitative) to ensure greater validity and reliability.

The participants were 25 final-year undergraduate primary teachers (16 females and 9 males) in the Department of Primary Education at the University of the Aegean, who were attending the compulsory course "Teaching Mathematics – Practicum Phase" during the 2008–2009 spring semester.

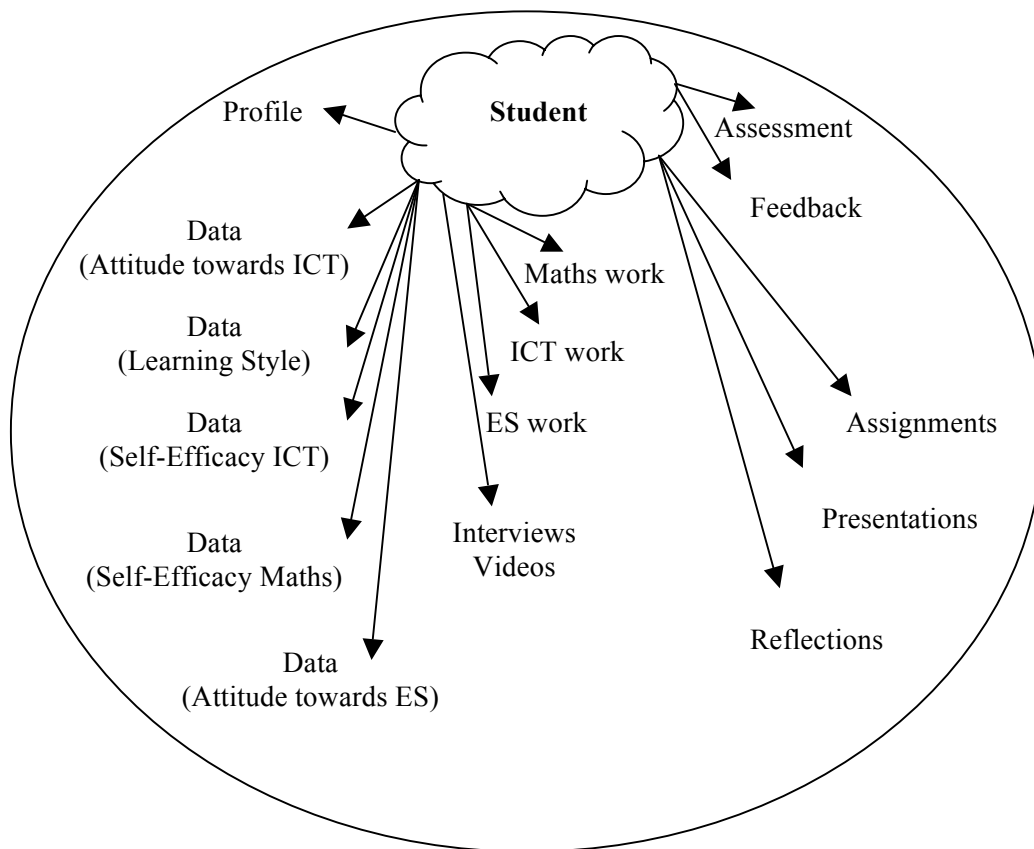
Two researchers had a three-hour meeting with the undergraduate primary teachers in the mathematics lab, twice a week. The lab held 12 PCs, with Windows XP, MsOffice 2003, internet access, mathematical software (Educational Software of Pedagogical Institute for Mathematics (ESPIM), Geometer's Sketchpad, Mathematica) and presentation tools. In the Department of Primary Education of the Aegean University, the department's website was used by tutors to provide students with electronic material, to communicate via e-mail and to post announcements. So advantage was taken of:

- the educator's website ([www.pre.aegean.gr](http://www.pre.aegean.gr)), where students could download course material;
- the course's electronic mail, which permitted asynchronous communication between students and educators and where the former sent in their assignments.

However, the need for a technologically elaborate working environment that would encourage students to use the technology led the research team to

- use Moodle as the Course Management Information System (CMIS). Moodle was used by educators to facilitate the management of student material. The existence of the CMIS proved a necessity because of the large body of research data, the direct communication with students and the need for a speedy search and recovery of participants' characteristics (Figure 2);

Figure 2: The components of the CMIS



- create a forum ([www.maths.forumotion.net](http://www.maths.forumotion.net)), where students via personal messages or messages to the entire group, could achieve synchronous or asynchronous communication with their peers and tutors;
- take advantage of the research team's blog ([maths-gr.blogspot.com](http://maths-gr.blogspot.com)), where thoughts and proposals were published;
- incorporate the usage of sms via which students can be notified of news on their course, their assignments, meetings, etc. (McGovern, Collier, & Mangina, 2006).

In using the above electronic services two parameters were taken into consideration: technophobia and the need to strike a balance between security and privacy of information (Stamatellos, 2009).

The research work was divided into five stages during the spring semester 2008–2009.

### **Stage One**

During the first stage and before the beginning of the first lesson, quantitative data were gathered regarding undergraduate primary teachers':

- background (studies, family background, etc.);
- individual learning style according to Felder & Silverman's instrument Index of Learning Styles (Felder & Silverman, 1988);
- attitudes towards ICT based on Roussos' Greek Computer Attitudes Scale (GCAS) (Roussos, 2007);
- self-efficacy in ICT according to Kassotaki & Roussos' Greek Computer Self-efficacy Scale (Kassotaki & Roussos, 2006);
- attitudes towards ES; for this purpose we designed a scale (Educational Software Attitudes Scale, ESAS) which was based on Roussos' Greek Computer Attitudes Scale; and
- self-efficacy in mathematics according to the content principles of the CCTF.

The same data were gathered from the participants at two more instances (after three months and at the end of the semester), in order to measure possible quantitative differences.

### **Stage Two**

Cobb et al.'s (2003) experiment design procedure constituted the second stage, in particular:

- Undergraduate primary teachers were given a suitable worksheet and they worked on mathematics and geometry problems.
- After their paper and pencil work, they tried to solve the same problems by using the National Educational Software of the Pedagogical Institute for Mathematics (ESPIM). Each lesson consisted of the teaching of those strategies that incorporate the usage of ICT, so as to involve undergraduate primary teachers in the investigation of geometrical shapes and forms. Teaching was limited to the investigation of geometry problems so that when undergraduate primary teachers come up with their own teaching scenarios (Kynigos, 2006) they will be able to use the suitable technological tools that are both efficient and investigatory. The educational software used consisted of the microworlds: “Geo-board”, “3D solid manipulation (Solid-board)”, “Calculator” and “Table Tracking” from the ESPIM.
- In each lesson, researchers used technological tools while undergraduate primary teachers participated as students taking a lesson in class.
- At the end of each lesson, undergraduate primary teachers were asked to fill out an electronic feedback form, contributing thus further to a discussion of the 3 hours lesson that had just finished. The form focused on the development of TPACK in mathematics, with questions on the technological tools, the teaching strategies and the benefits gained from the lesson.

This procedure was repeated eight times during the spring semester 2008–2009.

### **Stage Three**

Undergraduate primary teachers had to complete an assignment (first assignment) that consisted of the search for all geometry problems, activities and exercises involving geometrical shapes and solids in the national maths textbooks of 5th and 6th grade as well as 7th, 8th and 9th grade; they also had to work on two activities, two exercises and two problems of their choice (from the above units) using ESPIM. Furthermore, and without any assistance by the researchers, they were asked to create a spontaneous lesson plan for teaching the chapter of Area of a Parallelogram or the Volume of a Parallelepiped from 6th grade mathematics (Kassoti, Kliapis, & Economou, 2006, pp. 149–150, 157–158).

### **Stage Four**

Undergraduate primary teachers were asked to participate and act as students in an educational scenario (Kynigos, 2006) created by the research group for the purposes of the lesson. The title of the scenario was “Creating Mobile Phone Networks” and it constituted a holistic picture of a learning environment, without limitations but with the ability to focus on those aspects that the educator judged to be of importance. Then undergraduate primary teachers were asked to create their own educational scenario to be

used with the chapter of the lesson plan they had already created. Therefore, with the theoretical knowledge and the experience gained, undergraduate primary teachers produced their own educational scenario over the following two weeks. Each educational scenario was presented to their peers, who acted as students of a class. The latter provided their feedback and assessed the scenario on an especially designed form. After that, the undergraduate primary teacher, creator of the scenario, having taken his/her peers' comments into consideration, returned two weeks later and presented his/her improved scenario version. Security and originality were safeguarded as all scenarios had been posted before the beginning of the presentations. Scenario presentations were recorded on a digital camera so they could be further analysed. Finally, undergraduate primary teachers were self-assessed and gave feedback on their own scenario.

### **Stage Five**

During the above process, semi-structured interviews were conducted very frequently. The initial students' interview took place after the submission of the first assignment and the final interview was conducted after the completion of the second presentation of the educational scenario. The purpose of these interviews was twofold; on the one hand, it was to investigate the procedures followed by undergraduate primary teachers during the writing up of their first assignment, as well as of their scenario, their perceptions of TPACK in mathematics and the reasons behind their inclusion or non-inclusion of ICT in the lesson plan. On the other hand, the purpose of the interview was to determine whether or not this constructivism design experiment procedure was suitable for them personally. Interviews were recorded for further analysis.

In the last meeting, undergraduate primary teachers were asked to anonymously complete a questionnaire regarding their satisfaction from the course. Twenty-four completed questionnaires were returned out of the twenty-five that were handed out (Doukakis, Koiliias, & Chionidou-Moskofoglou, 2009).

During the entire procedure the above data are recorded, stored and classified in the CMIS. The CMIS that is used is Moodle Learning Management System. Moodle is provided freely as Open Source software. The design and development of Moodle is guided by a "social constructionist pedagogy." The tools offered to the tutors allow them to easily manage their students' material as well as to communicate with them in an asynchronous and synchronous mode. Tutors and students alike have access to their feedback material, their evaluation criteria, their self-evaluation, their restructured scenarios and their teachers' comments, all of which constitute a digital portfolio. The purpose of CMIS is to improve the quality of communication and the information flow between the members of the academic community. What is initially a feeling later becomes a certainty that they are part of an interactive, integrative and participatory process that is set up between tutors and students.



## First Results

The results from the course satisfaction of participants as found in the research study showed a high satisfaction level from the course. The global satisfaction level reaches 98% whereas partial (per criterion) satisfaction levels range from 90% to 97%, the lowest rate corresponding to the theoretical component of the course (Doukakis et al., 2009). Moreover, data analysis showed a statistically non-significant improvement on participants' computer attitudes and self-efficacy in ICT and ES, but a significant improvement of self-efficacy in mathematics (Doukakis, Chionidou-Moskofoglou, Mangina-Phelan, & Roussos, in press).

## Conclusion

It is our belief that undergraduate primary teacher satisfaction in a learning environment that combines teaching in the classroom and support via an appropriate learning environment plays a crucial role in the sustenance of programmes that incorporate ICT in teaching and learning.

The findings raise a number of research questions regarding ICT integration in undergraduate primary teachers' teaching practice. Further analysis of qualitative data (interviews, narrative observations) concerning these research findings is currently under way. In addition, it seemed that the crucial factors for the integration of educational software and scenarios into the teaching of mathematics are positive attitudes towards ICT-educational software and self-efficacy in technological tools and mathematics.

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