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In the Pursuit of a Course Design: A TPACK-based Geometry for Preservice Mathematics Teachers

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Abstract
Preservice mathematics teachers seem to need professional support regarding the use of educational technologies to teach geometry topics. Particularly, our previous study showed that when it comes to their techno-pedagogical content knowledge (TPACK), they self-report to need guidance to teach with technology. The purpose of this study was to develop a 14-week course to increase their TPACK in hopes of bridging the knowledge gap identified in earlier studies. This paper summarized the course content with a humble expectation to get valuable feedback from an international audience. The developed course included lessons on components of TPACK, which were found to require improvement to best meet future students' needs in teaching geometry with technology. We hope that preservice teachers' TPACK levels will be improved after the course.

Keywords: Course design, design-based research, preservice mathematics teachers, technology, TPACK.

Introduction
Given that education is a multidimensional system, seeking the truth in education should be multi-elemental and evidence-based. Teachers being the most important elements of this system, the quality of teacher education, teachers' experiences, and current practices of the teachers are generally interrogated over the success of their students, being consequential (Curnow & Jurow, 2021; Shulman, 1986). However, by moving away from a top-down approach together with a central understanding with a bottom-up, researchers created a grassroot approach which reflected on the process of searching for a real truth (Milner, 2022). The skills of teachers can be revisited by researching the reasons for the depth of topics which were integrated in teacher education.

As teacher educators and academic researchers - we - to bear this torch could chart to identify essential sites for empirical research on preservice mathematics teachers' education. To state as an old fashion that this is the current perspective in preservice mathematics teachers' education, 'or there are still problems on preservice mathematics teachers' knowledge of technology, technological skills' means less to say that over the new fashion we have designed it to close this gap and that we have achieved it as a result at the end of this instruction. As a predictable consequence of these circumstances, we welcome a breadth of scientific and scholarly products in a course design for preservice mathematics teachers in order to say more than there exists (e.g., Buss & Foulger, 2022; Greene et al., 2022; Lyublinskaya & Du, 2022).

Researchers report that preservice mathematics teachers require some assistance while teaching geometry concepts (Bulut & Işıksal, 2019; DfE, 2019).

According to recent research, preservice mathematics teachers ask for more help to teach technology-based geometry, especially when it comes to their techno-pedagogical content knowledge (TPACK) (Blankenship et al., 2022; Saralar-Aras & Birgili, 2022). Moreover, with the Covid-19 pandemic, teaching programmes and curricula for K-12 started to be redesigned, and programmes for teacher education needed to be changed as some of the information included there was no longer up-to-date (Kim & Kwon, 2022). Given the need, the aim of this research is to create a 14-week course to improve preservice mathematics teachers' TPACK in order to close the knowledge gap discovered in the Saralar-Aras and Birgili's (2021) study and wider literature. With the humble expectation of receiving helpful comments from an international group of scholars, this paper described the content of a design-based course.

When it comes to TPACK, it is important to describe what the authors understand from it and what the recent reflections are, which were described in the theoretical framework section. Given the need, the aim of this research is to create a 14-week course to improve preservice mathematics teachers' TPACK in order to close the knowledge gap discovered in the Saralar-Aras and Birgili's (2021) study. With the humble expectation of receiving helpful comments from an international group of scholars, this article described the content of the design-based course.

Objectives

As stated before, the purpose of this study was to develop a 14-week TPACK-based geometry course relying on a design-based research to increase preservice mathematics teachers' TPACK in hopes of bridging the knowledge gap identified in the wider literature confirmed by our earlier study (Saralar-Aras & Birgili, 2021). This paper summarized the content of the geometry course with a humble expectation to get valuable feedback from an international group of researchers. This course was designed as a part of a design-based research, and will be improved in the next cycles.

Theoretical Framework

Recent improvements in technology, particularly after the Covid-19, affected not only various aspects of lives but also the theories of education. TPACK, being one of them, seems to be strengthened a lot during this process with different approaches to the framework, e.g. learning trajectories approach (Lyublinskaya & Du, 2022), coaching (Rock et al., 2022) and virtual reality (Huang et al., 2022). This paper employed a technological pedagogical content knowledge teacher knowledge framework for technology integration (originally TPCK, now known as TPACK, or technology, pedagogy, and content knowledge). This approach extends Shulman's (1986) pedagogical content knowledge (PCK) model to incorporate technological knowledge. Teachers' development of TPACK is crucial to effective technology-enhanced education. The nature of technologies (both analog and digital), as well as how incorporating technology into pedagogy affect and challenge teaching (Saralar-Aras & Güneş, 2022; Graham, 2011; Mishra & Koehler, 2006). The teacher knowledge TPACK framework is a complex interplay of three bodies of knowledge: content, pedagogy, and

technology. In other words, TPACK is described as the linkage of pedagogy, content and technology knowledge, and their interconnection as technological content knowledge, technological pedagogy knowledge, pedagogical content knowledge and technological pedagogical content knowledge as described in Koehler et al.'s (2013) study. The interplay of these three bodies of information, both theoretically and practically, results in the sorts of flexible knowledge required for successfully integrating technology into education.

While developing a course for preservice teachers, it seemed important to take this framework as a base, as its focus in many studies deemed to fit the needs of preservice teachers who will become teachers in classrooms in near future (Saralar-Aras & Birgili, 2022; Clausen et al., 2022).

Methodology

This study was the second study of wider design-based research (DBR) (Bakker, 2018), which aims to design a course to meet preservice mathematics teachers' needs about their future teaching by helping them improve their TPACK. The aim is to improve preservice mathematics teachers in all TPACK components, but particularly those which were found to be lower than expected (technology knowledge, technological content knowledge and technological pedagogy knowledge). The lessons of the course design were planned to be 3 h/w. (i.e. 5 ECTS, 140 hours workload).

Data sources

The percentages are responses of 70 preservice mathematics teachers (41 females, 29 males) to Bulut's (2012) perceived TPACK-level survey items on how confident they feel. Being a maths expert in TPACK and DBR, and instructional design accordingly, the researchers cross-checked each lesson in terms of content and skills for validity-evidence.

In each unit of the TPACK-based course, the researchers developed and designed instruction in line with the following knowledge and skills.

i. 1-week lesson on pedagogy knowledge: Pedagogy knowledge is about the understanding of teaching and learning processes and approaches (Saralar-Aras & Birgili, 2021). The competencies regarding PK which is believed by preservice mathematics teachers to be enhanced are about evaluating their students' in-class performances (88.6%), and managing their classes effectively while lecturing (87%).

ii. 1-week lesson on content knowledge: Content knowledge is on one's subject area expertise to be learnt or taught (Saralar-Aras & Birgili, 2021). The competencies regarding CK which is believed preservice mathematics teachers to be proficient in are how to do proofs in the geometry topics within the middle school mathematics curriculum (81%).

iii. 2-weeks lessons on pedagogical content knowledge: Pedagogical content knowledge covers issues related to the subject knowledge that concerns the teaching process (Saralar-Aras & Birgili, 2021). The competencies regarding PCK which is believed by preservice mathematics teachers to be proficient in

are how to identify students' misconceptions about geometry (87%) and to determine the reasons for students' misconceptions about geometry (84%).

iv. 10-weeks lessons on technology-related items (2-weeks on technology knowledge, 3-weeks on technological pedagogy knowledge, 3-weeks on technological content knowledge and 2-weeks on techno-pedagogical content knowledge): Technology knowledge is the knowledge of the tools, whilst technological content knowledge is regarding how to use technological tools to teach a topic, and technological pedagogy knowledge is on using these tools to teach with a teaching method (Saralar-Aras & Birgili, 2021). Hence, the course included topics on computer hardware (53%), software packages including audio-visual technologies (74%), and issues on how to solve technical problems with those (46% hardware; and 62% software-related issues) in TK lessons; on evaluating the practicality of new tools in education (80%) and determining appropriate hardware or software technologies for the teaching method that they would use (73%) in TPK lessons; and kinds of technologies used in geometry (71%) and software available for geometry subjects (57%) in TCK lessons.

Significance of the Study

Research evidence shows that preservice teachers prefer not to be instructed with theory-based teaching, they would rather prefer practicum-based environments (Bulut, 2012). This research is significant hence as one of the aims of any DBR, it bridges the gap between theory and practice. We know that there is still a gap between theory and practice in teacher education (Bakker, 2018; Radovic et al., 2020). These attempts are hoped to set an example for not only in Turkey but also wider Europe and the U.S.A, considering the case is not dissimilar there (Castera et al., 2020; Sointu et al., 2015). Therefore, our research is valuable as it comes from theory and research findings; and aims at improving preservice mathematics teachers practice with the knowledge they gained through the course. Furthermore, after the course, we expect them to perceive practical training content in other lessons faster than they did before.

Results and Conclusions

There are some expected outcomes of the designed course. Firstly, the course about geometry education for the teaching of mathematics in middle schools will be favored by preservice mathematics teachers because the draft course was based on the needs assessment of themselves (Saralar-Aras & Birgili, 2021). Secondly, preservice mathematics teachers may least benefit from the content for dimensions of PCK, CK and PK whilst the most benefitting from the design for dimensions of TK, TPK, TCK, TPCK, as being the most in need of improvement (Saralar-Aras & Birgili, 2022). Last but not least, it is expected that the course will support preservice mathematics teachers in improving their TPACK regarding geometry so that they could better prepare for their future lessons. It is not to say that preservice mathematics teachers' knowledge is insufficient but with the support from this course, we hope that some of the TPACK components will hopefully be improved for betterment of teaching effectiveness. Finally, we would further like to note that the developed course

would be an example for teacher education and be a helpful tool for preservice mathematics teachers.

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