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Developing Preservice Teachers' TPACK Through a Virtual Number Talks Field Experience: A Case Study

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Field experiences are an important part of preservice teacher education. However, interruptions caused by the COVID-19 pandemic and the sudden shift to virtual and hybrid learning presented challenges for implementing classroom-based field experience opportunities. In response to this challenge, the authors developed and implemented a virtual field experience based on the Number Talks routine in our elementary mathematics methods courses. We utilize case studies to explore the technological, pedagogical, and content knowledge (TPACK) development of two preservice teachers as they engaged in the Virtual Number Talks field experience.

Keywords: TPACK, field experience, virtual education, preservice teacher education, elementary mathematics education.

Introduction and Focus

In Fall 2020, schools across the United States were in a time of great instability due to the COVID-19 pandemic, with schools shifting between remote, hybrid, and in-person instruction. Mathematics teacher education was also at a time of great instability as in-person, school-based field experiences were no longer available to preservice teachers. In response to this challenge, the authors collaborated with other teacher educators to develop a Virtual Number Talks Teacher Learning Cycle (Joswick et al., 2020). The authors implemented this virtual mathematics field experience in their preservice mathematics methods courses in Fall 2020. For this study, we explore the following question: How does a virtual field experience based on the Number Talks routine develop preservice elementary teachers' technological, pedagogical, and content knowledge (TPACK)? The authors utilize case studies to illustrate examples of TPACK development as two preservice teachers engaged in the Virtual Number Talks field experience.

Background and Relevant Literature

Field experiences provide preservice teachers with opportunities to “observe and work with real students, teachers, and curriculum in natural settings (i.e., PK-12 schools)” (Huling, 1998). Due to the COVID-19 pandemic, teacher educators had to develop flexible field experiences that could be implemented in virtual or hybrid classrooms. For example, Zolfaghari et al. (2020) employed the use of multi-perspective 360 videos to provide a virtual preservice teacher field experience. Evagorou et al. (2020) shifted a conventional science, technology, engineering, and mathematics fair to a virtual delivery using technology to provide preservice teachers with this field experience while schools were shuttered. Number Talks were selected as the focus of our virtual field experience due to the structure, content, and length of the routine. A Number Talk is a short activity—usually 5 to 15 minutes long—during which a teacher facilitates a discussion with a whole class or a small group of students about a carefully designed sequence of problems (Parrish, 2010). Students solve problems mentally and the

teacher facilitates dialogue about students' strategies with open ended questions. The teacher records student thinking on the board using equations and visual models to help students consider others' ideas and make connections between strategies and representations (Parrish, 2010; Sun et al., 2018).

Number Talks are implemented in classrooms to achieve several important goals: to help students develop number sense and understanding of numerical relationships (Sun et al., 2018) and to shift focus towards making sense of strategies and away from a singular focus on solutions (Parrish, 2010). By centering students' thinking, Number Talks contribute to the development of a community of mathematics thinkers, doers, and learners in which "mathematical authority" is no longer held solely by the teacher and is instead shared among students (Lambert et al., 2017).

The US National Council of Teachers of Mathematics (2014) has identified a framework of essential teaching practices that stimulate meaningful mathematics learning: "establish mathematics goals to focus learning, implement tasks that promote reasoning and problem solving, use and connect mathematical representations, facilitate meaningful mathematical discourse, pose purposeful questions, support productive struggle in learning mathematics, build procedural fluency from conceptual understanding and elicit and use evidence of student thinking" (p. 10). Number Talks were chosen as the focus of our virtual field experience due to the potential for preservice teachers to engage in these essential mathematics teaching practices while facilitating virtual instruction.

Theoretical Framework: Technological, Pedagogical, and Content Knowledge

Built on Shulman's (1987) conceptualization of pedagogical content knowledge, Mishra and Koehler (2006, 2009) introduced the TPACK framework to account for the knowledge that must be developed for effective teaching practice given considerable technological change. The framework identifies the complex relationships that exist from the interactions between content, pedagogical, and technological knowledge for effective teaching practice (see Figure 1). Utilization of the framework, in a theoretical sense, provides a method of communicating the presence or absence of connections between content, pedagogy, and technological knowledge (Mishra & Koehler, 2006).

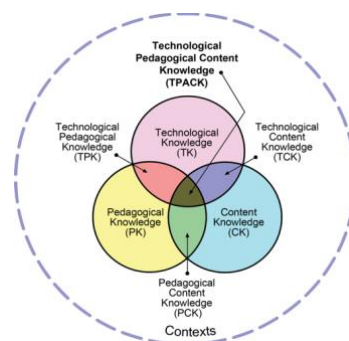


Figure 1: TPACK framework, reproduced by permission of the publisher, © 2012 by tpack.org

Pedagogical and content knowledge components of TPACK used in Number Talks can be categorized into the subdomains of mathematical knowledge for teaching (MKT, Ball et al., 2008). Common content knowledge (Hill & Ball, 2009) of school mathematics serves as the knowledge base needed to facilitate a Number Talk. Teachers need specialized mathematical knowledge (Hill & Ball, 2009) to record number relationships and operations using various visual models during Number Talks.

Knowledge of content and students is needed to anticipate and interpret students’ strategies, to be aware of common developing (mis)conceptions or points of confusion, and to make sense of nonstandard strategies (Ball et al., 2008). Knowledge of content and teaching (Ball et al., 2008) is needed in Number Talks to select appropriate tasks and to choose in the moment which representations to use, which strategies to explore deeply or save for later, and which probing questions to ask to best support students’ sense making. When facilitating Number Talks virtually, teachers must use their pedagogical and content knowledge and the subdomains of MKT to purposefully select and use technological tools to meet the mathematical goals of the Number Talk.

Methodology

Scientific and Cultural Context

Number Talks have become increasingly common in classrooms in the US as teachers have begun to incorporate the US Standards of Mathematical Practice, such as “make sense of problems and persevere in solving them, reason abstractly and quantitatively, and construct viable arguments and critique the reasoning of others” (NGACBP CCSSO 2010), into daily instruction. However, due to the COVID-19 pandemic and the switch to emergency remote instruction, much of the progress made in shifting mathematics teaching towards conceptual understanding and sense making came to a halt. Schools were forced to put together emergency remote instructional materials in a matter of weeks or even days, and many did so with packets of rote exercise worksheets and videos of direct instruction. As mathematics teacher educators, we sought to offer a field experience that translated best practices in mathematics teaching and learning into the digital environment.

Development of a Teacher Learning Cycle for the Virtual Number Talks Field Experience

The Association of Mathematics Teacher Educators’ (2017) Standards for Preparing Teachers of Mathematics calls for teacher preparation programs to incorporate practice-based experiences that “develop core pedagogical practices and pedagogical content knowledge for teaching mathematics” (Indicator P.3.4.). To provide such a field experience while many schools were operating remotely, we created a Teacher Learning Cycle (TLC) in which preservice teachers learned about and engaged in Virtual Number Talks (Joswick et al., 2020). The TLC was developed using Teacher Education by Design’s (University of Washington, 2014) learning cycle and includes four phases: learn, plan, implement, and reflect (see Figure 2).

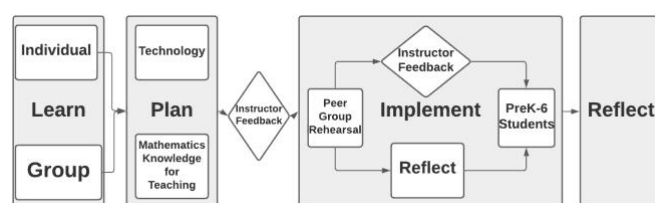


Figure 2: Teacher learning cycle for the Virtual Number Talks Field Experience

Setting and Participant Selection

The Virtual Number Talks Teacher Learning Cycle field experience was implemented in two sections of an elementary mathematics course taught at a university in the northeastern United States in Fall

2020. The course was a requirement for a master's degree in Elementary Education. 29 students, most of whom were preservice teachers, were enrolled between the two sections of the course. Of the 29 students enrolled, 21 students gave permission for their course assignments to be analyzed for research purposes. Most students took the course in the semester prior to their student teaching semester. The course was taught as a fully online course. Many students were working as school-based interns while enrolled in the course. Internship modalities ranged from fully online to hybrid and shifted during the semester due to changes in local COVID situations. Purposeful sampling was utilized to select "information-rich cases" (Patton, 1990, p. 169) to learn about the potential for TPACK development through the Virtual Number Talks field experience. In this paper, we chose to focus on two students, Tatum and Skyler, as illustrative cases (Yin, 2009) because they represented a range of prior teaching experience and prior technological knowledge and because they each demonstrated change over time in their knowledge of various elements of the TPACK framework.

Demographic Data: Tatum and Skyler

Tatum was a preservice teacher who worked for three semesters as an intern in a suburban public school for grades K-4 at the time of the project. Tatum completed the mathematics methods course and Virtual Number Talks Teacher Learning Cycle in their second year of an elementary education Master of Arts program during the fall semester before student teaching. Tatum had no prior teaching experience outside of their internship placement. Tatum's school was implementing a hybrid model at the time of the project; they completed their Virtual Number Talks Teacher Learning Cycle with three third grade students outside of their internship placement due to videotaping not being permitted at the school. Tatum demonstrated basic general technology knowledge at the start of the course.

Skyler was a preservice teacher who was working as an intern in a suburban public school for grades 3-5 at the time of this project. Skyler was in their fifth year of a five-year integrated Bachelor of Arts/Master of Arts program in elementary education, and they completed their mathematics methods course and the Virtual Number Talks Teacher Learning Cycle in the fall semester prior to student teaching. She previously worked as a paraprofessional in a summer school program for grades 9-12. Skyler completed their Virtual Number Talks Teacher Learning Cycle with three third grade students from their internship. Their school was implementing a hybrid cohort model at the time of the project. Skyler was adept at using newer technological tools and demonstrated more advanced technology knowledge at the start of the course.

Analysis

In a deductive approach and prior to analysis, *a priori* codes were developed from the three foundational areas of the TPACK framework. A code book containing these *a priori* codes along with their respective definitions from the existent literature was created to assist the analysis, create a consensus among coding members of the research team, and "maximize coherence among codes" (Creswell & Creswell, 2018, p. 199). Data sources for analysis existed in the form of nine assignments related to Number Talk learning, planning, implementation, and reflection completed by student participants throughout the semester. Each data source was then read and coded by members of the research team to the corresponding *a priori* codes. As a peer-debrief (Creswell & Creswell, 2018), members of the research team discussed themes emerging within the data for consistency,

verification, and discrepancies. Validity in qualitative research is identified as one of its methodological strengths and was achieved through the triangulation of themes among the multiple data sources (Creswell & Creswell, 2018), discussion of discrepant codes, and peer-debriefing.

Results

Tatum: Developing Technological Knowledge and TPACK

Tatum demonstrated growth in their technological knowledge as they moved through the components of the teacher learning cycle from planning to rehearsing to implementing their Virtual Number Talk. Though Tatum practiced their use of technology tools during the rehearsal of their Virtual Number Talk with peers, he experienced technical difficulties when working with children. In their reflection on their first Number Talk, Tatum discussed their technical difficulties and the need to practice the use of technology tools simultaneously.

In the beginning, I think that it was working well, but there was a time where I wasn't sure how to move from slide to slide from my screen in Zoom. I think that I should troubleshoot my number talk with all of my technology instead of both separately. It worked well during my rehearsal, but not as smoothly with my actual number talk. (Assignment 6, Reflection on first Virtual Number Talk)

In their final reflection after conducting two Virtual Number Talks, Tatum reflected on the growth of their technological knowledge through the peer rehearsal assignment and the benefit of teaching with technological tools.

After our rehearsal and hearing back from my peers, I was able to use controls in the Zoom toolbar to use as ways the students can show me what they're thinking. I also was able to fine tune how to use PowerPoint as a constructive tool to make the virtual lesson feel more like an in-class lesson. (Assignment 9, Final Reflection after conducting two Virtual Number Talks)

Beyond simply learning how to use technological tools, Tatum's knowledge of using technological tools for specific pedagogical purposes in mathematics teaching showed significant development. For both Number Talks, Tatum showed images of dots, asking students to share how many dots they saw and to describe their strategies (see Figure 3). In their first Virtual Number Talk, Tatum showed dot images by screen sharing a PowerPoint but otherwise focused the activity on a verbal discussion.

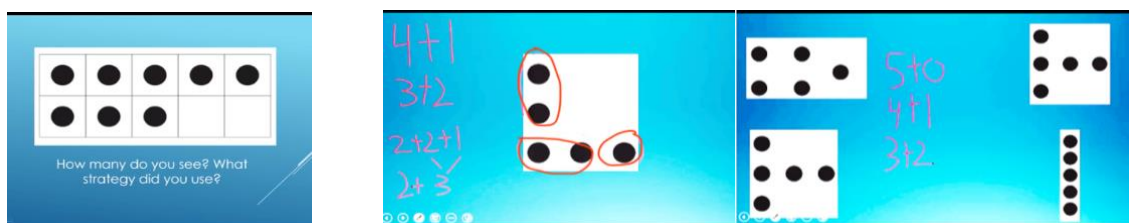


Figure 3: Images from Tatum's first (left) and second (middle and right) Virtual Number Talks

In their second Virtual Number Talk, Tatum once again showed dot images by screen sharing a PowerPoint, but this time used the pen tool to record on the screen throughout the conversation. By circling dots and writing equations to record student thinking, they made children's mathematical ideas visible to one another (see Figure 3). They closed the conversation by showing a slide with all

of the dot images from the Virtual Number Talk, using the pen tool as they facilitated a conversation about connections across the dot configurations showing different ways to decompose the number 5, demonstrating the knowledge of content and teaching subdomain of MKT (Ball et al., 2008).

Skyler: Developing Pedagogical Content Knowledge and TPACK

As Skyler engaged in the Virtual Number Talk Teacher Learning Cycle, they demonstrated growth in their both pedagogical content knowledge and TPACK. Skyler focused their first Number Talk on dot patterns, facilitating an exploration of composition and decomposition of small numbers with their students. For their second Number Talk, they focused again on number composition and decomposition, but this time through a series of double-digit addition problems, a significantly more challenging task to facilitate. Skyler's recording of student thinking at the start of their second Number Talk was disconnected from place value. She honored students' thinking by typing what children said verbatim, but they did not ask any follow up questions about the value of the digits being added in the tens place. In a discussion board post early in the teacher learning cycle, Skyler stated the following, "I know in my experiences as a child and adult I have always had a harder time with auditory/nonvisual problems. Once the teacher wrote the problem and strategy on the board it was easier to follow along" (Assignment 2, learning about Number Talks and discussing with peers). Though Skyler recognized the importance of making mathematical ideas visible for children, their use of technological tools did not allow them to achieve the mathematical goal or support student sense making.

Midway through their second Number Talk, Skyler stopped typing students' explanations on virtual sticky notes and started recording using the pen tool. In doing so, Skyler began to "mathematize" the children's thinking by connecting their verbal explanations to mathematical equations, demonstrating specialized mathematics knowledge, knowledge of content and students, and knowledge of content and teaching subdomains of MKT (Ball et al., 2008). Through their recorded equations, Skyler highlighted the place value understanding inherent in the student's partial sums strategy. Skyler's in-the-moment shift in their use of technology tools, shown in Figure 4, made one student's mathematical thinking accessible to the other children and helped them to focus the discussion on important place value concepts, demonstrating a significant development in their TPACK skills.

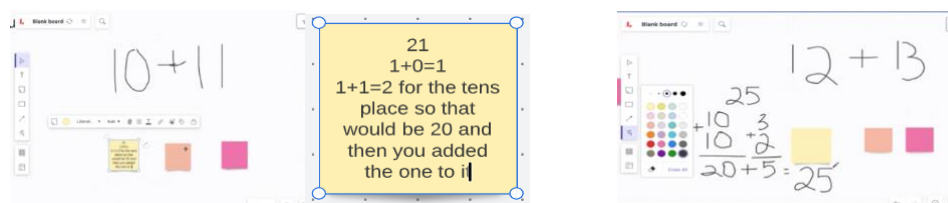


Figure 4: Images from the start of Skyler's second Virtual Number Talk (left and middle) versus the end of the Number Talk (right)

Benefits and Challenges of Virtual Number Talks as a Virtual Field Experience

There were several benefits to using Number Talks as a virtual field experience for preservice teachers. Virtual Number Talks allowed for maximum flexibility of implementation in terms of group size, content, and student location, creating access to teaching experiences for preservice teachers who were not able to enter schools due to COVID-19. While many classrooms shifted to videos of

direct instruction and worksheets of practice problems at the start of the pandemic, Virtual Number Talks provided preservice teachers the opportunity to facilitate a mathematical conversation with students, creating windows into student thinking that many of our students had not experienced previously. Planning for and facilitating Virtual Number Talks also aided preservice teachers in developing and practicing their technological pedagogical content knowledge (Koehler, & Mishra, 2009) as they learned to utilize technological tools to create and display visual models, record equations and strategies, and facilitate students' thinking, discussions, and learning in the virtual classroom.

There were also challenges in implementing the Virtual Number Talks field experience for preservice teachers. New privacy concerns have arisen from K-12 virtual instruction, which prevented some preservice teachers from being permitted to facilitate or video record instruction within school-based placements. Virtual classroom management, including using conferencing software and tech tools for displaying and recording models and equations while engaging students online, was challenging for many preservice teachers. Writing on a digital whiteboard space also proved to be difficult for preservice teachers who did not have access to a stylus or touch screen device and had to write with a track pad or mouse, impacting the amount and quality of recording of students' strategies done by preservice teachers during their Virtual Number Talks.

Conclusion

Number Talks contribute to the creation of a mathematics community in which all students' contributions are valued. Number Talks also allow for the development of teachers' MKT (Ball et al., 2008) through selecting tasks, anticipating strategies, facilitating discussions, and recording strategies with equations and visual models. Bringing Number Talks to online classrooms helps teachers to maximize limited synchronous class time with a short but effective instructional routine. Through Virtual Number Talks, teachers can leverage technology to provide high-quality learning opportunities that empower students, center students' thinking, and position students as creators of mathematics. To do so effectively, teachers must start with their mathematical goal in mind and use pedagogical and content knowledge, MKT subdomains, *and* technological knowledge to purposefully choose technological tools best suited for the mathematical goal. As a virtual field experience, Virtual Number Talks can allow preservice teachers to develop their technological, pedagogical, and content knowledge (TPACK) as they learn to engage in essential teaching practices, use technology to achieve mathematical and pedagogical goals, and foster a virtual mathematics classroom community.

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