REACTIONS OF PRE-SERVICE ELEMENTARY TEACHERS' TO IMPLEMENTING TECHNOLOGY BASED MATHEMATICS LESSONS

Esra Balgalmis
Middle East Technical University, Turkey

Kathryn G. Shafer
Ball State University, USA

Erdinc Cakiroglu
Middle East Technical University, Turkey

The results reported in this paper focus on the reactions of three pre-service elementary mathematics teachers (PSTs) after designing and implementing three GeoGebra lessons. The analysis of the data revealed that focusing on the mathematical concept more than technology and using technology when it is really necessary were the basic criteria for effective technology based lesson. PSTs defined GeogGebra as a tool that assisted them to promote students' learning and a helper for students to discover features of mathematical concepts. Pre-knowledge of students, classroom management and time management are important components of successful lesson implementation. The PSTs reported increased self-confidence and valued having a mentor to help them reflect on their lesson implementation.

Keywords: *Mathematics Teacher Education, Integrating Technology in Mathematics, GeoGebra*

INTRODUCTION

Educational technologies have become a significant part of the teaching and learning process in Turkey. The current elementary mathematics curriculum developed by the Ministry of National Education (MoNE) in Turkey emphasizes using technology effectively in teaching to provide students the opportunity for expressive mathematics teaching (MoNE, 2009). Dynamic technology-supported instruction presents an opportunity to enhance mathematical reasoning. For instance, with the help of dynamic geometry software, students explore various conjectures by constructing geometric shapes and making connections between them (MONE, 2009). In order to be an effective teacher, pre-service teachers need to learn fundamental concepts, knowledge, skills, and attitudes for applying technology in educational settings (NETS•T, 2008). It is our claim that the field experience is a crucial element in the development of TPACK. The purpose of this report is to examine three pre-service teachers' (PSTs) reactions to implementing three technology-based mathematics lessons in the context of a field experience.

LITERATURE REVIEW

Technology plays an ever-increasing role in the lives of elementary school students. Dynamic software packages, such as GeoGebra and Geometer's Sketchpad are vital in raising student awareness, challenging their conceptual understanding and motivating the synthesis of mathematical notions (Hollebrands, 2007; Kaput & Thompson, 1994; Peressini & Knuth, 2005). Construction of mathematical objects, creating models and conducting interactive explorations are available via GeoGebra by dragging objects tracing points, changing parameters and measuring objects.

According to the National Council for Accreditation of Teacher Education standards (NCATE, 2002), the new professional teacher who graduates from a department of education should be able to integrate technology into instruction to effectively enhance student learning. To achieve the technological goals stated by NCATE, teachers have to be prepared for their new roles in a technological environment (Thompson & Kersaint, 2002). To design and structure learning environments, researchers have suggested that teacher educators need to integrate technology into their teaching and their technology integration should go well beyond teaching technical skills (Kim & Baylor, 2008). Therefore, many teacher training programs and professional development initiatives integrate technology, with educational aims, into the courses to develop pre-service teachers' knowledge of technology (Koehler & Mishra, 2005; Katic, 2007).

Examples of undergraduate courses intended to promote Technological, Pedagogical, and Content Knowledge (TPACK) are found in (Kersaint, 2007), (Ozgun-Koca et al., 2009/2010) and (Powers & Blubaugh, 2005). These three courses share a few common characteristics. All of the courses include activities that focus primarily on pedagogical and content-related tasks. For example, PSTs engaged in technological training, then they examined the activities by discussing how and when to use appropriate technology in mathematics instruction. A second way in which the three courses are similar is that they include student-centered teaching methods such as guided discovery (Powers & Blubaugh, 2005), collaborative teaching (Kersaint, 2007) and inquiry-based learning with open-ended questioning (Ozgun-Koca et al., 2009/2010). Microteaching is found in the methods course developed by Ozgun-Koca, et al. By providing these types of experiences, PSTs are challenged to reorganize their subject matter knowledge and use educational technology on the development of that subject itself (Niess, 2005).

FRAMEWORK

Teacher training courses should provide PSTs a rich technological environment to develop TPACK. Unfortunately, it is our experience that most pre-service teachers are unable to integrate what they learn from teacher education programs into their future teaching practice. Consider balancing the technological/pedagogical training with experiences of classroom observation implication and reflection. A methodology used to support the development of TPACK is found in the Situated Technology Integration (SiTI) model (Hur, Cullen & Brush, 2010). It is the opinion of the authors that the recommendations found in this model are well crafted due to the focus on didactical modeling, tool use, and skill practice. The SiTI model includes aspects of TPACK that occur within the broader context of the classroom. An emphasis on implementation of technology in the classroom is emphasized in the guidelines (italics were added by the authors). Three out of five SiTI guidelines were used to frame this study.

SiTI Guidelines:

- **Provide concrete experiences:** To assist pre-service teachers in understanding the relationship between theory and practice, various examples and concrete experiences should be provided.
- **Assist in application:** To help pre-service teachers apply knowledge learned in real situations, opportunities to observe expert teacher's classrooms and *chances to utilize knowledge in actual classrooms should be included.*
- **Develop Technological Pedagogical and Content Knowledge:** To successfully integrate technology into their future classes, pre-service teachers should be called on to develop plans to use their technological knowledge in a meaningful way in relation to their content and classroom teaching knowledge. (pg. 167)

To position these guidelines in their teacher preparation program, Hur, Cullen and Brush (2012) developed a three-phased approach (preparation, exploration and implementation). They readily acknowledge difficulties in providing pre-service teachers with a field experience as part of a mathematics methods course. These three guidelines provide information about the role of the teacher educator in pre-service teacher field experiences.

METHODOLGY

The Elementary Mathematics Education Teacher Program is an undergraduate program under the Department of Elementary Education in the Faculty of Education at Middle East Technical University (METU) in Ankara. The population for the study were elementary mathematics majors who had taken ELE 430 and were enrolled in ELE 435 (the course descriptions follow).

ELE 430 – Exploring Geometry with Dynamic Geometry Applications (Spring 2011): Introduction to Geogebra software with emphasis on technical and pedagogical skills needed to teach geometry in grades 6-8.

ELE 435 – School Experience (Fall 2012): Introduction to grade 6-8 learning environment through classroom observations, and the planning and implementation of a learning-center activity.

During the ELE 430 course, pre-service teachers were not only presented with the features of GeoGebra software program, but also with how they can support students' mathematical understanding via this program. The instruction provided was aligned with the recommendation to **provide concrete experiences** SiTI guideline. An example used by the instructor was "Activity Exterior Angles of Polygons" (GeoGebra Wiki, 2010). The goal of the activity was to explore this topic within the dynamic geometry environment. In this activity, an exterior angle of a polygon was formed by a side and an extension of an adjacent side. PSTs were guided to create the dynamic sketches. In the first sketch, PSTs created and used a slider to resize a triangle. They discussed the sum of the exterior angles of a triangle. They observed that changes in the angle measures did not affect the sum of the exterior angles.

In the class sessions, the instructor's primary role was to facilitate discussion by asking PSTs pedagogical questions. She also asked them to answer and ask new questions about the activity. There were two types of pedagogical questions. The first type of questions asked PSTs to discuss the mathematical reasoning they encountered when constructing figures in GeoGebra. Some examples of the first type of questions are: *Why is it important to construct this object first? Can you show us your thoughts by constructing via GeoGebra? How can you represent your thinking? Is there any other way to construct this activity? What would you do if...?* After finishing the activity, the instructor asked a second type of questions. These questions required that the PSTs discuss implementation of the geometrical activity in an actual classroom environment. Some examples of second type of questions are: *How might this activity be useful for you as a teacher with your students? What kind of "what if" questions can you ask students on this task to facilitate their learning? Do you think the use of this sketch can somehow change the learning environment? Which difficulties do you think can be encountered when conducting this activity?*

A total of sixteen PSTs had taken ELE 430, and from this group, eight were enrolled in the ELE 435. Six of the eight PSTs agreed to participate in the study and three of these participants were chosen as subjects for the post hoc case study analysis; Meltem, Pelin, and Ali (pseudonyms). Meltem exhibited an especially strong knowledge of technology, Pelin showed substantial change in the success of implementation from the first to the third and Ali showed a strong technological knowledge but claimed to not feel the need to use technology to teach mathematics unless it was required. These three PSTs were chosen by a purposeful sampling method because this sampling strategy provides access to people who will provide rich information about the research question (Creswell, 2007). A small stipend was paid to all six of the student volunteers.

Three limitations that can affect the generalizability of the reported results include:

- The population of students accepted into the teaching program at the METU is inherently biased. These students possess strong content knowledge;
- Researcher bias is possible because the lead author was a mentor to the PSTs;
- A case study methodology was used. The results that follow focus specifically on the data gathered in the final interview (completed January 2012).

DATA ANALYSIS and RESULTS

To analyse the final interview data, the researcher's focus was especially on the **assist in application** and **develop TPACK** guidelines found in the SITI Model. The PSTs had developed and implemented their plans in actual classrooms. The purpose of the final interview questions was to promote and document reflection on their experience. The 50-minute interviews were transcribed and translated into English by the researcher in order to collaborate with an associate professor from USA. From each transcript, significant phrases and sentences directly related to the interview questions were identified. For example, the 18th question was about time: Because of using educational technology in your teaching, did you have any problems in terms of time management?

A total of 21 theme items emerged and were numbered as they arose. Sorting the theme items into nine distinct categories followed this analysis. While analysing the data, an associate professor experienced with qualitative research and analysis, reviewed the data, validated the emerging themes and collaborated in the assignment of categories. In the text that follows, each of the identified categories is followed by two to four theme items and selected quotes (with time stamps) from the interviews.

The first category, **Content Criterion**, is important because it indicates that the PSTs were focused on the mathematics content and not just the technology. The PSTs stated that to integrate educational technology into mathematics education there should be some criterions to follow. The three theme items that emerged related to content criterions to teach a geometrical concept via GeoGebra were:

- Use technology when it is really necessary,
- To implement lesson in computer lab or classroom environment make a decision based on the lesson objectives,
- Focus on one concept; focus on concepts not technology.

> *I think, we should use technology when it is necessary to teach a geometrical concept. We need to focus on one objective, otherwise, as we see from my implementation it makes students confused. [Ali.13:25-14:00]*

Ali was referring to his third lesson implementation where he taught three objectives related to factorization. That lesson covered greatest common factor, factoring by grouping and factoring quadratic polynomials. His GeoGebra activity was constructed to teach factorization of quadratic polynomials. He reported during the interview that some of the students appeared to be confused because of learning three objectives in a single lesson and had some difficulties to focus on a GeoGebra activity at the end of the lesson.

Time management is the second category identified. PSTs stated that, if there is no technical problem, educational technology helps teacher use time economically. The two theme items categorized as time management were;

- Technology helps PST use time economically,
- Have a back up plan in case of any technical problems.

> *I think when we use technology in math education, it provides time saving. [Ali.14:03-14:27]*
>
> *All the time we need to have a plan B in case of any technical or other problems. [Pelin.35:20-35:51]*

In some cases, the technology saved time. For example, in Meltem's first implementation she was able to demonstrate how to make a triangle with the same area by dragging one of the vertex points of the polygon (instead of drawing on the board for each situation). In other cases, technology problems wasted class time. In Pelin's third implementation, the electricity cut off and she couldn't project the screen onto the board. Nevertheless, her laptop battery was full and she displayed the GeoGebra file via laptop screen by grouping students into the three parts.

Classroom Management is the third category. PSTs said that educational technology makes classroom management harder. The two theme items that came out related to classroom management were;

- Technical problems make classroom management harder,
- Following students is more difficult in technology-based classroom.

Most of the classroom management problems arose from technical problems. [Ali.12:15-12:24]

To follow students at the same time is more difficult when I was using GeoGebra. [Meltem.13:05-13:34]

The fourth and fifth categories that generated strong reaction appeared in each of the interviews was named **Tool Use**. PSTs defined educational technology as a tool for teachers and students separately in order to have effective teaching and learning. **For Teachers,** technology is a tool to promote students' learning. The two theme items that came out related to tool use for teachers were;

- Technology is a tool to help teachers support their students reasoning,
- Technology gives opportunity for teacher to implement student-centered lesson (Problem solving, questioning).

It is a really helpful tool for mathematics teachers if they want to make students discover geometric objects. One of the GeoGebra features that can be used was hiding objects. It gives an opportunity for teachers to hide something and let students discover, … teacher can show the objects step-by-step to confirm students reasoning. [Ali.24:25-25:20]

For Students, technology is a tool to help them learn easier. The theme items were;

- Technology is a tool 1) used for discovering features of geometrical concepts, 2) to help students transfer their mathematical knowledge, 3) used for testing students' answers,
- With the help of technology, students learn geometrical rules conceptually without memorizing.

GeoGebra helps students to observe and discover features of geometric concepts… GeoGebra can help students make abstract concepts concrete. [Ali.23:30-24:22]

As you observed in my third implementation, students could transfer their knowledge, they learned in previous lesson, to another problem situation while drawing a circle when only three points to pass through are given. [Meltem.16:52-17:20]

For example, in Ali’s third implementation, he modelled algebra tiles via GeoGebra and taught factoring quadratic expressions. With the help of GeoGebra, students could visualize $2x^2 + 5x + 2$ and its factors. Another example is from Meltem. In her second implementation, she asked the students to find the circumcenter of a dynamic triangle first by dragging a point (that was connected to the three vertices). This was followed by an exploration of the use of the perpendicular bisectors of each side of the triangle to find the circumcenter of the given triangle. In Meltem’s third implementation, she asked students to create a circle when only three points to pass through were given. In the second step of the activity, a few of the students made a connection to the previous lesson, and found the correct solution for the problem (this was observed in the video tape of this lesson).

The sixth category that also generated strong reaction when it appeared in each of the interviews was named **Implementation**. During the interviews, PSTs reported contributions of the implementation experience to their future teaching. For example, they reported an increase in confidence in teaching and predicting what students might ask. The theme items that related to implementation were;

- The more they implement lessons in a real classroom context, the more the PSTs have self-confidence in teaching,
- The more implementations in real classroom contexts, the more PSTs interpret what will happen in the lesson,
- The more implementation in real classroom contexts, the more the PSTs see their weaknesses,
- Personal reaction to lesson implementations.

> *The more we have teaching experiences in real classrooms, the more we have knowledge about students’ reactions…. As a teacher, I feel more comfortable in real classroom environment now. [Meltem.34:57-35:20]*

> *In the third implementation I could predict what kind of questions students will ask me, about the task. [Ali.08:30-08:45]*

> *Luckily all of the class activities that I implemented in real classroom context was really close to what I imagine while designing… Normally I thought that I could not implement what I planned, since I am looking for ideal students that have mathematical content knowledge very deeply as a pre-knowledge and they will answer whatever I asked to them related to content [Meltem.04:09-04.30]*

> *There is an improvement in my opinion. My best implementation was the last one. [Ali.05:41-05.52]*

The seventh category was **Recommendations**. The last question of the interview was; do you have any recommendation about training teachers in terms of using technology? PSTs gave recommendations to the teacher training programs. The four remaining theme items that came out related to recommendation were;

- Teacher training programs should have more technology courses,

- Integrate technology into methods course,
- PSTs should improve their techno pedagogical skills before graduation,
- PSTs need more lesson plan implementations in real classroom contexts to have more experiences before graduation.

There should be more obligatory courses about educational technology in our national teacher training programs. [Pelin.46:04-46:20].

Teacher training programs need to integrate technology into method course [Ali.35:37-35:48].

I need more experiences in real classroom context before graduation [Ali.35:03-35:21].

Two remaining categories were identified by one theme item each;

- Need to know student's pre-knowledge,
- Mentoring is helpful to improve lesson plan.

The need to know students' **Prior Knowledge** appeared in each of the interviews. All three of the PSTs commented on the impact of not having a good understanding of the students' knowledge when designing and implementing a lesson.

Therefore, just because I didn't know students' pre-knowledge, my lesson implementation was not effective. Without any reasoning, they answered the questions. It was not a challenging activity for them. [Ali.04:49-05:15]

We need to have information about students' pre-knowledge to prepare effective lesson plan. [Pelin.33:57-34:06]

The last category that emerged was **Mentoring**. While it was not anticipated, this category is in alignment with the SiTI guideline "assist in implementation." The PSTs commented on the feedback and advice offered by the researcher in her role as a mentor.

While I was creating GeoGebra activities, I took your opinions about in which part of the lesson I need to use that activity ... Based on our discussion during the interviews I made some changes in my lesson plan. [Ali.05:54-06.15]

DISCUSSION and CONCLUSION

The purpose of this report is to examine three pre-service teachers' (PSTs) reactions to implementing three technology-based mathematics lessons in the context of a field experience. Three of the five the SiTI Guidelines provided a framework for the PSTs coursework and the additional field experience that participation in this study provided. The overarching goal of developing the PST's TPACK can be observed in five of the categories identified in the final interviews. Issues that emerged with regard to classroom management and time management could be considered technological pedagogical knowledge (TPK). Issues that emerged with regard to content criterion and tool use (teacher and student) could be considered as technological content knowledge constructs. Pre-knowledge could be considered as necessary to a teacher's pedagogical content knowledge, which for these PSTs affected the overall success of their lesson implementation. What is interesting is that the PSTs did not specifically reflect on the technological aspects of their lesson implementation. This might be due to the questions asked in the interview or to the PST's past experience with regard to using GeoGebra and/or preparing the files used in the lessons.

The remaining two categories provide important information about the field experience as a whole. The PSTs valued the implementation experience, recommended that this type of experience be included in a teacher education program, and reported positively on the role of the mentor.

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