An Online Laboratory School research on pre-service mathematics teachers' experiences and mathematics teaching anxiety

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Abstract
During the COVID-19 pandemic, we founded an Online Laboratory School (OLS) under the roof of a university in Turkey to support students from public schools that were not technologically prepared for an online education and to provide an opportunity for our pre-service teachers (PSTs) to continue their internship by teaching online. The purpose of this research, consisting of two studies, was to examine experiences of 43 PSTs (first-, third- and fourth-years) during the OLS period of 8 weeks and how the OLS affected their mathematics teaching anxiety during Fall 2020. In the first study, we administered a survey to inquire into PSTs' views on their experiences at the OLS, and in the second study we examined their mathematics teaching anxiety before and after the OLS experience using another survey. One main result was that the OLS experience served as an effective introduction to the profession for first-year PSTs and fourth- and third-year PSTs reported learning in-depth about online teaching in terms of the planning, teaching, and reflecting cycle. Another main result was that PSTs had mathematics teaching anxiety from "a little" to "a moderate amount" before the OLS and their teaching anxiety did not significantly change during the OLS period of 8 weeks. PSTs experienced highest mathematics teaching anxiety when they were observed and evaluated by supervisors during their teaching. The implications of these findings are discussed for teacher education programs.

Keywords Covid-19 pandemic · Distance education and online learning · Higher education · Mathematics teaching anxiety · Online Laboratory School (OLS) · Pre-service teachers (PSTs)

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1 Introduction

With the global spread of the COVID-19 pandemic in early 2020, face-to-face education and teaching processes were disabled, and online teaching became the norm instead of merely serving as an alternative for course delivery. Educators in most countries made efforts to ensure that students continued their education at the most accessible levels by using digital products and platforms in order to not disrupt the educational processes. There were several approaches taken—in Turkey and globally—to address internship problems for fourth-year PSTs who were approaching graduation, as well as to maintain quality of teacher education programs (Ersin et al., 2020; Vu & Fisher, 2021). Instead of regular internships, some teacher educators designed experiences so that PSTs viewed videos of teaching and provided reflections based on their observations (Vu & Fisher, 2021). Others implemented microteaching practices where PSTs prepared lesson plans and taught them to their peers (Ersin et al., 2020), while yet other practices involved recording videos of teaching those students from their community with whom they could work (under pandemic restrictions) and sharing them with the teacher educators (Barnes et al., 2020).

Our approach for addressing the internship problems was to found an Online Laboratory School (OLS) under the roof of a university in Turkey to provide PSTs with real teaching experience during the pandemic period. During the first semester after the pandemic started in Spring 2020, The Centralized Higher Education Council in Turkey lifted all the internship requirements for the teacher education programs. In comparison to public schools that were not prepared technologically for having their education online, the private schools had less difficulty to continue their education during pandemic. However, due to the privacy concerns of parents, pandemic further prevented K-12 private schools in Turkey from fully adjusting to their roles as teacher education partners in this new situation. Therefore, as teacher educators at the university we investigated different solutions regarding how to provide opportunities for PSTs so they could continue practicing their internship. In order to support students from public schools that were not technologically prepared for an online education and to provide an opportunity for our PSTs to continue their internship by teaching online under the guidance of university supervisors, we founded the Online Laboratory School (OLS) at our university.

Unlike Laboratory Schools (Mayhew & Edwards, 2007), the OLS experience does not rely on a physical school. However, there is a similar motivation in traditional laboratory schools and our OLS which is to connect school and university practices in order to improve the quality of teacher education (Mayhew & Edwards, 2007). Parallel to the use of laboratory in any other field, laboratory schools were historically designed to test different models of education and reflect on the outcomes (Mayhew & Edwards, 2007). Such laboratory schools are special in the sense that they provide opportunities for research on 'teaching' as well as practicing in the classroom. In addition, these schools are connected to universities, and they differ from regular schools, especially in terms of management and the role of teachers.

Similar to traditional laboratory schools OLS was founded and directed by the Faculty of Education, wherein teacher educators and experienced teachers work and collaborate as supervisors to guide PSTs' practices and provide feedback online. OLS

provides teaching practice opportunities for PSTs who are expected to act as reflective practitioners (Schön, 1987) and work in collaboration with peers and supervisors in implementation of new models of teaching. OLS is an online school where PSTs' pedagogical and practical knowledge are supported, and classroom management skills are strengthened as they work with real middle school students. To support PSTs' professional development in their online teaching competencies and to improve teacher education programs based on the needs of PSTs, there is a critical need to investigate PSTs' experiences and how they view such experiences in the framework of the OLS.

To prepare PSTs for the teaching profession vis a vis real teaching experience such as in the OLS, it is also critical to identify their anxiety levels for teaching mathematics. We argue that PSTs are expected to gain much more experience by teaching online during their internship if they have low levels of anxiety for teaching mathematics. Past research has shown that teachers having anxiety about mathematics influence their students' learning mathematics and mathematics achievement negatively (e.g., Ramirez et al., 2018). It is also known that teachers who have difficulties in teaching mathematics can cause their students to experience anxiety about learning mathematics (e.g., Beilock et al., 2010). In a few studies that examined the relationship between teaching experience and mathematics teaching anxiety (thereafter, math teaching anxiety), in-service elementary teachers with one year of teaching experience tended to have higher math teaching anxiety than those teachers with more years of teaching experience (Hadley & Dorward, 2011). However, to our knowledge, no studies have examined how internship experience, specifically whole class teaching or online class teaching experience, is related to PSTs' math teaching anxiety. Therefore, the purpose of our research was to examine PSTs' experiences at the OLS and how such experiences affected their math teaching anxiety levels.

1.1 Research questions

Our research consists of two studies (which we labeled an experience study and an anxiety study, respectively) and addresses the following five research questions:

1. How do PSTs view their experiences of internship in the OLS in terms of professional development?
2. How do PSTs' views of and experiences in the OLS differ based on the cohort they belong to (i.e., first-, third-, and fourth-year PSTs)?
3. What are the math teaching anxiety levels of PSTs?
4. Are there significant relationships among PSTs' math teaching anxiety levels and their educational backgrounds such as the number of methods courses completed so far?
5. Is there a significant relationship regarding PSTs' math teaching anxiety levels before and after eight-weeks of the OLS?

The first two questions applied to the experience study, examining PSTs' professional gains and experiences in the OLS. The last three questions were utilized in the anxiety study, investigating math teaching anxiety levels of PSTs, exploring the relation-

ships between math teaching anxiety and educational background variables such as grade levels and number of methods courses completed so far, and assessing whether PSTs' math teaching anxiety levels changed during their eight-week OLS experience.

1.2 Laboratory schools for teacher education

References to laboratory schools are usually based on young children's learning and their upbringing as active members of the society. However, there is also some attachment to the education of teachers in these schools. Dewey's (1904) conception of how the 'teaching profession' should be learnt suggested an 'apprenticeship' model and that it should be applied 'in a laboratory setting.' In this apprenticeship model, 'practice and practicum' are central, and teaching and classroom management strategies are usually given the most importance for PSTs to observe, teach and learn. In the practicum PSTs can observe and practice these skills. Different from only engaging in practicum, in the laboratory setting a perspective based on practice, constructing ideas for theoretical instruction as an element of practice and, in addition to doing the practice, developing a theory to give meaning to practice are all emphasized (Dewey, 1904). American laboratory schools are important and revolutionary for both children and teacher education. Parallel to those laboratory schools, similar teacher education models in other countries have been successfully founded, such as in Finland (Toom et al., 2010) and The Netherlands (Henning et al., 2015). In addition to general acceptance of the functions of laboratory schools in teacher education, research exists on building theories related to how PSTs learn instruction. In similar veins, a study by Gravett & Ramsaroop (2017) focuses on teaching schools at a South African university which embrace Dewey's ideas. They suggest that the cognitive apprenticeship model can be thought of as a bridge between practicum and laboratory setting. In this model, they suggest that if more experienced teachers are explicit about communicating how they teach or what decisions they take, and explain the reasons behind those decisions, such communication might enhance PSTs' learning beyond just superficial observations. The cognitive apprenticeship suggests new opportunities for developing 'teaching skills' even if these skills might not be immediately evident or directly connected to PSTs' practice when investigated; they can nonetheless affect PSTs' thought processes and consequently turn into actions in their professional lives. Therefore, we value the contributions of experienced teachers playing a more active role in this apprenticeship model for not only being observable objects but as active agents who contribute to the knowledge construction of 'teaching'.

Some studies reported that in regular practicum, PSTs or beginning teachers usually struggle with classroom management and feel frustration, anger, and confusion (Korthagen, 2010). As benefits of teaching schools which focus mainly on 'teaching practice', PSTs reported that they also learn about different skills to teach diverse learners and these schools provide opportunities 'to align teaching and learning experiences' between teacher education institutions and schools (Gravett & Ramsaroop, 2017, p. 3).

In our current work, laboratory school concept entails trying new ideas such as using and implementing technology in lesson plans or developing teaching skills for mathematics concepts in a learning community. The OLS that our study is based on is

a unique environment unlike the traditional laboratory schools. OLSis designed to be wholly online with real students, real preservice teachers, and university supervisors and in a laboratory setting. Because we aim to investigate PSTs' laboratory school experiences in *online* learning environments, those experiences may differ from what is stated in the existing literature. Thus, we believe that explicit support from more experienced teachers and university supervisors; well-organized laboratory school structure; clearly stated expectations from PSTs; and opportunities for reflection on their experiences, help not only for developing better teaching practices but also for influencing PSTs' math teaching anxiety. A hundred years after Dewey's ideas on laboratory schools were published, with the influence of the pandemic, we investigate these ideas related to experiences of PSTs in a new environment: the OLS.

1.3 Integrating theory and practice in teacher education

Because internship is a fundamental aspect of teacher education (Flores, 2016), we implemented a teacher education model called the University within School model (Özcan, 2013) based on an integration of theory and practice through rich internship experiences between university and schools in teacher education programs. Internship practices in the context of the University within School model and the OLS experiences are designed by considering situated learning perspectives (McLellan, 1996). Like realistic teacher education perspective (Korthagen, 2010), PSTs learn the profession of teaching not by thinking of teaching but by actively engaging in core practices of teaching in a gradual way and by reflection on such practices. According to this perspective of learning, PSTs need to interact in authentic contexts and with real students in an online mathematics class, and experience online teaching as a member of group with similar goals and values in order to grow professionally in online teaching of mathematics (Kennedy & Archambault, 2012). In the context of OLS, PSTs share responsibilities based on their cohort, with increasing responsibilities of conducting observations, engaging in planning and reflection meetings, acting as a teaching assistant, and then as a teacher. In this way, different cohorts of PSTs (first-, third- or fourth-year) can not only observe but participate, collaborate, and reflect on some of the core practices of teaching, which includes: planning lessons; preparing assessments; using interactive software to enhance student participation; and teaching meaningful mathematics by considering student thinking in a synchronous way.

The realistic approach to teacher education (Korthagen, 2010) puts emphasis on interactions between teacher educators and PSTs, as well as among PSTs. It is also important that PSTs engage in systematic reflection practices as a group of learners. OLS provided a context for building an online learning community (McLellan, 1996) and fostering reflection during the core practices of teaching as it was easier to plan, observe, teach, and reflect as a group of learners because of an online context without limitations of transportation and location.

The university where this study took place is a private university which was considered as the world's first "fully flipped" university (Sahin & Kurban, 2016). All instructors at the university are committed to engage in flipped learning approach and active learning strategies in their courses. The instructors are also encouraged to use

Blackboard software actively. In this context, PSTs are already familiar with different types of educational technologies and active learning approaches in their courses throughout their university education. The Faculty of Education is committed to situated learning in all areas, particularly internship practices.

1.4 Role of online practices in learning to teach

Online K-12 education and online teacher education have become more and more popular due to the growth of technology in recent years (Lieberman & Pointer Mace, 2010). There is a lot to know about how to implement better online K-12 mathematics teaching and prepare teachers for online teaching practices in different forms (Jack & Jones, 2019). Researchers and teacher educators recommend providing opportunities in online fieldwork for PSTs, as online teaching is expected to be more common. Therefore, PSTs need to have specialized knowledge and strategies to become better online teachers (Kennedy et al., 2013; Lieberman & Pointer Mace, 2010).

Results of studies about online teaching experiences indicated that PSTs reported positive outcomes related to online fieldwork; their beliefs about online teaching were also transformed as an outcome of this experience (Compton & Davis, 2010; Jackson & Jones, 2019; Kennedy et al., 2013; Luo et al., 2017). A study by Luo et al., (2017), for instance, surveyed PSTs' perceptions of online fieldwork. They discovered that 14 out of 34 participating PSTs believed that online teaching would be hard to implement in a student-centered manner and it would be difficult to establish teacher student interactions in an online context. After experiencing online internships, 13 of the PSTs changed their views that online teaching could also be interactive and student-centered, while only one PST's view remained unchanged. Similarly, a study by Kennedy et al. (2013) investigated experiences of some PSTs who participated voluntarily in an online school teaching activity for four weeks. The PSTs reported that the online fieldwork should be mandatory for all PSTs in teacher education programs and not only for those interested in online teaching careers. Another key result was the importance of guidance and support from supervisors who were devoted and knowledgeable in their jobs as mentors. In a qualitative study, Jack & Jones (2019) investigated teachers' experiences and perceptions of participating in an online teaching certification program and online fieldwork, as the teachers also engaged in online discussions with each other. Similar to the results in other studies, Jack and Jones also found positive outcomes. However, teachers reported that online fieldwork was more challenging and time consuming to plan than what they had anticipated prior to participating in the program. The results of this study suggested that what the participants valued the most about the online fieldwork was participating in an online community: sharing best practices and difficulties with each other and learning from each other.

It is important to distinguish different forms of learning in different online contexts and programs. For instance, in some online schools, PSTs may not be responsible for planning and designing of the course. The PSTs' roles may be to reteach a challenging topic, provide feedback for students about their homework and communicate with parents and students (e.g., Feher & Graziano 2016). Previous research does not focus on online teaching of specific content areas (i.e., teaching mathematics online)

and is regarded as disconnected from K-12 students (DiPietro et al., 2008). There is a need for studies where online PST practices are closely monitored and guided by the university (Kennedy & Archambault, 2012).

In summary, the review suggests there is a need for studies involving experiences and perceptions of PSTs where they are actively engaged in core practices of teaching. It is particularly important to study PSTs as a community of learners in the context of close collaboration between the online school and the university in teaching mathematics and interacting with students. The results of this study have the potential to provide insights into new avenues of PSTs' learning and professional growth during online internships.

1.5 Math teaching anxiety

Math anxiety, "feelings of tension and anxiety that interfere with the manipulation of numbers and the solving of mathematical problems" (Richardson & Suinn, 1972, p. 551), is an important construct that might cause students to avoid taking mathematics courses and to follow career paths that do not involve mathematics (Ma, 1999). Some negative outcomes of math anxiety include low academic performance (Ashcraft, 2002), reduced working memory functioning (Ashcraft & Moore, 2009), and low perceptions of one's own abilities (Hembree, 1990). Past research has reported that one main reason for students' math anxiety stems from their early negative experiences with teachers in classrooms (Bekdemir 2010; Bryant, 2009). In particular, teachers' math anxiety influences students' math anxiety with the use of some pedagogical practices such as overreliance on rote memorization rather than encouraging conceptual understanding (Vinson 2001).

In conjunction with math anxiety, math teaching anxiety can be defined as "pre- and in-service teachers' feelings of tension and anxiety that occurs during teaching mathematical concepts, theories, and formulas or during problem solving." (Peker, 2009, p. 336). Thus, math anxiety and math teaching anxiety are two related, but distinct constructs (Hadley & Dorward, 2011). Teachers can have math teaching anxiety because they think that they are not capable of teaching mathematics to their students. However, they can still be very confident and lack anxiety when it comes to their mathematical knowledge. In a study with 692 in-service elementary teachers, Hadley and Dorward (2011) found that students in classrooms where their teachers had lower levels of math teaching anxiety were more successful in mathematics than those students whose teachers had higher levels of math teaching anxiety.

To avert long-term negative impacts of math teaching anxiety, it is important to identify math teaching anxiety levels of PSTs so that appropriate interventions can be provided to decrease math teaching anxiety before they teach in real classrooms. The OLS was unique in this regard, with teacher educators and experienced teachers collaborating as supervisors for guiding PSTs' teaching practices with real middle school students in simultaneous and interactive teaching. We anticipated that PSTs' math teaching anxiety would be lower in this learning community setting, which afforded PSTs more support in reducing their anxiety about teaching mathematics.

Fig. 1 Description of the OLS practices including planning, teaching and whole group reflection.
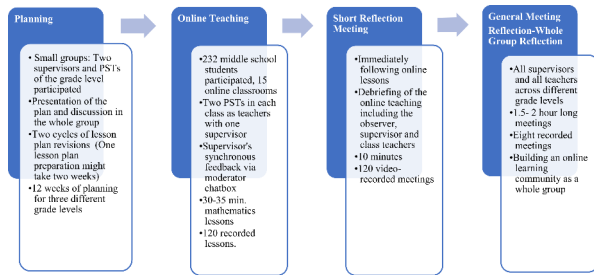
2 Materials and methods

2.1 Context, participants, and structure of the OLS

The University, where the study was conducted, adopted Flipped Learning approach when it was first founded 8 years ago (Şahin & Kurban, 2016). All the full-time faculty agreed to use technology and implement this approach in their classes. It is a young and very technology savy institution. A week before the first case of COVID-19 broke in Turkey in March 2020, our president announced that all the classes at the university were online. Therefore, the university instructors and university students had such advantage in the transition to online.

During Spring 2020, we conducted a pilot project of the OLS for 5 weeks. After realizing its success in terms of providing PSTs opportunities to do internships, we decided to continue this school for the 2020–2021 academic year. In Fall 2020, we brought our first year PSTs into the project, in parallel to a course that the first author was teaching. For that semester, the OLS admitted 232 children from all over Turkey; seven university supervisors (all with different teaching experience background) and 43 PSTs participated in this school for a duration of 8 weeks. There were 15 online mathematics classes including 4th, 5th and 6th grades and there were 10–15 children in each class. We used Blackboard (BB) Collaborate as a meeting platform in the OLS. Figure 1 presents the description of the OLS practices that include planning, teaching, and whole group reflection.

Based on Fig. 1, the OLS practices started with planning sessions which usually took 1-1.5 h. Planning meetings started four weeks ahead of the teaching schedule. All PSTs joined these planning sessions and fourth- and third-year PSTs took the responsibility of planning the lessons under the close guidance of two supervisors. Later all fourth- and most of the third-year PSTs taught their lessons online. There was a moderator chat box tool in BB where supervisors (not seen by students) could support PSTs during online teaching. Following the observed lesson, a short reflection meeting took place with the PSTs, co-teachers (teaching assistants) and a supervisor (10–15 min.). Additionally, every week, a general meeting was held for all PSTs and supervisors. We discussed the implemented lessons in each class and grade level (1-1.5 h). All the meetings and classroom sessions were video recorded.

2.2 Data collection and analysis

We implemented a mixed method approach: both qualitative and quantitative data collection and analysis are presented. This mixed methodology helped us understand PSTs' experiences and math teaching anxiety in the online environment. For the first, experience study, which employs a qualitative approach, we used a survey called 'Experience Survey' at the end of the 8-week experience. The Experience Survey had open-ended questions and one multiple options question. We analyzed the responses using content analysis. For the second, anxiety study, which utilizes a quantitative approach, we adapted a survey called 'Anxiety Survey' from the literature (Hadley & Dorward, 2011) to understand their teaching anxiety and PSTs filled out the Anxiety Survey before and after 8-week experience. We analyzed the responses using paired sample t-tests and independent sample t-tests.

2.2.1 Experience study

To collect data for the experience study that examined PSTs' experiences related to the OLS, we designed and administrated surveys for all stakeholders: students, parents, PSTs, and university supervisors at the end of the OLS in Fall 2020. There were a total of 43 PSTs including 10 fourth-year, 13 third-year, and 20 first-year PSTs who participated in the OLS. In this study, we report the survey results of 33 PSTs who filled the survey (7 fourth-year, 12 third-year, and 14 first-year PSTs) after the OLS experience. We asked the following five survey questions (one multiple-option and four open-ended) to understand PSTs' views and experiences about the OLS:

a. In what ways have you improved professionally during the OLS experience? (This question had multiple options and they could choose more than one option, see Fig. 2)
b. Please provide at least one detailed example that you think helped you improve during the OLS experience.
c. What approaches of university supervisors helped (or did not help) you? It can be positive or negative contributions, indicate and please give an example (no need to give any supervisors' name).
d. How was your OLS experience different than your traditional/regular internship experience at public or private schools?
e. Please explain whether you would suggest your OLS experience to other PSTs and justify your decision.

In terms of data analysis for the experience study, we analyzed the first two research questions ("How do PSTs view their experiences of internship in the OLS in terms of professional development?" and "How do PSTs' views of and experiences in the OLS change based on the cohort they belong to [i.e., first-, third-, and fourth-year PSTs]?") using content analysis (Cohen et al., 2007). Specifically, we identified themes related to PSTs' responses to the open-ended questions in the Experience Survey (b through d) and investigated patterns of the themes related to their year in the program and their comments. After reviewing PSTs' responses to the open-ended questions, each

Fig. 2 PSTs' answers to Question a)
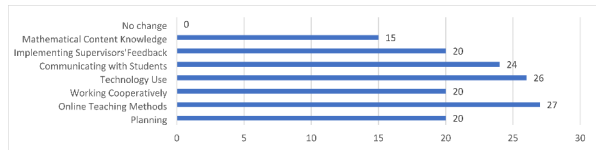
of us determined individually what the categories were, including *students' thinking, specific pedagogical content knowledge (e.g., teaching fractions), technology use, teacher's role, communication with students, lesson planning*, and so on. Then, each of us compared these categories using PSTs' survey open-ended responses. If there were differences in categories, then we discussed them until we achieved consensus on final categories which best reflected PSTs' responses.

2.2.2 Results of the experience study

In this section, we report the results of the survey focusing on the five questions of the Experience Survey and discuss the differences among fourth-year, third-year and first-year PSTs regarding their experiences at the OLS.

Professional Development

For Question a) "In what ways have you improved professionally during the OLS experience?", PSTs reported that they improved their online teaching methods (27 out of 33 PSTs), technology use (26 out of 33 PSTs) and communication with students (24 out of 33 PSTs). These were the three categories in which PSTs thought they had improved themselves most through this experience (see Fig. 2). The less frequently identified categories of professional development were Planning (20 PSTs), Working Cooperatively (20 PSTs), Implementing Supervisor's Feedback (20 PSTs), and Mathematical Content Knowledge (15 PSTs).

OLS learning experiences

For Question b) "Please provide at least one detailed example that you think helped you improve during the OLS experience", generally fourth-year PSTs gave examples related to how they improved in anticipating and managing students' different approaches to specific problems in class as well as using that information in planning lessons to build on students' thinking (4 out of 7 PSTs). As an example, one PST wrote:

> For example, I learned a lot when I planned a lesson related to how to calculate a fractional part of a quantity. It was difficult for me to be prepared for children's possible incorrect solutions. But when I created a plan where I thought through this situation, I realized that my teaching went well. I used problems where they calculated unit fractional parts of quantities and it went as I planned. So, I think I improved in teaching fractions.

Third-year PSTs mentioned more general aspects of their learning. For instance, they experienced how to communicate with students or manage a classroom (5 out of 12 PSTs), both of which were typically accessible to them in theory only before their OLS experience. Third-year PSTs also mentioned how their lesson planning prac-

tice changed with the role of technology use in the OLS (6 out of 12 PSTs). As an example, one PST wrote:

> I think I started integrating more technology when I prepared my lesson plans. The most advantageous part of this online experience is that I developed myself in use of technological tools. I can say that I also started to pay attention more to what the lesson plan should contain, the suitability of learning goals and the content of the plan and including more of the possible students thinking in the plan.

First-year PSTs also gave general comments, but the comments focused on the change of perception related to teaching or the teaching profession. They mostly mentioned three specific categories: how to communicate with students, how to manage students' different thinking during teaching (7 out of 14 PSTs), and how to create lesson plans (2 out of 14 PSTs). As an example, one PST wrote:

> I think I developed myself in many areas during OLS. I think I developed myself most in effective communication with students as a teacher. OLS helped me to think, question and reflect about how to give good impressions to my students about mathematics, how to teach the subject in best ways.

Supervisor's feedback

For Question c) "What approaches of university supervisors helped (or did not help) you? It can be positive or negative contributions, indicate and please give an example (no need to give any supervisors' name)". Almost all fourth-year PSTs provided positive comments. Positive ones included supervisors giving motivational feedback and approaches indicating something was problematic (5 out of 7 PSTs). They felt that supervisors also encouraged them to make things better by acknowledging they were just learning how to teach, interact and ask questions as teachers. As an example, one PST wrote:

> They gave us feedback every week when we were lesson planning. They gave ideas for making the plans better. They also gave feedback at the end of the lesson implementations for how to develop our teaching or they made motivational comments such as, 'your voice tone was very good, or interact with each student so they feel present or part of the class.' I felt supported.

On the other hand, there was a sharp distinction in terms of how third-year PSTs viewed supervisors' contributions. They briefly mentioned that they appreciated comments but only the ones that were positive and encouraging. They also mentioned that in general they were discouraged with the ones that focused on their weaknesses. As an example, one PST wrote:

> While teaching I spent lots of time with one student since I did not know how to handle the misconception. My supervisor who observed me during the teaching did not help me out via moderator chat box in terms of how to guide the student.

Later in the general meeting she mentioned that I spent so much time on one student and gave negative comments.

This PST had difficulty in how to approach an individual student's misconception and continued with whole class discussion. The supervisor was probably unaware that the PST was a third-year who just started teaching and needed more support. The PST found the comments as evaluative and negative feedback. We found that this type of comment was common among the third- year PSTs' responses (Eight out of 12 PSTs made such comments).

On the other hand, all first-year PSTs were satisfied with the supervisors' support and stated that supervisors included them to the discussions in the short reflection meetings and in the general meetings. As an example, one PST wrote:

There were some challenging situations in our class observations. Supervisors gave us examples from their own experiences, and it was great to have such contributions from the supervisors.

Differences between OLS and regular internship

For Question d) "How was your OLS experience different than your traditional/ normal internship experience at public or private schools?", all the fourth-year and third-year PSTs (19 PSTs) stated that OLS provided them opportunities to be more active with such experiences as lesson plan preparations and being responsible as a classroom teacher, compared to their experiences at internship schools. For example, one PST wrote:

The biggest difference is that in the regular internship (face-to-face) you are an assistant teacher or candidate teacher, and you are bound to the mentor teacher. However, you are a teacher in the OLS. And we, as pre-service teachers, have the right to make the decisions. We discuss everything from planning to the teaching and we design them. While we teach only once during whole semester in the face-to-face internship, I taught every week in OLS, and I became the teacher.

Similarly, two PSTs wrote that OLS was helpful for receiving feedback from their supervisors during the class and having an opportunity to discuss their observations after the class in a more regular setting, in comparison to their traditional/regular internship experience. For example, one PST wrote:

It was very different in many aspects. For example, the most important difference was that I was able to get feedback (via moderator chat boxes) while I was teaching and on the spot. By this way, I think the lessons were more effective. This was the most positive and enhancing aspect of the OLS setting.

On the other hand, this question did not apply to most first- year PSTs. They were not in a position to make a comparison between OLS and internship schools. First- year PSTs were having one-to-one tutoring experience as part of another project, but they

did not have the experience of a regular internship because they were in the first year of their program.

Lastly, 5 PSTs (of 33 PSTs) from all grade levels mentioned that use of technology in the OLS was very advantageous compared to traditional school settings. As one PST wrote:

> It was different because of the technology effect. Because of the physical situations in schools, the opportunities are limited. But in the OLS, technology use was very easy. I think we contacted and reached students more easily and we used technology more actively.

Realization of professional growth

For Question e) "Please explain whether you would suggest your OLS experience to other preservice teachers and justify your decision." All PSTs (except one who would not suggest this experience in terms of heavy workload for lesson planning) reported they would suggest OLS experience to a peer due to the opportunity of having teaching experience. All of the 33 PSTs wrote that OLS provided them with online teaching experience and that it provides opportunities for being like a real classroom teacher. Nine of them commented that online teaching is a different skill than teaching in a physical classroom environment and they should get prepared for this online teaching for the future even after the pandemic ends. Seventeen of the 33 PSTs commented that the OLS makes them feel like a classroom teacher due to a variety of decisions they need to take before, during, and after teaching. For example, one PST wrote:'…to have the entitlement of decision making lets us develop ourselves better, it makes us to think more and be more active. I think because of these PSTs should definitely live this experience.'

Moreover, fourth- and third-year PSTs' justifications were mostly based on the experiences which were categorized as 'understanding student thinking, developing ability to prepare lesson plans, and receiving feedback from supervisors.' For example, one PST wrote, "I definitely recommend this experience for others, since it was very effective to experience children's thinking and prepare lesson plans." Another responded that the OLS was helpful at least for having an opportunity to reflect on her own teaching performance after teaching:

> Even if we assume that no one is giving feedback after we teach in OLS, we, as PSTs, had the opportunity to reflect on our own teaching (the videos were recorded) and by this way I would learn something. Because it was such an environment…Therefore, I recommend this experience.

On the other hand, first-year PSTs mostly justified their decision for recommending OLS experience by providing general statements such as learning how to communicate with students and how to use technology in a classroom. For example, one first-year PST wrote:

> I recommend this experience. Even though I am a first-year student, I learned a lot of information, got to know a lot of nice students, and had the

opportunity to meet with nice teachers. While many of my friends in other universities learn theoretical knowledge related to teaching, I moved to the 'communication' stage with the students. This was a very important opportunity for all of us.

Conclusion for the experience study

In terms of professional development PSTs reported they benefited from learning online teaching methods, improving in technology use, and communicating with students. Third-year PSTs reported professional growth but also seemed to be 'challenged' with the experience. There were differences between the third- and fourth-year PSTs that we had not realized in-depth during the OLS experience. Third-year PSTs' comments revealed that they needed a lot more support and motivation to build their confidence in planning lessons and implementing them. They could be easily discouraged. Therefore, the beginning of third year is an important time for gaining these skills, so supervisors should be more careful and thoughtful while giving feedback.

2.2.3 Anxiety study

The sample for the second study during Fall 2020 consists of 43 PSTs (20 first-year, 13 third-year, and 10 fourth-year) for the pre-OLS survey data prior to the eight-weeks of the OLS, and 27 PSTs (7 first-year, 11 third-year, and 9 fourth-year) who completed both pre-OLS survey and post-OLS survey when the OLS had ended. Remember that third- and fourth-year PSTs' role at the OLS was to plan and teach middle school mathematics lessons under the guidance of supervisors for eight weeks, while first year PSTs' role was only to conduct observations and discuss their observations in group meetings.

2.2.4 Data collection and analysis for the anxiety study

To collect data for the anxiety study to examine math teaching anxiety levels of PSTs, the relationships between math teaching anxiety and several variables, and changes in PSTs' mathematics teaching anxiety levels during eight-weeks of the OLS, we administered a math teaching anxiety survey and demographic information questionnaire before and after the OLS. First, Hadley and Dorward (2011) developed the Anxiety about Teaching Mathematics scale by adapting from Mathematics Anxiety Rating Scale-Revised (MARS-R; Hopko, 2003) a scale based on teaching situations. The scale has 12 items with five response categories for each item ranging from "not at all," "a little," "a moderate amount", "a lot" to "very much." The scale has some validity evidence based on expert reviews and the coefficient alpha was 0.90. In this study, we adapted this scale to online teaching situations and added two more items. Thus, the new scale, the Math Teaching Anxiety (MTA) scale, has 14 items with the same five response categories and the coefficient alpha in the present study is 0.93. While a minimum possible score of 14 indicates no math teaching anxiety, a maximum possible score of 70 indicates high math teaching anxiety. PSTs completed the MTA scale during approximately 20 minutes of a class period. The MTA scale items

Table 1 The MTA scale items

Items	Content	Mean	SD
Item 1	I become anxious when looking through the pages in MEB or similar mathematics books.	1.84	0.90
Item 2	I become anxious when teaching students how to use and interpret tables, graphs, and charts.	2.00	0.85
Item 3	I become anxious when preparing students for a math exam that will take place in their schools.	2.09	0.97
Item 4	I become anxious when working out math equations online in front of a class of students.	2.28	1.08
Item 5	I become anxious when preparing a presentation about a lesson plan for Online Lab School.	2.56	1.10
Item 6	I become anxious when preparing to teach students a new math concept that will be challenging to them in the Online Lab School.	2.56	1.16
Item 7	I become anxious when a parent may be present during my online teaching.	1.93	0.99
Item 8	I become anxious when talking to a student who is eager to use a different way to solve a math problem than the way taught in the Online Lab School.	1.79	0.86
Item 9	I become anxious when writing a lesson plan for online teaching of a new math concept.	2.67	0.99
Item 10	I become anxious when waiting whether my students will be able to respond to my questions.	2.02	0.96
Item 11	I become anxious when my supervisor or mentor teacher evaluates my performance during a math lesson I am teaching.	2.79	1.15
Item 12	I become anxious when going online and thinking about teaching a math lesson.	2.16	1.05
Item 13	I become anxious when investigating online tools (or applications) to support my teaching of mathematics.	2.14	1.04
Item 14	I become anxious when I assess my students' learning during online teaching.	2.07	1.06

Note: SD indicates standard deviation.

are presented in Table 1. We also administered a demographic information questionnaire to obtain information about various characteristics, such as the number of methods courses completed.

In terms of data analysis for the anxiety study, we responded to the third and fourth research questions ("What are the math teaching anxiety levels of PSTs?" and "Are there significant relationships among math teaching anxiety and their educational backgrounds such as the number of methods courses completed so far?") by administering the MTA scale to 43 PSTs before the eight-weeks of the OLS during Fall 2020 as pre-OLS survey data. For the third research question asking PSTs' math teaching anxiety levels, we examined descriptive statistics. For the fourth research question asking the relationships among their educational backgrounds, such as grade levels, we compared correlations among the variables. To answer the fifth and last research question ("Is there a significant relationship regarding PSTs' math teaching anxiety levels before and after eight-weeks of the OLS?"), we administered the same MTA scale to 27 PSTs after the OLS and compared those 27 PSTs' math teaching anxiety before and after the eight-weeks of the OLS by applying paired sample t-tests. Moreover, we compared PSTs' math teaching anxiety across grade levels using independent sample t-tests.

2.2.5 Results of the anxiety study

Math teaching anxiety based on pre-OLS survey data.

For the third research question asking PSTs' math teaching anxiety levels, the mean math teaching anxiety score was 30.91 with standard deviation of 10.25. While the minimum score was 14, the maximum score was 54. Thus, it can be said that on average, PSTs had math teaching anxiety from "a little" to "a moderate amount" before the OLS. In Hadley and Dorward's (2011) study with 692 in-service elementary teachers, the mean score for the 12-item survey was 21.55 with standard deviation of 7.41, indicating that the PSTs in the present study had higher math teaching anxiety than those teachers. The MTA scale items are presented in Table 1 with item mean and standard deviation.

Based on Table 1, most of the MTA scale items (11 of the 14 items) had item means over 2.00, indicating higher anxiety responses than the teachers in Hadley and Dorward's (2011) study, which had only four of 12 items with item means over 2.00. The highest anxiety response was 2.79 for the item "I become anxious when my supervisor or mentor teacher evaluates my performance during a math lesson I am teaching." This indicates that PSTs experienced highest math teaching anxiety when their university supervisors or mentor teachers observed and evaluated their teaching.

Relationships among several variables based on pre- OLS survey data.

To answer the fourth research question, Table 2 presents the relationships among several variables, including the number of whole class teaching hours; the number of online class teaching hours; the number of mathematics courses completed; the number of methods courses completed; the number of general education courses completed; and GPA. Based on Table 2, math teaching anxiety was only significantly correlated with the number of methods courses completed ($r = -.34$, $p < .05$). This indicates that PSTs who had completed more methods courses during their teacher preparation program had significantly less math teaching anxiety. However, there was no significant relationship between math teaching anxiety and the number of mathematics courses (e.g., analytical geometry), or the number of general educa-

Table 2 Correlations among several variables based on pre-OLS survey data (N=43)

	MTA	Whole Class Hours	Online Class Hours	# of Math Classes	# of Methods Classes	# of Edu Classes	GPA
MTA	1	−0.15	−0.05	−0.02	−0.34*	−0.18	0.04
Whole Class Hours		1	0.30	0.10	0.35*	0.24	−0.07
Online Class Hours			1	0.06	0.20	0.15	0.19
# of Math Classes				1	0.59**	0.73**	0.57**
# of Methods Classes					1	0.66**	0.42**
# of Edu Classes						1	0.65**
GPA							1

Note: MTA=Math Teaching Anxiety; # = number; *$p<.05$, **$p<.01$

Table 3 Paired sample t-tests across grade levels based on pre-OLS survey and post-OLS survey

	MTA Pre-OLS survey	MTA Post-OLS survey
First year PSTs	23.86	25.29
Mean	3.58	($p=.62$)
SD	7	5.59
N		7
Third year PSTs	35.18	37.18
Mean	8.81	($p=.38$)
SD	11	9.61
N		11
Fourth year PSTs	28.11	33.33
Mean	9.98	($p=.09$)
SD	9	12.94
N		9
All PSTs	29.89	32.82
Mean	9.28	($p=.053$)
SD	27	10.85
N		27

Note: PST=preservice teachers; SD=standard deviation; MTA=Math Teaching Anxiety; *$p<.05$

tion courses (e.g., classroom management) completed so far. Similarly, there was no significant relationship between PSTs' internship experience based on the number of whole class or online teaching hours and their math teaching anxiety. This indicates that PSTs' completing more mathematics courses or general education courses and their having more teaching experience were not significantly related to their math teaching anxiety.

Math teaching anxiety during eight-weeks of the OLS

For the fifth and last research question asking whether there was a significant relationship regarding PSTs' math teaching anxiety during eight-weeks of the OLS, we applied paired sample t-tests for the 27 PSTs who completed both pre-OLS and post-OLS surveys. We found that first-, third-, and fourth-year PSTs' math teaching anxiety did not significantly change during the OLS. This indicates that the OLS did not contribute to a decrease in math teaching anxiety (see Table 3 for means and standard deviations across grade levels).

Finally, we compared PSTs' math teaching anxiety across grade levels for both pre-OLS and post-OLS survey data using independent sample t-tests (see Table 3 for mean scores). We found that third-year PSTs had significantly higher math teaching anxiety than first-year PSTs based on both pre-OLS ($p = .01$) and on post-OLS surveys ($p = .01$). Moreover, no significant difference existed between first- and fourth-year PSTs' math teaching anxiety based on both pre-OLS ($p = .30$) and post-OLS ($p = .15$) results. Similarly, there was no significant difference between third- and fourth-year PSTs' math teaching anxiety based on both pre-OLS ($p = .11$) and post-OLS ($p = .46$) data.

3 Discussion and conclusions

As stated at the outset, we founded the OLS as a means for overcoming the internship problem of PSTs and increasing the quality of internship practices through opportunities of 'teaching' experience during the pandemic period. In addition to providing PSTs teaching experience by working with real middle school students, the OLS enabled teacher educators and experienced teachers to work and collaborate as supervisors so that PSTs received continuous feedback during planning, teaching, and reflecting practices. The present research, consisting of two studies, investigated PSTs' experiences at the OLS and the possible effects of such experiences on their math teaching anxiety. For the experience study that examined PSTs' experiences in the OLS, the qualitative analysis of PSTs' written answers indicated that the OLS provided a very productive environment for all PSTs, especially for fourth- and first-year PSTs. Their written answers mainly differentiated in their conception of how supervisors contributed to their learning. This experience provided opportunities for all PSTs' to become more independent, taking ownership of teaching while planning and implementing the lessons within a teamwork. Most of the PSTs reported they benefited from online support they received through moderator chat boxes which might be thought of as post-modern version of giving spontaneous feedback by experienced teachers.

In addition, as indicated from PSTs' answers to the survey questions, different groups of PSTs worked together as a team and were supported with many supervisors. Therefore, this OLS was an opportunity to build a learning community which had been difficult to do in the physical face-to-face internship model. Lesson planning, technology integration to plans and lesson implementations were also great opportunities and PSTs experienced these opportunities in more focused ways compared to the face-to-face internships. These features are new and insightful additions to laboratory school settings and play important roles in PSTs' learning of the profession.

The purpose of the anxiety study was to examine PSTs' math teaching anxiety levels, to explore the relationships between math teaching anxiety and educational backgrounds, and to understand how PSTs' math teaching anxiety changed during eight-weeks of the OLS. The results revealed that on average, PSTs had math teaching anxiety from "a little" to "a moderate amount" degree before the OLS and their math teaching anxiety did not significantly change during the OLS. In particular,

PSTs experienced highest math teaching anxiety when their university supervisors or mentor teachers observed and evaluated their teaching. This result reveals a need to find alternative ways to evaluate PSTs' performance in teacher preparation programs. Similarly, in a recent study that examined anxiety perceptions and experiences of 76 students who studied part-time at a distance and enrolled in an undergraduate, online module of a university, anxiety was common among the students and fear of negative evaluation was one of the causes for anxiety (Hilliard et al., 2020). Regarding the relationships between math teaching anxiety and educational backgrounds, math teaching anxiety was only significantly correlated with the number of methods courses completed so far. This indicates that math methods courses rather than PSTs' teaching experience opportunities at the OLS contributed to a decrease in math teaching anxiety. Previous studies reporting that math methods courses were helpful for decreasing math anxiety levels of elementary PSTs (e.g., Gresham 2007; McGlynn-Stewart, 2010; Olson & Stoehr, 2019; Stoehr & Olson, 2021; Tooke & Lindstrom, 1998), were confirmed by results we obtained, showing that math methods courses were indeed helpful for decreasing math teaching anxiety levels of PSTs. Therefore, as aligning with Olson and Stoehr's (2019) suggestion about math anxiety, providing PSTs opportunities in methods courses to share their personal stories about teaching mathematics and how to deal with these stories might be helpful for decreasing math teaching anxiety levels.

Finally, we found that third-year PSTs had significantly higher math teaching anxiety than first-year PSTs both before and after the OLS. Although taking more math methods courses contribute to less math teaching anxiety, being responsible for teaching in the OLS seems to increase third-year PSTs' math teaching anxiety levels. This may be expected as it was the first semester that third-year PSTs were required to plan and experience online teaching and they mostly reported being challenged by the teaching experience in the OLS, based on the results of the experience study. In this way, results of the qualitative analysis of the PSTs' views on OLS in the experience study provided insights into interpreting the results of the anxiety study, which indicated the gap between math teaching anxiety levels among different cohorts. Considering the fact that our research had relatively small sample size, especially for the anxiety study, future studies should continue to examine PSTs' math teaching anxiety levels with larger samples by considering the context and PSTs' views and experiences. For the future implementations, third- year and fourth-year PSTs' responsibilities may also be reconsidered. As suggested by both qualitative and quantitative results, the beginning of third year might be too challenging for PSTs to take on the full responsibilities of a teacher and lead to increase math teaching anxiety levels. Lastly, online teaching experience requires PSTs to use technology such as guiding students on a Nearpod activity, asking students to draw geometric figures using Geogebra software, or evaluating students' performance at the end of the class through Socrative. Therefore, a further direction for future work would be to compare how PSTs' competencies for using technology might be related to their math teaching anxiety levels.

All in all, PSTs recommended this experience to their peers and also suggested having part of the internship experience online even if things go back to pre-pandemic normal. Future implementations of OLS may be adjusted based on the survey

results, such as considering developmental strengths and weaknesses of PSTs. The supervisors' role was also proven to be an important feature of the laboratory school. The survey results indicated that there were differences among supervisors in how they provided feedback through moderator chat box or how PSTs felt about the support they received. We can suggest that there should be some common practice that supervisors use in terms of how to support PSTs during online teaching and how to evaluate them after the teaching. In addition, even though all supervisors had experiences of giving feedback in physical face-to-face internship settings, we can suggest that there should be adaptations to giving feedback practices in online and laboratory settings, the main one being how to give spontaneous, in the moment support during teaching sessions.

This study provided insights both on the PSTs' views on their experiences related to professional learning and math teaching anxiety in the context of a uniquely designed online internship. Future research is needed to focus on and assess professional learning of PSTs and the depth of integration of technology as evident in their teaching and planning as a result of participating in the OLS.

Declarations

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