CHALLENGES INFLUENCING SECONDARY MATHEMATICS TEACHER'S TRANSITION TOWARDS TEACHING WITH VIRTUAL MANIPULATIVES

Lindsay Reiten
University of Northern Colorado
lindsay.reiten@unco.edu

To increase teachers' use of virtual manipulatives and tasks within secondary mathematics classrooms and support changes to teachers' instructional practice, this study investigated situational challenges influencing teachers' implementation efforts during the course of a professional development (PD) opportunity. Identified situational challenges included: using Chromebooks, teachers' curriculum resource package, student needs, instructional time/planning, and teachers' collaborators. To promote the success of future PD opportunities, recommendations for acknowledging and embracing the situational challenges are provided.

Keywords: Technology, Instructional Vision, Teacher Education – Inservice / Professional Development

Despite expectations for teachers to use technology to support students' sense making and mathematical reasoning (AMTE, 2017), teachers claim that they are not prepared to use technology effectively in their instruction (Albion, Tondeur, Forkosh-Baruch, & Peeraer, 2015). Effectively teaching *with* technology describes teachers using technology to promote students' development of understanding through communicating and reflecting on mathematics, as well as through using and connecting mathematical representations (Reiten, 2018b). Using an interactive whiteboard and a virtual manipulative (VM) to explore how changing the slope and *y*-intercept of a graph changes its equation is an example of teaching *with* technology. Students reflect and build on possible relationships shared by themselves and peers. Through the use of the VM, they dynamically see the resulting graphs when the equations are changed. A VM is "an interactive, technology-enabled visual representation of a dynamic mathematical object…that presents opportunities for constructing mathematical knowledge" (Moyer-Packenham & Bolyard, 2016, p. 13). Teaching *near* technology describes using technology in a manner that does not promote opportunities for students to communicate, reflect, or connect mathematical representations. Using technology merely as an attention grabber (an example of teaching *near* technology) is a misuse of technology (Suh, 2016).

Though teachers have been encouraged to implement VMs for decades (e.g., NCTM, 2000), their use of VMs decrease as students get older (Moyer-Packenham & Westenskow, 2013). To increase teachers' use of VMs and tasks within middle and high school mathematics classrooms and support changes to teachers' instructional practice, this study investigated a targeted professional development (PD) opportunity aimed at supporting teacher learning (Driskell et al., 2016). To promote the success of future PD opportunities, this study investigated situational challenges teachers experienced (Yamagata-Lynch & Haudenschild, 2009) during the course of the PD opportunity that influenced their use of VMs and tasks. Which leads to the question at the core of this study, *what challenges faced the teachers, participating in a targeted PD opportunity, as they transitioned from teaching* near *towards teaching* with *VMs?*

Methods

Fourteen teachers participated in a year-long professional development (PD) opportunity aimed at supporting their use of VMs and tasks aligned with their curricular units (Reiten, 2018a, 2020). Grounded in activity theory (Engeström, 1987), this study investigated the teachers' participation during a PD and their reported practices related to implementing VMs and tasks. Rather than

In: Sacristán, A.I., Cortés-Zavala, J.C. & Ruiz-Arias, P.M. (Eds.). (2020). *Mathematics Education Across Cultures: Proceedings of the 42nd Meeting of the North American Chapter of the International Group for the Psychology of Mathematics Education*, Mexico. Cinvestav / AMIUTEM / PME-NA. https:/doi.org/10.51272/pmena.42.2020

studying teachers' practices in isolation, teachers' reported practices were considered mediated by several factors (e.g., tools and mediating artifacts, community members, rules). Specifically, this study investigated the situational challenges the middle and high school (i.e., secondary) mathematics teachers faced as they transitioned from teaching *near* technology towards teaching *with* technology.

Figure 1 is an example of an activity system in this study. Teachers' conversations and reflections throughout the PD were used to investigate the situational challenges teachers experienced (Yamagata-Lynch & Haudenschild, 2008) as they began shifting their practices towards teaching *with* technology. Situational challenges or tensions (i.e., internal contradictions between and within components of an activity system) are opportunities for growth and learning (Engeström & Sannino, 2010). Interviews with four volunteer teachers (two 6th grade, one 6th/7th intervention teacher/former 8th grade teacher, and one high school teacher) provided insight into teachers' reactions to tools and VM tasks introduced during the PD, teachers' practices (during the PD and their classroom practices related to implementing VM tasks), and teachers' thoughts regarding what supported their implementation efforts.

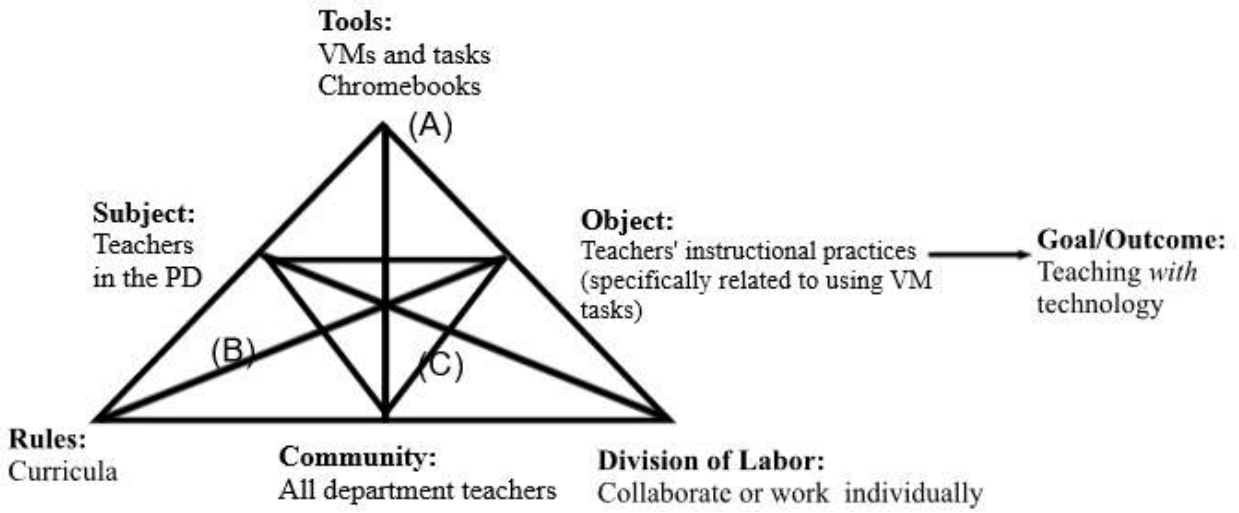

Figure 1: Example of an Activity System and Identified Challenges

The constant comparative method (Glaser & Strauss, 1967) was used as it drew our attention to the situational challenges (tensions) teachers experienced through simultaneous coding and analysis. Transcripts were coded to identify challenges based on what teachers reported (e.g., time, limitations of tools) and contradictions the researcher identified in the data (e.g., use of time during PD). Challenges within the same category were compared and category definitions were refined based on the commonalities and themes between coded data excerpts within the tension category. Data excerpts contained at least a complete sentence, and often consisted of multiple sentences (or small paragraphs) focused on the same topic. The number of data excerpts is provided to give readers a descriptive understanding of the relevance of various tensions.

Findings

Drawing from the ways teachers described using technology in their classroom, findings indicate that at least 11 out of 14 teachers in the PD transitioned towards teaching *with* technology. Initially, teachers reported using technology due to district, parent, and student expectations or because they thought the students may enjoy a particular technology-based task or game. By the end of the PD, teachers were selecting VMs and tasks based on their potential for supporting student understanding (Reiten, 2020). However, as teachers made changes to their practice, they experienced challenges

within and between components of an activity system for the PD (e.g., see *A*, *B*, and *C* in Figure 1). Numbers in parentheses indicate the number of data excerpts for the identified challenge. The most common challenges related to: using Chromebooks (35), their curriculum package (26), student needs (24), use of worktime during the PD (25), and collaborators (22). It is posited that these challenges are relevant to other PD opportunities aimed at supporting teachers to teach with technology as the identified challenges extended beyond the particular technology tool to consider aspects of the teachers' community (e.g., teachers with whom they taught as well as the students in their classroom) and structure of the PD opportunity.

Figure 1 highlights three challenges confronting the eighth grade teachers (i.e., Erin, Mari, Pam, and Stan) in the PD that influenced their implementation of VMs and tasks. Occurring within and across components of an activity system for the PD, challenges teachers faced as they strove to teach *with* VMs and tasks included *(A)* limitations of the tools, *(B)* their curriculum resource package, and *(C)* their collaborators.

During the November PD session, as the eighth grade teachers were critiquing a VM task, Stan, Mari, and Erin became frustrated. They wanted to either enter specific side lengths for right triangles or have the side lengths always be integers. Neither option was capable with this VM (see *A* in Figure 1*)*. Specifically, Stan said, "I wish that this would be whole numbers. I wish it would stick to whole numbers. 'Cause the decimals, that doesn't even register with ME, [Erin: Right] if those are equal." Due to rounding errors, Stan and Erin thought that some of their students might struggle to identify the pattern in the table, thus feeling uncertain whether this VM would be worthwhile. Due to this challenge (located within the *tools* component), the teachers chose not to implement this particular VM with their students.

The eighth grade team of teachers also found it challenging to integrate VMs and tasks within their instruction due to their curriculum investigations building on each other *(*see *B* in Figure 1*)*. Mari wanted to use a VM to replace an investigation or as a pre-teaching tool with her "lowest students." She was not able to do so because all 8th grade math teachers needed to implement the same thing. Replacing an investigation in one part of the unit with a VM could lead to investigations in the following lessons needing to be modified due to students not having the background information from previous investigations. Specifically, Stan stated, "[w]ith our curriculum, if you were going to use this (the VM), it would have to be in addition to or a summary. Or a reflection. Because otherwise, why do you do investigation one and two? … There's no reason to use Section 3.1, if you're not going to continue on." This situational challenge existed between the *rules* and *object* components of the activity system depicted in Figure 1. Additionally, drawing from his experience with a previous K-12 math leader, Stan was adamant that VM tasks could not replace investigations. Rather they needed to "trust and stick to the curriculum" even when students struggled to understand the investigation (see *C* in Figure 1). This situational challenge existed between the *community* and *object* components of the activity system depicted in Figure 1. Meaning Mari's instructional practices related to implementing a VM task were influenced by teachers in her community (e.g., Stan) beyond her control. Stan's belief in the role of his curriculum resource package as well the curriculum itself influenced if and how he chose to implement a particular VM task.

Discussion and Conclusion

Despite the expectation for secondary mathematics teachers to use technology tools in an effective and innovative way, many teachers report that they are not prepared to do so (Albion et al., 2015). How teachers are supported to teach *with* technology as opposed to *near* technology is an important issue facing the field. Teachers do not work in isolation, rather a variety of components influence their practices related to teaching *with* technology. Ultimately, the situational challenges described earlier influenced teachers' transition towards teaching *with* VMs and tasks. When acknowledged

and embraced, these challenges provide opportunities for teachers to grow in their understanding of how to teach *with* technology tools. When designing opportunities to support teachers to teach *with* technology, the challenges highlighted in this study are important to consider and address.

The following recommendations highlight embracing challenges as opportunities to support teachers' growth rather than as something to be ignored. Because teachers often do not teach in isolation, it is important to address the ways teachers' peers support their integration efforts. When designing PD, intentionally integrating opportunities for collaborators to discuss and recognize personal beliefs related to the role of technology, curriculum, and so forth is important.

To address challenges related to teachers' curricula packages, consider supporting teachers in aligning specific VMs or tasks to their curricular units. Providing examples of VMs or tasks aligned to instructional units may initially support teachers in understanding the different ways tasks may be used in relation to their current curriculum (e.g., supplementing, replacing, or introducing their curricular investigations). Another way to start this process might be to have teachers observe other teachers teaching with technology while implementing the same curriculum. Debriefs after the observations provide additional opportunities to address challenges related to the role of the curriculum in deciding when, how, and why to add in specific technology based tasks. In the case of this PD, teachers were initially provided specific VM tasks aligned to their unit. As the PD progressed, teachers took on the responsibility for selecting VMs and tasks to explore that aligned to their learning goals.

Rather than focusing only on positive aspects or benefits when using a specific technology tool, acknowledging the limitations of a particular tool and potential ways to address the limitations may support teachers' comfortability with the tool. It is especially important to acknowledge how tool limitations may influence students' engagement in the mathematics and strategies for addressing the limitations. In the case of the 8th grade teachers, they chose to not use a VM task due to concerns over whether students would recognize the intended pattern due to rounding errors. Potential strategies for addressing this concern include giving students dimensions of triangles to explore, reviewing with students the influence of rounding errors when squaring decimals, and looking for a new VM. Due to the cumbersome nature for creating triangles with given side lengths, the teachers chose not to use the initial VM and instead explored a different one that allowed students to enter measures of specific leg lengths.

The aforementioned suggestions are in response to the challenges revealed in the examples with the eighth grade teachers. It is important to keep in mind, that teachers may experience the various situational challenges differently compared to their peers. Therefore, we recommend providing opportunities for teachers to see successful integration efforts and reflect on their practice. Furthermore, though the recommendations stem from working with teachers during a PD, we posit these recommendations are important to consider when preparing and supporting pre-service teachers to teach *with* technology.

References

Albion, P. R., Tondeur, J., Forkosh-Baruch, A., & Peeraer, J. (2015). Teachers' professional development for ICT integration: Towards a reciprocal relationship between research and practice. *Education and Information Technologies, 20*(4), 655-673.

Association of Teachers of Mathematics Teacher Educators (AMTE). (2017). *Standards for Preparing Teachers of Mathematics.* Retrieved from https://amte.net/standards.

Driskell, S. O., Bush, S. B., Ronau, R. N., Niess, M. L., Rakes, C. R., & Pugalee, D. K. (2016). Mathematics education technology professional development: Changes over several decades. In M. Niess, S. Driskell, & K. F. Hollebrands (Eds.), *Transforming mathematics teacher education in the digital age* (pp. 107-136). Hershey, PA: Information Science Reference.

Engeström, Y. (1987). Learning by expanding: An activity-theoretical approach to developmental research. Helsinki: Orienta-Konsultit Oy.

Engeström, Y., & Sannino, A. (2010). Studies of expansive learning: Foundations, findings and future challenges. *Educational Research Review, 5*(1), 1-24.

Glaser, B. G., & Strauss, A. L. (1967). The discovery of grounded theory: Strategies for qualitative research. Chicago, IL: Aldine.

Moyer-Packenham, P. S., & Bolyard, J. J. (2016). Revisiting the definition of a virtual manipulative. In P. S. Moyer-Packenham (Ed.), *International perspectives on teaching and learning mathematics with virtual manipulatives* (pp. 3-24). Switzerland: Springer International Publishing.

Moyer-Packenham, P. S., & Westenskow, A. (2013). Effects of virtual manipulatives on student achievement and mathematics learning. *International Journal of Virtual and Personal Learning Environments, 4*(3), 35-50.

National Council of Teachers of Mathematics. (2000). *Principles and standards for school mathematics*. Reston, VA: Author.

Reiten, L. (2018a). Teaching WITH (not near) virtual manipulatives. In E. Langran & J. Borup (Eds.), Proceedings of the Society for Information Technology & Teacher Education International Conference (pp. 1826-1835). Washington, D.C., United States: Association for the Advancement of Computing in Education (AACE). https://www.learntechlib.org/primary/p/182776/.

Reiten, L. (2018b). Teaching WITH (not near) technology. *Mathematics Teacher, 112*(3), 228-235.

Reiten, L. (2020). Why and how secondary mathematics teachers implement virtual manipulatives. *Contemporary Issues in Technology and Teacher Education-Mathematics, 20*(1), 55-84.

Suh, J. M. (2016). Ambitious teaching: Designing practice-based assignments for integrating virtual manipulatives into mathematics lessons. In P. S. Moyer-Packenham (Ed.), *International perspectives on teaching and learning mathematics with virtual manipulatives* (pp. 301-321). Switzerland: Springer International Publishing.

Yamagata-Lynch, L. C., & Haudenschild, M. T. (2009). Using activity systems analysis to identify inner contradictions in teacher professional development. *Teaching and Teacher Education, 25,* 507-517.