THE IMPACT OF A TECHNOLOGY METHODS COURSE ON PROSPECTIVE TEACHER TECHNOLOGICAL AND EPISTEMOLOGICAL BELIEFS

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This study examined the effect of a teaching mathematics with technology course on preservice elementary teachers' (PSETs) and preservice secondary mathematics teachers' (PSTs) beliefs about teaching with technology and beliefs about the nature of learning and teaching mathematics. All preservice teachers enrolled in the methods course engaged in technology lesson rehearsals, critiqued peers' technology lessons, taught a lesson involving technology in an area school, and reflected on that teaching experience. The group of PSTs had larger change values from the initial to final belief questionnaire than the group of PSETs, but both changes were statistically significant. PSETs experienced a statistically significant change from initial to final belief in five out of ten belief categories. PSTs experienced a statistically significant change from initial to final belief in seven out of ten belief categories.

Keywords: technology, preservice teacher education, teacher beliefs

Multi-representational tools (Thurm & Barzel, 2020) currently available to mathematics teachers and their students have many powerful features including interconnected mathematical representations. Many of these tools are free and available, dependent only on an individual's or school's connection to the internet. One example of these tools is Desmos Activity Builder. Users can create an activity consisting of multiple screens each of which can contain mathematical action technologies (e.g., graphing calculator) (Dick & Hollebrands, 2011) as well as conveyance technologies (Dick & Hollebrands) that communicate information from the teacher to students and from students to the teacher while students are engaging in the activity. Nonetheless, despite this easy access to powerful technological tools built for educational purposes teachers have incorporated them into their daily instruction of mathematics in only limited ways (Drijvers, 2019).

Researchers have identified several factors such as the school culture, external assessment policies, teacher knowledge, and teacher beliefs that influence teachers' uptake of these tools (Drijvers, 2019). In this paper we investigate the beliefs of preservice elementary (PSETs) and preservice secondary mathematics teachers (PSTs) at the beginning and end of a unique teaching mathematics with technology course. In this paper we follow Philipp's (2007) definition of beliefs as "psychologically held understandings, premises, or propositions about the world that are thought to be true" (p. 259). The significance of beliefs and their impact on teacher practices regarding technology have not been lost on researchers. For example, there is a growing body of research that teachers with more traditional beliefs tend to deploy technology for low level uses (e.g., offloading calculations or graphing to technology) while those with more constructivist beliefs use technology for high level uses (using technology to develop mathematical ideas) (e.g., Judson, 2006). Thomas and Palmer (2014) surveyed 452 practicing New Zealand secondary mathematics teachers in 2005 and found that 22.4% of teachers mentioned a lack of confidence in using computers and 42.4% of teachers mentioned a lack of confidence in using calculators as obstacles in their implementation of technology. We also know that the relationship between beliefs about technology or mathematics and use of technology are not straightforward (Ertmer, Ottenbreit-Leftwich, & Tondeur, 2015). For instance, teachers may hold both traditional and constructivist beliefs about teaching (Tondeur, Valcke, & van Braak, 2008), hold beliefs with different levels of conviction (Ertmer et al., 2012), and other variables such as the school culture may supersede teacher beliefs (Hennesy, Ruthven, & Brindley, 2005).

Thurm (2018) investigated the connections between teacher beliefs and frequency of use for 160 German teachers in a federal state where technology use is compulsory. Despite the compulsory aspect of technology use in the schools, most participating teachers had little experience with technology. He found that positive beliefs about use of technology to support multiple representations led to significant use of technology in this area. Furthermore, teachers who hold the belief that technology can support discovery of mathematical ideas not only use technology more frequently to support that discovery but also use technology in other areas such as when students practice content. On the other hand, if teachers believed that technology integration was too time consuming it led to a significant lower use in a variety of areas such as discovering and practicing mathematical ideas.

Thurm & Barzel (2020) used a beliefs questionnaire similar to the one in this study with practicing teachers to determine the effect of a professional development program on their beliefs regarding technology and epistemological beliefs. There were 39 teachers enrolled in the professional development with 88 teachers comprising a control group. The experimental group had more positive beliefs after the professional development that were statistically significant in the areas of supporting multiple representations ($p = 0.01$), technology time use ($p < 0.01$), and mindless working ($p < 0.01$). There were no statistically significant effects regarding epistemological beliefs involving the nature of mathematics and the learning of mathematics.

Thurm & Barzel (2022) examined the connections among practicing secondary mathematics teachers' beliefs about technology, epistemological beliefs about mathematics, self-efficacy measures involving technology, and reported uses of technology (e.g., discovery learning). They found three relationships. First, they found connections among beliefs about teaching in more constructivist ways with technology, epistemological beliefs about active learning, self-efficacy beliefs about task design with technology, and modes of technology use involving discovery learning. Second, they found that beliefs about teaching with technology involving multiple representations were not connected to epistemological beliefs or self-efficacy beliefs. Third, they found that epistemological beliefs about the nature of mathematics and teacher beliefs about the risks of technology use were less central concerns for teachers teaching with technology.

Previous research involving single item belief measures have found that a technological methods courses involving field experiences had a statistically significant effect on PSTs and PSETs regarding mathematical action technologies in general and beliefs about computer algebra systems (CAS) in particular (Davis, 2020). However, this study relied on a belief questionnaire that consisted of single item measures that have questionable reliability (Gliem & Gliem, 2003). The beliefs questionnaire used in the current study is rooted in previous research about teachers and technology (e.g., Fleener, 1995) and includes connections to epistemological beliefs which others (e.g., Tharp et al., 1997) have found to be connected to teachers' use of technologies for educational purposes. This questionnaire has been used to primarily investigate practicing teachers' beliefs about technology (e.g., Thurm & Barzel, 2020), thus its use in this study with PSETs and PSTs provides important information about the beliefs of these individuals about technology as well as how those beliefs might be impacted by a unique teaching mathematics with technology course.

Three research questions guided this study.

1. What differences exist between initial and final overall beliefs questionnaire means for individual preservice elementary teachers and individual preservice secondary math teachers after experiencing a teaching mathematics with technology course?
2. What differences exist between initial and final overall beliefs questionnaire means for a group of preservice elementary teachers and a group of preservice secondary math teachers after experiencing a teaching mathematics with technology course?
3. What differences exist across ten initial and final beliefs questionnaire category means for a group of preservice elementary teachers and a group of preservice secondary math teachers after experiencing a teaching mathematics with technology course?

Framework

The beliefs questionnaire used in this study consists of two sub-dimensions: beliefs about teaching mathematics with technology and epistemological beliefs about the nature of learning and teaching mathematics. Based upon previous research involving teacher beliefs and technology the beliefs about teaching mathematics sub-dimensions were broken down into six categories: skill loss (BTT-SL); mindless working (BTT-MW); prior mastery of mathematics by hand (BTT-PM); discovery learning (BTT-DL); multiple representations (BTT-MR); and time requirement (BTT-TR). For instance, previous research has identified that teachers often believe that students must first learn how to perform mathematical procedures with paper and pencil before those procedures are offloaded to technology (Fleener, 1995). The epistemological beliefs sub-dimension was broken down into four categories: nature of mathematics as rules and procedures (EB-RP); nature of mathematics as a process of inquiry (EB-I); learning mathematics through teacher direction (EB-TD); and learning mathematics through active learning (EB-AL). The benefit of this questionnaire is that it uses multi-item categories which do not suffer from reliability issues as is often the case with single item categories (Gliem & Gliem, 2003).

Methods

The questionnaire at the heart of this study was composed of two sub-dimensions, beliefs about teaching mathematics with technology (Thurm, 2017) and epistemological beliefs (Blömeke et al., 2008), each of which used a Likert scale consisting of *strongly disagree, disagree, neutral, agree, and strongly agree.* The questionnaire consisting of both sub-dimensions was administered before the technology methods course began and again at the end of the course. We considered strongly disagree to be a *1*, disagree a *2*, and so on up to strongly agree which had a score of *5*. We reverse scored items that were worded negatively leading to strongly disagree as a *5*, agree as a *4*, and so on. This matches the approach used by Thurm (2020). Previous research has found that the 51 items on the questionnaire exhibit good reliability and validity (Thurm, 2018). We found the mean value for each of the PTs and analyzed them by groups: PSTs and PSETs. We used a dependent two-tailed *t*-test to investigate the statistical significance of differences from initial to final administration of the questionnaire at an alpha level of 0.05. We used a dependent *t*-test as the initial and final belief scores were from the same preservice teacher and we used a two-tailed level of significance to account for the fact that beliefs associated with technology may have increased or decreased. We used *t*-values and the degrees of freedom to calculate effect size (Rosnow & Rosenthal, 2005). There were five degrees of freedom for the PSTs and nine degrees of freedom for PSETs. The dependent *t*-test rests on the assumption that the differences between initial and final beliefs questionnaire scores are normally distributed. Using the Shapiro-Wilk test of normality on belief score differences we found that the total belief questionnaire values for PSTs and PSETs were normally distributed. The belief score differences for all ten categories for the PSETs were normally distributed. For PSTs differences across two categories violated our normality assumptions: BTT-DL and BTT-TR. For these two categories we used the Wilcoxon Signed Ranks test (Field, 2009).

A total of 16 preservice teachers (PTs) participated in this study. Six of them were PSTs while the remaining 10 were PSETs. All teacher names are gender specific pseudonyms. The study took place in a teaching mathematics with technology methods course at a medium sized university in the midwestern portion of the U.S. PTs were considered juniors or seniors with one to two additional semesters of study before beginning their student teaching internships.

The technological methods course where this research took place had several unique features. First, all PTs enrolled in the course had a field experience that involved mathematical action and conveyance technologies. The PTs were either given a lesson involving Desmos Activity Builder or worked with the instructor to create a lesson. Second, PTs rehearsed (Kazemi, Ghousseini, Cunard, & Turrou, 2016) the lesson in the technology methods course and received feedback on lesson design and lesson implementation from other PTs enrolled in the course as well as the instructor. Third, PTs taught the lesson in an area elementary, middle, or high school. Fourth, all PTs reflected on the planning, rehearsal, and field experience involving the lesson in a written assignment. These lessons involved a variety of different mathematics content areas, but always focused on a rich conceptual understanding of mathematics content (Nilsson, 2020).

Results

Table 1 shows the average initial belief score, average final belief score, and change from initial to final belief score by individual PTs in each group. We see that the initial belief scores of the PSETs were higher than the PSTs. The PSETs also had higher final beliefs than the PSTs. The average score on the initial beliefs questionnaire for the PSTs was 3.59 which lies between neutral and agree on the Likert scale. Their final average rating of 4.08 was at the level of agree. The average initial score for the PSETs was 3.84 with the average final score of 4.16. Looking at individual PTs we see that there were three PSTs (Jerry, Matt, and Todd) and three PSETs (Phillip, Sarah, and Kate) that remained below the agree level on the final belief questionnaire. The change from initial to final belief questionnaire score for the group of PSTs was statistically significant ($t = -5.118$, $p = 0.004$) with a large effect size of 0.92. The change from initial to final belief questionnaire score for the group of PSETs was statistically significant ($t = -6.091$, $p < 0.001$) with a large effect size of 0.89.

Table 1: Belief Questionnaire Means – Initial and Final by PT Group

PT	Initial	Final	Change
	PSTs		
Jerry	2.96	3.86	0.90
Julie	3.75	4.04	0.29
Matt	3.37	3.73	0.36
Paula	3.90	4.29	0.39
Joseph	4.08	4.67	0.59
Todd	3.51	3.86	0.35
Item Mean	**3.59**	**4.08**	**0.49**
	PSETs		

Donald	3.98	4.51	0.53
Kevin	3.69	4.08	0.39
Rebecca	4.06	4.29	0.23
Anne	3.84	4.29	0.45
Cathy	3.69	4.16	0.47
Phillip	3.53	3.82	0.29
Karen	3.84	4.29	0.45
Sarah	3.76	3.94	0.18
Kate	3.82	3.84	0.02
Teresa	3.98	4.14	0.16
Item Mean	**3.84**	**4.16**	**0.32**

We also examined the differences by categories for each category as seen in Table 2. The smallest positive change among PSETs was in the nature of mathematics as a process of inquiry. A sample item in this category was the following. *If you engage in mathematical tasks, you can discover new things (e.g., connections, rules, concepts).* It is important to note that even though the change was very small, most of the PSETs had very high initial values in this category with a mean of 4.42. The only drops were from an initial rating of 5 (strongly agree) to a rating of 4 (agree). The second smallest change by PSETs as a group was in beliefs about teaching with technology discovery learning. A sample item in the category was the following. *Technology supports tasks where students can explore new content on their own.* The largest positive change for PSETs was in beliefs about teaching with technology prior mastery of mathematics by hand. A sample item in this category follows. *Technology may only be used by students if the mathematics the technology involves is mastered by them with pencil and paper.* Overall, the category of beliefs about teaching with technology involving multiple representations for the group of PSETs was negative but by a very small amount.

For the group of PSTs, the smallest positive change was in the category of epistemological beliefs: learning mathematics through active learning. A sample item in this category is as follows. *Time used to investigate why a solution to a mathematical problem works is time well spent.* The group of PSTs experienced a small decrease from initial to final belief questionnaire in the category nature of mathematics as a process of inquiry. The largest change for the group of PSTs was in beliefs about teaching with technology prior mastery of mathematics by hand with a movement of agree/neutral to disagree on items such as the following. *Technology may only be used to ease students' procedural work if the procedures are already mastered without technology*.

Table 2: Belief Questionnaire Categories – Initial and Final by PT Group

Belief Category	Group	Initial	Final	Change
BTT-SL	PSET	3.25	3.90	0.65
	PST	3.25	4.08	0.83
BTT-MW	PSET	3.24	3.72	0.48
	PST	2.60	3.40	0.80
BTT-PM	PSET	3.45	4.28	0.83
	PST	2.5	4.13	1.63
BTT-DL	PSET	4.34	4.40	0.06
	PST	4.23	4.63	0.40

Lamberg, T., & Moss, D. (2023). *Proceedings of the forty-fifth annual meeting of the North American Chapter of the International Group for the Psychology of Mathematics Education* (Vol. 2). University of Nevada, Reno.

BTT-MR	PSET	4.50	4.43	-0.07
	PST	4.17	4.74	0.57
BTT-TR	PSET	3.90	4.47	0.57
	PST	4.06	4.56	0.50
EB-RP	PSET	2.65	2.98	0.33
	PST	2.19	2.56	0.37
EB-I	PSET	4.42	4.47	0.05
	PST	4.41	4.30	-0.09
EB-TD	PSET	4.18	4.37	0.19
	PST	3.85	4.25	0.40
EB-AL	PSET	4.33	4.50	0.17
	PST	4.33	4.39	0.06

Table 3 shows the results of the paired *t*-test for each belief category for each group of PTs. We found that among the PSETs, five out of ten of our category changes were statistically significant at the 0.05 level. This included the following categories: BTT-SL; BTT-MW; BTT-PM; BTT-TR; and EB-RP. All these statistically significant values had large effect sizes of greater than 0.60 (Rosnow & Rosenthal, 2005). For the group of PSTs, changes from the initial to final belief questionnaire in the following categories were statistically significant: BTT-SL; BTT-SW; BTT-PM; BTT-MR; EB-RP; EB-I; and EB-TD. Recall that two category differences were not normally distributed so we used the Wilcoxon Signed Ranks test to examine their statistical significance. Neither the BTT-DL ($Z = -1.947$, $p = 0.052$) nor BTT-TR ($Z = -1.890$, $p = 0.059$) category differences for the PST group were statistically significant.

Table 3: Paired Samples t-tests For Each Category and Group

Belief Category	Group	t	Significance	Effect Size
BTT-SL	PSET	-3.788	$p = 0.004$	0.78
	PST	-5.000	$p = 0.004$	0.91
BTT-MW	PSET	-6.018	$p < 0.001$	0.89
	PST	-4.297	$p = 0.008$	0.89
BTT-PM	PSET	-2.984	$p = 0.015$	0.71
	PST	-7.050	$p < 0.001$	0.95
BTT-DL	PSET	-0.669	$p = 0.520$	0.22
	PST	--	--	--
BTT-MR	PSET	-.302	$p = 0.770$	0.10
	PST	-2.646	$p = 0.046$	0.76
BTT-TR	PSET	-3.431	$p = 0.008$	0.75
	PST	--	--	--
EB-RP	PSET	-2.410	$p = 0.039$	0.63
	PST	-3.081	$p = 0.027$	0.81
EB-I	PSET	-.474	$p = 0.647$	0.16
	PST	2.712	$p = 0.042$	0.77
EB-TD	PSET	-1.449	$p = 0.181$	0.43

	PST	-3.230	$p = 0.023$	0.82
EB-AL	PSET	-1.342	$p = 0.213$	0.41
	PST	-.674	$p = 0.530$	0.29

Discussion

This study is a unique contribution to the preservice teachers' beliefs about teaching with technology body of research. It used a belief questionnaire with two sub-dimensions and a total of ten categories, each of which consisted of multiple items resulting in greater reliability and validity than single item measures (Gleim & Gleim, 2003). Moreover, this belief questionnaire had only been used with practicing teachers up to this point (e.g., Thurm & Barzel, 2022). In this study, we saw that PSETs had higher initial beliefs than PSTs in nearly every belief category except two: beliefs about teaching with technology – skill loss (BTT-SL) and learning mathematics through active learning (EB-AL). We conjecture that this may have to do with their university preparations up to the point of this technology methods course. The group of PSETs complete five mathematics courses that are taught using an active learning approach where students work in cooperative groups, engage in sense making, and discuss different mathematical approaches with their classmates. The group of PSTs, on the other hand, experienced at least five upper-level mathematics courses where the primary instructional routine was teacher lecturing and student notetaking.

In terms of sub-dimensions, there was greater change for both groups around beliefs about teaching with technology. In the sub-dimension of epistemological beliefs, both groups of preservice teachers experienced statistically significant changes in the category of the nature of mathematics as consisting of rules and procedures. We conjecture that this change occurred for both groups due to the focus of the teaching mathematics with technology course. Recall that while the lessons covered a range of different mathematics content areas from elementary through upper high school, these lessons focused on rich conceptual understanding (Nilsson, 2020) and less on using technology to teach procedures (Drijvers, 2015). While PSETs experienced reform-oriented or active learning of concepts in their mathematics courses before the course at the center of this study those courses did not focus on specifically using technology in the learning or teaching of concepts. For PSTs, technology was not used to learn concepts in their upper-level mathematics courses. Thus, it is not surprising that both groups experienced change in this category.

Thurm & Barzel (2020) found statistically significant differences in the categories of technology to support multiple representations (BTT-MR), time constraints (BTT-TR), and mindless working (BTT-MW). This study found that there were statistically significant differences in these areas for various groups of PTs in this study. There were statistically significant differences for PSTs in the category of BTT-MT, PSETs in the category of BTT-TR, and both groups in the category of BTT-MW.

As mentioned earlier, the teaching mathematics with technology course provided all students with a field experience in neighboring elementary, middle, and high schools. Many of the cooperating teachers that we worked with in these schools were former students of the instructor of the course (first author) who had completed technology beliefs surveys in earlier versions of the technology course. When the first author observed these former students' lessons involving technology, it was typically not used to develop students' conceptual understandings, nor was it used in dynamic ways as it was used in the technology course. These informal observations suggest that either other factors such as the school environment or teachers' experiences after the technology course had altered or superseded their previously strong beliefs about technology. Consequently, further research needs to be conducted to understand the nature of the beliefs of these beginning teachers and the forces that affect these beliefs during their student internship and beginning teaching experiences.

It is difficult to construct an argument that one belief category might be greater than another, but the category with the greatest change was beliefs about teaching with technology prior mastery of mathematics by hand. In addition to the field experiences that all PTs experienced in the course the students enrolled in the course also completed journal writing addressing specific prompts. One of these prompts involved their previous experiences with technology as students in grades K-12 mathematics classrooms. They related stories where they used technology to do mathematics (Drijvers, 2015) after they had learned these procedures with paper and pencil. The significant change in this belief category suggests that the PTs may be willing to disrupt this trend and provide their students with very different experiences than they experienced themselves. Despite this strong change in beliefs, it is important to understand just what types of technology experiences these beginning teachers provide in their mathematics classrooms. Powerful technologies are now prevalent in classrooms, but if teachers do not believe that they contribute to developing students' mathematical understandings they will continue to be underused.

References

Blömeke, S., Müller, C., Felbrich, A., & Kaiser, G. (2008). Epistemologische Überzeugungen zur Mathematik. In S. Blömeke, G. Kaiser, & R. Lehmann (Eds.), *Professionelle Kompetenz angehender Lehrerinnen und Lehrer* (pp. 219–246). Münster: Waxmann.

Davis, J. D. (2020). The effects of a technology course with collaborative design on prospective teachers' knowledge and beliefs. In A. I. Sacristan, J. C. Cortez-Zavala, & P. M. Ruiz-Arias (Eds.), *Mathematics education across cultures: Proceedings of the 42nd meeting of the North American Chapter of the International Group for the Psychology of Mathematics Education* (pp. 2165-2173), Mexico. Cinvestav.

Dick, T. P., & Hollebrands, K. F. (2011). Introduction to Focus in High School Mathematics: Technology to Support Reasoning and Sense Making. In T. P. Dick & K. F. Hollebrands (Eds.), *Focus in high school mathematics: Technology to support reasoning and sense making* (pp. xi-xvii). Reston, VA: National Council of Teachers of Mathematics. New York: Springer.

Drijvers, P. (2015). Digital technology in mathematics education: Why it works (or doesn't). In S. J. Cho (Ed.), *Selected regular lectures from the 12th International Congress on Mathematical Education* (pp. 135-151). London: Springer.

Drijvers, P. (2019). Head in the clouds, feet on the ground – A realistic view on using digital tools in mathematics education. In A. Büchter, M. Glade, R. Herold-Blasius, M. Klinger, F. Schacht, & P. Scherer (Eds.), *Vielfältige Zugänge zum Mathematikunterricht* (pp. 163–176). Springer.

Ertmer, P. A., Ottenbreit-Leftwich, A., & Tondeur, J. (2015). Teacher beliefs and uses of technology to support 21st century teaching and learning. In H. R. Fives & M. Gill (Eds.), *International handbook of research on teacher beliefs* (pp. 403-418). New York: Routledge.

Ertmer, P. A., Ottenbreit-Leftwich, A., Sadik, O., Sendurur, E., & Sendurur, P. (2012). Teacher beliefs and technology integration practices: A critical relationship. *Computers and Education, 59*, 423-435. 10.1016/j.compedu.2012.10.008

Field, A. (2009). *Discovering statistics using SPSS (3rd ed.)*. Los Angeles, CA: Sage.

Fleener, M. J. (1995). A survey of mathematics teachers' attitudes about calculators: The impact of philosophical orientation. *Journal of Computers in Mathematics and Science Teaching, 14*(4), 481-498.

Gliem, J. & Gliem, R. (2003). *Calculating, interpreting, and reporting Cronbach's Alpha Reliability Coefficient for Likert-type scales.* Midwest Research to Practice Conference in Adult, Continuing and Community Education. Columbus, OH.

Hennesey, S., Ruthven, K., & Brindley, S. (2005). Teacher perspectives on integrating ICT into subject teaching: Commitment, constraints, caution, and change. *Journal of Curriculum Studies, 37*(2), 155-192.

Judson, E. (2006). How teachers integrate technology and their beliefs about learning: Is there a connection? *Journal of Technology and Teacher Education, 14*, 581-597.

Kazemi, E., Ghousseini, H., Cunard, A., & Turrou, A. C. (2016). Getting inside rehearsals: Insights from teacher educators to support work on complex practice. *Journal of Teacher Education, 67*(1), 18-31.

Nilsson, P. (2020). A framework for investigating qualities of procedural and conceptual knowledge in mathematics – An inferentialist perspective. *Journal for Research in Mathematics Education, 51*(5), 574-599.
Philipp, R. A. (2007). Mathematics teachers' beliefs and affect. In F. K. Lester (Ed.), *Second handbook of research on mathematics teaching and learning* (pp. 257-315). Charlotte, NC: IAP.
Rosnow, R. L., & Rosenthal, R. (2005). *Beginning behavioral research: A conceptual primer (5th ed.)*. Englewood Cliffs, NJ: Pearson/Prentice Hall.
Tharp, M. L., Fitzsimmons, J. A., & Ayers, R. L. B. (1997). Negotiating a technological shift: Teacher perception of the implementation of graphing calculators. *The Journal of Computers in Mathematics and Science, 16*(4), 551-575.
Thomas, M. O., & Palmer, J. (2014). Teaching with digital technology: Obstacles and opportunities. In A. Clark-Wilson, O. Robutti, & N. Sinclair (Eds.), *The mathematics teacher in the digital era: An international perspective on technology focused professional development* (pp. 71-89). Dordrecht, Netherlands: Springer.
Thurm, D. (2017). Psychometric evaluation of a questionnaire measuring teacher beliefs regarding teaching with technology. In B. Kaur, W. K. Ho, T. L. Toh & B. H. Choy (Eds), *Proceedings of the 41st conference of the International Group for the Psychology of Mathematics Education (Vol. 4, pp. 265-272)*. Singapore.
Thurm, D. (2018). Teacher beliefs and practice when teaching with technology: A latent profile analysis. In L. Ball, P. Drijvers, S. Ladel, H.S. Siller, M. Tabach, & C. Vale (Eds.), *Uses of technology in primary and secondary mathematics education* (pp. 409-419). Cham: Springer.
Thurm, D., & Barzel, B. (2020). Effects of a professional development program for teaching mathematics with technology on teachers' beliefs, self-efficacy and practices. *ZDM, 52*, 1411-1422. https://doi.org/10.1007/s11858-020-01158-6
Thurm, D., & Barzel, B. (2022). Teaching mathematics with technology: A multidimensional analysis of teacher beliefs. *Educational Studies in Mathematics, 109*, 41-63. https://doi.org/10.1007/s10649-021-10072-x
Tondeur, J., Valcke, M., & van Braak, J. (2008). A multidimensional approach to determinants of computer use in primary education: Teacher and school characteristics. *Journal of Computer Assisted Learning, 24*, 494-506. doi: 10.1111/j.1365-2729.2008.00285.x