Preservice and inservice teachers' views on digital tools for diverse learners in mathematics education

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Although teachers are expected to use digital tools in their mathematics teaching in many countries, little is known about preservice and inservice teachers' digital competence, especially in relationship to specific groups of school students. Results from a survey of 394 preservice teachers and 61 inservice teachers, at three Norwegian institutions, provide information on how they considered different digital tools would support differentiated teaching, related to a student's mathematical progress, and in multilingual classes. The results suggest that preservice and inservice teachers evaluated similarly the usefulness of different digital tools for differentiated mathematics teaching and in multilingual classrooms. However, for the majority of tools, the standard deviations indicate that the responses were somewhat spread, suggesting uncertainty in how they could use digital tools to support specific groups of students.

In Norway, incorporating digital tools into teaching at all levels, including in mathematics education, has been a goal since the 2006 curricula reforms (Kunnskapsdepartementet, 2006). Nevertheless, concern has been expressed that teacher education is not providing appropriate support to preservice and inservice teachers about how to incorporate digital tools into their teaching. Søby (2013) in an editorial discussing a report on technology use in schools in Norway, identified that "initial teacher training and in-service training is lagging behind in the digital domain" (p. 189) and would be the biggest challenge to "teaching, learning and creative enquiry" in the following five years. More recently, a survey by Guđmundsdóttir and Hatlevik (2018) of newly-qualified teachers found that nearly half felt their professional digital competency was insufficient and a result of poor initial teacher education. Guđmundsdóttir and Hatlevik (2018) suggested that teacher education has a role in supporting preservice teachers' self-efficacy in using digital tools in their teaching.

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To achieve this aim, teacher educators need to identify the background knowledge and skills that preservice and inservice teachers have when entering these courses so that they can be designed appropriately. This is particularly important when considering recent calls for equity and inclusion to be a focus in mathematics education (Meaney, 2018).

Preservice teachers are often thought to arrive with relevant experiences of digital tools from their own school mathematics, but there is little research to show this is the case (Olando & Attward, 2016). Ten years ago, Lange and Meaney (2011) found that 15 % of preservice primary teachers had very limited, if any, experience with web-based resources for teaching/learning mathematics. In a study of preservice teachers in Turkey, Karatas et al. (2017) found males were much more confident about integrating digital tools into their teaching. They suggested that different experiences outside of the teacher education courses may have contributed to these results. The researchers suggested that a teacher education course should be designed to match the needs of specific groups of preservice teachers.

Although classroom teachers may have more experience teaching with digital tools than preservice teachers, teachers are documented as being resistance to incorporating technology into their teaching (Niess, 2006; Attard & Holmes, 2022). In the Norwegian curriculum, ”digital skills” are situated as one of five ”basic skills”, that are to be included in mathematics lessons (Kunnskapsdepartementet, 2019). New requirements, such as the inclusion of computational thinking and programming into mathematics teaching (Kunnskapsdepartementet, 2019) may increase mathematics teachers' uncertainty about incorporating digital tools in their teaching of different groups of students. Consequently, there is a need to know more about preservice teachers' experience with digital tools prior to and in teacher education and their view of how and when to incorporate digital tools in their own teaching.

As noted by Handal et al. (2013) when discussing inservice teachers' needs, ”identifying current teachers' ICT learning and teaching skills has strategic value for planning professional development programs at both the school and systemic level” (p. 23). Therefore, our research question is: How do preservice and inservice mathematics teachers view different digital tools as supporting the learning of mathematics through differentiated teaching and in multilingual classes? In this article, we define ”view”, following the work of Grudgeon et al. (2009), who provided an overview of several mathematics teacher education courses that incorporated digital technologies, where ”each course was based on assumptions or beliefs about technology in mathematics education related to classroom implementation of technology and teacher preparation. This chapter uses the word ”views” to denote these assumptions or beliefs” (p. 330).

Using digital technologies for differentiated mathematics and in multilingual mathematics classrooms

Incorporation of digital tools, which include different technologies, such as interactive whiteboards, as well as applications such as Scratch, into mathematics education to support diverse students' learning is complex. In research from Sweden, it was found that rather than using digital tools to transform mathematics education, teacher education can reinforce traditional mathematical teaching practices (Player-Koro, 2013).

Integrating digital tools into mathematics teaching for diverse learners has a chequered history. For example, although promoted as being beneficial to mathematical thinking, digital tools rarely produce improvements in results for multilingual students (Ganesh & Middleton, 2006; Libbrecht & Goosen, 2016). Of the limited research available on this topic, multilingual students tended to be considered as a homogenous group, both in regard to their fluency in the language of instruction and the backgrounds they bring to the classroom. An exception is the study by Kim (2018) which identified differences in the effect of ICT, in particular computer use, on students who were first-generation, second-generation immigrant students and non-immigrant students. They found that low-level tasks for practicing school mathematics content had a negative effect on both first- and second-generation immigrant students, whereas computer programming had a positive impact for second-generation immigrant students, when connected to self-efficacy. They also identified that results differed according to the socio-economic status and gender of the students. In research on the use of digital tools for teaching mathematics in Indigenous schools in New Zealand during the covid lockdown, it was found that socio-economic circumstances combined with a lack of digital resources in the Indigenous language, te reo Mãori, resulted in reduced opportunities (Allen & Trinick, 2021). When considered in relationship to Player-Koro's (2013) findings about digital technologies reinforcing rather than transforming mathematics teaching, digital tools can have a negative, rather than a positive effect on multilingual students' learning.

Similarly, although digital apps have been promoted as providing opportunities for differentiated teaching to match students' individual performance levels, there are few research results showing this (Calder, 2015). Attard and Holmes (2022) found that some teachers in their studies valued digital technologies, because it allowed them to provide differentiated learning experiences for students. Pepin et al. (2017) in an overview of studies, found that teachers valued the flexibility from using digital curricula resources, such as digital textbooks, to differentiate their teaching. However, as Kim (2018) noted underperforming students could be restricted to using practice tasks which required limited cognitive engagement. Nevertheless, Guđmundsdóttir and Hatlevik (2018) found that Norwegian, newly-qualified teachers were positive towards ICT contributing to them being able to differentiate their teaching, although they did not investigate what these teachers considered this involved. Similarly, Norwegian teacher educators, in responding to a Likert scale survey, indicated overwhelmingly they considered they were familiar with digital tools for diverse teaching (Madsen et al., 2018). Nevertheless, without clarification on what the teachers meant in these survey results, it is difficult to know exactly how digital tools support differentiated teaching.

TPACK

Teaching mathematics with technology requires coordination of a range of knowledges and skills (Viberg et al., 2020). Following Handal et al. (2013), we chose to base our survey on the components of the technological pedagogical content knowledge (TPACK) model of Mishra and Koehler (2006) (see figure 1). Mishra and Koehler (2006) described a range of technologies, the focus of the model on digital technologies:

> It attempts to capture some of the essential qualities of teacher knowledge required for technology integration in teaching, while addressing the complex, multifaceted, and situated nature of this knowledge. We argue, briefly, that thoughtful pedagogical uses of technology require the development of a complex, situated form of knowledge that we call Technological Pedagogical Content Knowledge (TPCK). In doing so, we posit the complex roles of, and interplay among, three main components of learning environments: content, pedagogy, and technology. (p. 1017)

In collaboration with others, Mishra and Koehler (Schmidt et al., 2009) developed a survey for preservice teachers based on each of the seven components (see figure 1). However, in some research studies, only certain aspects of TPACK have been considered. For example, Zelkowski et al. (2013) only considered technological knowledge (TK), technological content knowledge (TCK) and TPACK in relationship to secondary school mathematics. Zambak and Tyminski (2020) focussed on the TCK of preservice teachers of middle grades using Geometer's Sketchpad. In our study, we focused on the technological pedagogical content knowledge in the centre of the model, but also asked for preservice and inservice teachers' views on the other six components:

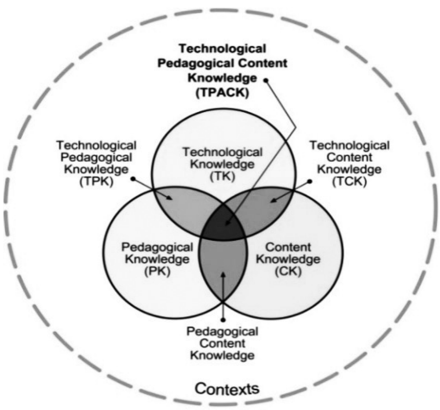

Figure 1. *The components of Mishra and Koehler's (2006) TPACK model*

Content knowledge (CK) is according to Mishra and Koehler (2006) "knowledge of central facts, concepts, theories, and procedures within a given field; knowledge of explanatory frameworks that organize and connect ideas; and knowledge of the rules of evidence and proof" (p. 1026). In mathematics, this would include topics such as algebra or geometry.

Pedagogical knowledge (PK) is "deep knowledge about the processes and practices or methods of teaching and learning and how it encompasses, among other things, overall educational purposes, values, and aims" (Mishra & Koehler, 2006, p. 1026).

Pedagogical content knowledge (PCK) is "knowledge of pedagogy that is applicable to the teaching of specific content. [...] PCK is concerned with the representation and formulation of concepts, pedagogical techniques, knowledge of what makes concepts difficult or easy to learn, knowledge of students' prior knowledge, and theories of epistemology" (Mishra & Koehler, 2006, p. 1026). This would include knowledge about how to teach algebra or geometry.

Technology knowledge (TK) is "knowledge about standard technologies, such as books, chalk and blackboard, and more advanced technologies, such as the Internet and digital video. This involves the skills required to operate particular technologies" (Mishra & Koehler, 2006, p. 1027).

Technological content knowledge (TCK) is "knowledge about the manner in which technology and content are reciprocally related. Although technology constrains the kinds of representations possible, newer technologies often afford newer and more varied representations and greater flexibility in navigating across these representations." (Mishra & Koehler, 2006, p. 1028).

Technological pedagogical knowledge (TPK) is "knowledge of the existence, components, and capabilities of various technologies as they are used in teaching and learning settings, and conversely, knowing how teaching might change as the result of using particular technologies" (Mishra & Koehler, 2006, p. 1028).

Technological pedagogical content knowledge (TPCK) "requires an understanding of the representation of concepts using technologies; pedagogical techniques that use technologies in constructive ways to teach content; knowledge of what makes concepts difficult or easy to learn and how technology can help redress some of the problems that students face; knowledge of students' prior knowledge and theories of epistemology; and knowledge of how technologies can be used to build on existing knowledge and to develop new epistemologies or strengthen old ones. [...] [It] requires a thoughtful interweaving of all three key sources of knowledge: technology, pedagogy, and content" (Mishra & Koehler, 2006, p. 1029). This would include knowing how to use the affordances of different technologies, including different digital tools, to support students learning of mathematical content, such as algebra and geometry.

The survey

An electronic survey was designed by mathematics educators at three tertiary institutes in Norway to gain an understanding of the background of preservice and inservice teachers and their knowledge and opinions about integrating digital technologies into mathematics teaching. There were 90 questions, with most being multiple choice, with potential for the participants to provide extra information. The survey was inspired by questions in earlier surveys (for example, Guđmundsdóttir & Hatlevik, 2018; Handal et al., 2013). In this article, we focus on the questions surrounding multilingual students and differentiated teaching (TPK) and mathematical topics (TCK) and whether there were any differences between the responses of pre- and in-service teachers.

The survey questions that we report on are categorised according to the TPACK model:

- How far were they in their studies?
  This provided us with some details about how far they were in their teacher education

- What did the preservice and inservice teachers consider to be digital tools? (TK)
  Schmidt et al.'s (2009) survey classified similar questions as being about technology knowledge.

- What experience did the preservice and inservice teachers have with digital tools
  - In mathematics from school (TCK)
    From their experiences from school, we presumed that preservice and inservice teachers would have views on how technology could be used to support mathematics learning (Schmidt et al., 2009).
  - Private/leisure time/hobby (TK)
    By understanding what experiences preservice teachers and inservice teachers had out-of-school, we could understand how their knowledge about technology had been gained.
  - In teacher education (TPK)
    In Schmidt et al.'s (2009) a question about preservice teachers' technological pedagogical knowledge was about the teacher education that they had received.

- What were their main pedagogical reasons for integrating technology into their future mathematics classrooms? (TPK)
  The preservice and inservice teachers were also asked to choose two main reasons for integrating technology into their future classrooms regarding pedagogical purposes of digital tools. The choices and results can be seen in table 4. This question was similar to the statements given to preservice teachers in Schmidt et al.'s (2009) survey that were classified as being about technological pedagogical knowledge.

- How did they view the use of different digital tools in mathematics and pedagogical settings? (TPACK)
  Our questions that connected specific digital tools, common in Norwegian classrooms, to different mathematics topics – (1) numeracy, algebra and functions, (2) geometry, spatial understanding and visualization, and the more didactical theme of (3) problem solving, inquiry-based activities and reasoning– and to two pedagogical settings (A) multilingual classrooms and (B) differentiated teaching. We considered that these questions provided more information than the response statements in Schmidt et al.'s (2009) survey.

The participants were asked to rank the different tools from 1 "completely useless" to 5 "very useful" against the five contexts. Those participants who said they were unfamiliar with the digital tools were not asked to answer further questions about this tool. Consequently, the number of responses differed for each digital tool. The total number of responses for each question is provided in table 1 (multilingual classroom and differentiated teaching) and table 2 (numeracy, algebra and functions, geometry, spatial understanding and visualization, and problem solving, inquiry-based activities and reasoning). When 65 % or more of preservice teachers were unfamiliar with a particular tool, we decided not to report on the results so that the focus was on digital tools used nationally, rather than ones only used at one institution. Tables 1 and 2 show the digital tools reported on.

The survey was conducted at three institutions during 2019. The responses to the surveys were collected anonymously, using an electronic survey tool that excluded the collection of identifying information such as IP addresses. Participants were provided with the link to the survey through their regular teacher educators.

The participants were 61 inservice teachers enrolled in further teacher education courses and 395 preservice teachers enrolled in teacher education courses for Grades 1–7 (50 % of the 395) and for Grades 5–10 (50 % of 395). 70 % / 67 % of the preservice/inservice teachers identified as women and 30 % / 33 % as men. This gender distribution is typical for teachers in Norway. Of the preservice teachers, 10 % were younger than 20 years, 75 % were 20–25 years and 15 % were older than 25. Of the inservice teachers 34 % were between 20–25 years old, 8 % were between 26–30 years old, 23 % were 31–40 and 34 % were older than 40.

55 % / 72 % preservice/inservice teachers attended Western Norway University of Applied Sciences, 26 % / 26 % University College in Østfold and 19 % / 2 % the Arctic University of Norway. Of the preservice teachers 39 % were in their first year of teacher education, 42 % in their second year and 19 % in their third year. The inservice teachers were enrolled in further courses to increase their competence for teaching mathematics. These courses are usually for one year.

In Tables 1 and 2, we use descriptive statistics to report the results. To describe differences between the preservice and inservice teachers, Cohen's d (Cohen, 1988) was used (see table 3).

Results and discussion

We begin by describing the results from the general questions about experiences with digital technologies in different contexts. Then, we present general trends for these five contexts (A–B and 1–3), before presenting more details for each tool and possible effects of differences between preservice and inservice teachers (table 3). Finally, we discuss the results for the two pedagogical settings (A) and (B) in more detail.

There were large differences between the preservice and inservice teachers about the frequency of using digital technologies when they learnt mathematics at school. 26 % of preservice teachers agreed that they used digital technologies *frequently* whereas only 7 % of inservice teachers did. In contrast, the percentage of those who claimed they had *never* engaged with digital technologies were 6 % (preservice teachers) and 48 % (inservice teachers), while 19 % / 18 % indicated they used them *rarely* and 49 % / 26 % indicated they used them *sometimes*. The differences could be explained by an increase in use of digital tools in schools, following the requirement for digital tools to be included in the 2006 curriculum (Kunnskapsdepartementet, 2006), as the majority of preservice teachers were younger than the inservice teachers. Consequently, inservice teachers may only have experiences with using digital tools currently at the schools where they teach. To increase their technological knowledge (TK) (Mishra & Koehler, 2006), they may need to be introduced to a wider range of digital tools, to make more informed choices about which digital tools are most appropriate for teaching specific mathematics to particular groups of students.

In their teacher education, 10 % / 13 % of the preservice/inservice teachers felt that they had used digital technologies to a *great degree*, 23 % / 20 % to a *sufficient degree*, 49 % / 46 % to *some degree* and 18 % / 21 % to only a *small degree*. This suggests the two groups' views about using digital technologies in their teacher education did not differ and they considered their exposure limited. These results align with those of Guðmundsdóttir and Hatlevik (2018) who had found that newly-qualified teachers felt that their professional digital competency, gained from their teacher education, was insufficient. This reinforces the need for teacher education to offer more experiences with different digital tools (TK) for them to make informed choices about the use of digital tools in their teaching of mathematics.

The calculated means and standard deviations for the rankings of digital technologies for teaching mathematics in (A) Multilingual classrooms and (B) Differentiated teaching are given in table 1, and for (1) Numeracy, algebra and functions, (2) Geometry, spatial understanding and visualization, and (3) Problem solving, inquiry-based activities and reasoning in table 2.

For the majority of digital tools, the mean was just above 3, in the middle of the possible set of responses, suggesting that the groups of teachers were neither agreeing, nor disagreeing, with the use of the tools for the five different settings. As well, the standard deviations were generally larger than 1, indicating that responses were somewhat spread. These results suggest that the respondents did not have clear preferences,

Table 1. *Rankings of digital tools for teaching mathematics in the two pedagogical settings A and B*

Digital tools (n=number of responses)	Multilingual classrooms		Differentiated teaching	
	Mean	SD	Mean	SD
Interactive whiteboard				
(Preservice, n=361 / 358)	4.14	1.02	4.23	0.94
(Inservice, n=51 / 51)	4.06	0.99	4.02	1.08
Digital textbook				
(Preservice, n=214 / 214)	3.73	1.14	4.34	0.91
(Inservice, n=31 / 31)	3.59	1.22	4.22	1.05
Geogebra				
(Preservice, n=364 / 362)	3.52	1.31	3.81	1.15
(Inservice, n=54 / 54)	3.75	1.21	4.13	1.01
Excel				
(Preservice, n=369 / 367)	3.47	1.23	3.61	1.20
(Inservice, n=55 / 55)	3.70	1.18	3.70	1.18
Minecraft				
(Preservice, n=220 / 220)	3.43	1.44	3.89	1.34
(Inservice, n=22 / 23)	3.73	1.09	4.09	0.93
Kahoot				
(Preservice, n=368 / 366)	3.55	1.21	3.61	1.26
(Inservice, n=55 / 54)	3.27	1.25	3.40	1.24
Powerpoint				
(Preservice, n=370 / 368)	3.55	1.19	3.49	1.22
(Inservice, n=55 / 55)	3.45	1.10	3.23	1.24
Programming				
(Preservice, n=191 / 189)	3.13	1.30	3.38	1.30
(Inservice, n=22 / 23)	3.09	1.28	3.22	1.02
Social media				
(Preservice, n=362 / 360)	2.97	1.44	2.84	1.41
(Inservice, n=54 / 54)	2.38	1.37	2.36	1.37

perhaps due to a lack of knowledge of one or more of the various components of the TPACK model.

However, when the mean for a digital tool was ranked above 4, then the standard deviation was often below 1, suggesting that in these cases the two groups of teachers had a more definite view. This was the case for both sets of teachers in relationship to using: the Interactive whiteboard in all 5 contexts; Geogebra for Numeracy, algebra and functions and Geometry, spatial understanding and visualization; Excel for Numeracy, algebra and functions; and digital textbooks for Differentiated teaching and Numeracy, algebra and functions. As well, the mean for inservice teachers' ranking of Minecraft was high for Differentiated teaching, with a smaller standard deviation. When the preservice and inservice teachers were more certain about how to utilise a digital tool in their mathematics teaching, there was a higher degree of certainty in their responses.

When a tool was ranked lower than 3, the standard deviations generally increased, suggesting no clear trend. For example, the preservice

Table 2. *Rankings of digital tools for the three mathematical contents and didactical settings 1–3*

Digital tools (n=number of responses)	Numeracy, algebra and functions		Geometry, spatial understanding and visualization		Problem solving, inquiry-based activities and reasoning	
	Mean	SD	Mean	SD	Mean	SD
Interactive whiteboard						
(Preservice, n=367 / 363 / 360)	4.43	0.83	4.21	0.92	4.00	0.93
(Inservice, n=52 / 52 / 51)	4.21	0.76	4.26	0.73	3.94	0.93
Digital textbook						
(Preservice, n=222 / 212 / 213)	4.12	0.90	3.89	1.03	3.47	1.15
(Inservice, n=34 / 30 / 31)	4.11	0.89	3.81	1.00	3.13	1.32
Geogebra						
(Preservice, n=369 / 368 / 365)	4.41	0.86	4.33	1.02	3.21	1.32
(Inservice, n=55 / 55 / 54)	4.52	0.80	4.55	0.82	3.64	1.33
Excel						
(Preservice, n=375 / 372 / 369)	4.10	1.00	2.96	1.36	3.33	1.21
(Inservice, n=56 / 56 / 55)	4.33	0.82	3.28	1.27	3.79	1.24
Minecraft						
(Preservice, n=235 / 220 / 221)	2.62	1.27	3.75	1.39	2.90	1.40
(Inservice, n=24 / 22 / 22)	2.88	1.01	3.77	1.24	3.05	1.46
Kahoot						
(Preservice, n=374 / 369 / 367)	3.58	1.13	2.86	1.22	3.08	1.26
(Inservice, n=56 / 56 / 55)	3.32	1.16	2.91	1.19	2.91	1.23
Powerpoint						
(Preservice, n=376 / 374 / 370)	3.49	1.20	3.07	1.24	3.21	1.18
(Inservice, n=56 / 56 / 55)	3.47	1.20	3.25	1.20	2.93	1.16
Programming						
(Preservice, n=201 / 192 / 192)	3.31	1.20	2.84	1.29	3.24	1.34
(Inservice, n=25 / 19 / 23)	3.40	1.13	2.74	1.16	3.22	1.18
Social media						
(Preservice, n=368 / 362 / 363)	2.42	1.21	2.04	1.17	2.55	1.36
(Inservice, n=55 / 52 / 54)	2.05	1.11	1.89	1.18	2.27	1.27

and inservice teachers rated Social media as being less useful, for all five contexts, but with a standard deviation well above 1, with Multilingual classrooms and Differentiated teaching (TPK) having the highest standard deviations, close to 1.5. There were, however, exceptions. The inservice teachers rated Minecraft, as a resource for working with Numeracy, algebra and functions (TCK), with a mean below 3 (2.88) and a standard deviation close to one (1.01). This suggested that there was more certainty about this digital tool not being useful for developing students' understandings of this topic.

Apart from the Interactive whiteboard and Social media, which had approximately the same results across the five contexts (Interactive whiteboard with means 4–4.5 and Social media in the range 2–2.5), there were differences between settings, for the other 7 tools. The preservice and inservice teachers seemed to distinguish more between the use of digital tools, for teaching Numeracy, algebra and functions and Geometry, spatial understanding and visualization. For the Multilingual classroom, Differentiated teaching and Problem solving, inquiry-based activities and reasoning, the means were between 3 and 3.5. This suggests that the preservice and inservice teachers distinguished between the usefulness of the different tools, depending upon the mathematical content (TCK), but seemed more uncertain about the usefulness of different digital tools, in regard to pedagogical and pedagogical content knowledge (TPK and TPCK). Therefore, although preservice and inservice teachers may need more support in understanding how to integrate digital tools into the teaching of specific mathematical topics, they were more uncertain about using digital tools for mathematics learning in Multilingual classrooms and Differentiated teaching and for teaching Problem solving, inquiry-based activities and reasoning. These results provide insights for teacher educators in planning courses for preservice and inservice teachers at a general level, but the results also provide information about individual digital tools.

In Tables 1 and 2, both the preservice and inservice teachers ranked Social media as being the least useful for learning mathematics, generally with means between 2 and 2.5. However, for the preservice teachers the means are closer to 3 for the settings of Multilingual classrooms and Differentiated teaching. This suggests that this tool was still considered

Table 3. *Cohen's d for samples of uneven sizes measuring effect of differences in means between pre- and in-service teachers*

	Multilingual classrooms	Differentiated teaching	Numeracy, algebra and functions	Geometry, spatial understanding and visualization	Problem solving, inquiry-based activities and reasoning
Interactive whiteboard	0.079	0.219	0.268	-0.056	0.065
Digitalised textbook	0.122	0.129	0.011	0.078	0.290
Geogebra	-0.177	-0.282	-0.129	-0.221	-0.325
Excel	-0.188	-0.075	-0.235	-0.237	-0.379
Minecraft	-0.212	-0.153	-0.208	-0.015	-0.107
Kahoot	0.230	0.167	0.229	-0.041	0.135
Powerpoint	0.085	0.213	0.017	-0.146	0.238
Programming	0.031	0.126	-0.075	0.078	0.015
Social media	0.412	0.342	0.309	0.128	0.208

Note. Small effects (chosen from ±0.2) marked with light shading and those approaching medium effects (chosen from ±0.4) in darker shade. Negative sign indicates that the in-service teachers were more positive.

appropriate by many teachers for the students in these two settings. The results in table 2 suggest that Social media was considered less useful for teaching specific strands of mathematics (TCK) and Problem solving, inquiry-based activities and reasoning, particularly by inservice teachers. Table 3 shows the effect of the differences between the inservice and preservice teachers. In valuing Social media, there were small to medium effects in all settings, except Geometry, spatial understanding and visualization. The largest effects are for Multilingual classrooms and Differentiated teaching. Although both groups of teachers had similar experiences using Social media in their teacher education (17 % / 13 %), inservice teachers ranked this tool lower than preservice teachers, especially in the context of Multilingual classrooms and Differentiated teaching, where the effect is the highest.

Figure 2 illustrates the differences between the preservice and inservice teachers, when the percentage of responses that ranked Social media as 4 "useful" or 5 "very useful" are combined. At the time the survey was undertaken, there were discussions in Norwegian media about banning smart phones in classrooms because they were distracting (see for example Vinje, 2020). These discussions may have affected inservice teachers' views more than those of preservice teachers. These differences need to be taken into consideration by teacher educators planning courses on integrating digital tools into mathematics teaching.

In contrast with Social media, both preservice and inservice teachers considered Interactive whiteboards to be useful (see tables 1 and 2), with mean values over 4 and generally standard deviations less than one. This was somewhat surprising, as it is known that Interactive whiteboards can result in students being passive or engaging in superficial learning (Zevenbergen & Lerman, 2008). In table 3, the preservice teachers were shown as generally more positive than the inservice teachers about using

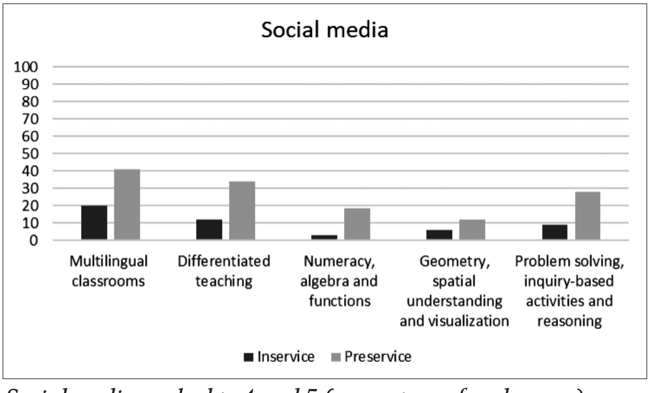

Figure 2. *Social media ranked to 4 and 5 (percentage of each group)*

Interactive whiteboards, with no differences or small differences in the setting of Differentiated teaching and Numeracy, algebra and functions.

Digitalised textbooks were considered the most useful tool for Differentiated teaching, by both preservice and inservice teachers. This tool was also considered useful in teaching mathematical content (Numeracy, algebra and functions and Geometry, spatial understanding and visualization), but not so much for Problem solving, inquiry-based activities and reasoning. This was also the only setting with a noticeable small effect of differences where the preservice teachers were more positive (see table 3). Given the traditional role that textbooks, and more recently digitalised textbooks, have had in supporting differentiated teaching (Braathe & Ongstad, 2001), this is perhaps not that surprising.

For the three tools Geogebra, Excel and Minecraft, Tables 1 and 2 show that generally the inservice teachers ranked these as being more useful than the preservice teachers. In table 3, Cohen's d shows there is a measurable small to medium effect for three of the five settings, for the digital tools of Geogebra and Excel, but small effects for Minecraft in two contexts. The highest effect was found in relationship to using Excel for Problem solving, inquiry-based activities and reasoning (TCK). To illustrate some of these effects, figure 3 shows the percentage of respondents who considered Excel to be 4 "useful" or 5 "very useful".

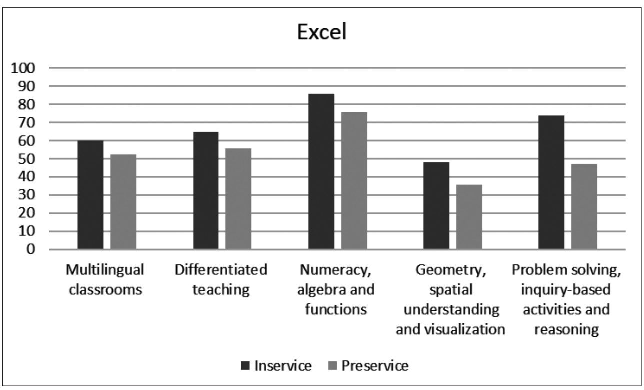

Figure 3. *Excel ranked to 4 and 5 (percentage of each group)*

Given that Geogebra and Excel would have been used by preservice teachers when they were learners in school, it may be that these experiences provided them with different expectations about their usefulness than teaching did for the inservice teachers. Teacher educators may need to develop courses which provide experiences for both, taking into account experiences from being learners and from being teachers.

Nevertheless, both preservice and inservice teachers differed in how they ranked Geogebra, Excel and Minecraft across the five contexts, showing that both groups recognised different settings affecting the usefulness of a digital tool (see for example, figure 3).

For the remaining three tools, Programming, Kahoot and Powerpoint, the same trend appears across all five settings for both preservice and inservice teachers (tables 1 and 2): The mean is between just under 3 and up to approximately 3.6, with the standard deviation lying around 1.2 ±0.1. This is confirmed by the Cohen's d analysis, at least to some degree (see table 3). For programming, there was no effect in differences between the teacher groups, but this was the digital tool least well-known by respondents. There were some small effects in differences for Kahoot and Powerpoint (see table 3). The small variations across the five settings may indicate that teacher educators need to develop courses that support the different groups of teachers to understand how different digital tools could affect opportunities for learning.

Comparing Differentiated teaching and Multilingual classrooms, the preservice and inservice teachers showed a small positive trend towards digital tools being more useful for Differentiated teaching of mathematics than in Multilingual classrooms. This was particularly the case for Digital textbooks which ranked as considerably more appropriate for Differentiated teaching. These results may reflect the fact that differentiated teaching has an established history in Norwegian mathematics teaching (Fauskanger et al., 2018). Certainly, Guđmundsdóttir and Hatlevik (2018) also noted that preservice teachers were positive about using digital tools for differentiated teaching. On the other hand, Meaney and Rangnes (2022) found that preservice and inservice teachers mainly saw digital tools as a way of supporting school students to interpret mathematical tasks written in Norwegian. Therefore, an explanation for the relatively high ranking of Powerpoint, Kahoot and Digital textbooks could be that they were seen as a way of providing visualisations to support multilingual students to complete classroom tasks.

In table 4, the results from the last survey question show that the majority of preservice and inservice teachers did not identify supporting multilingual students as the main purpose of integrating digital tools into their mathematics teaching. Respondents could choose the two responses they considered the most appropriate and supporting multilingual students was the response that the least number of preservice or inservice teachers chose (about 10 %). The uncertainty shown in the larger standard deviations for Multilingual classrooms in table 1, particularly for preservice teachers, along with the responses in table 4 suggests that there is a lack of knowledge about how to use digital tools to

Table 4. *Responses to do with pedagogical purposes of digital tools*

	It allows for varied forms of teaching	It provides in-depth learning	It's fun for the students	It provides opportunities for visualization and increased spatial understanding	It supports multilingual students in their learning
Preservice	82.01 %	16.35 %	31.96 %	59.67 %	10.35 %
Inservice	77.05 %	22.95 %	21.31 %	52.46 %	9.84 %

support multilingual students to learn mathematics, by both preservice and inservice teachers. However, if they considered supporting multilingual students through visualisations, the second most common response could also be considered to cover this group of students' needs. As Geogebra and Interactive whiteboards were the only tools with means above 4 in table 2 in relationship to teaching Geometry, spatial understanding and visualization, it could be that teacher educators need to broaden what kinds of assistance digital tools can provide to multilingual students.

Conclusion

The TPACK model (Mishra & Koehler, 2006) provides insights about preservice and inservice teachers' views on different aspects of incorporating digital tools into mathematics lessons. In this paper, we have described how preservice and inservice teachers at three Norwegian institutions viewed different digital tools for differentiated teaching and multilingual classrooms, connected to the TPK component of TPACK. We have further compared these two settings with their evaluation of the same digital tools, mostly related to the TCK component of TPACK to do with Numeracy, algebra and functions; Geometry, spatial understanding and visualization; and Problem solving, inquiry-based activities and reasoning. Overall, the teachers' views provide insights into how they value the use of different digital tools in the different settings, which can be used to develop their knowledge and skills for TPACK.

As tables 1 and 2 show, there were a different number of responses from teachers to the questions about the different tools, indicating that not all the preservice or inservice teachers were familiar with the different tools. Therefore, teacher educators will need to provide opportunities to become familiar with common digital tools in Norwegian classrooms when planning courses – increasing the technological knowledge (Mishra & Koehler, 2006). The fact that fewer teachers had knowledge of programming, a recent addition to the Norwegian mathematics curriculum (Kunnskapsdepartementet, 2019), indicates one area where teacher educators will need to raise teachers' awareness, especially for the teaching of mathematics. However, the varying results from ranking digital tools according to the five contexts showed that preservice and inservice teachers were able to make distinctions between the content and the needs of particular groups of students when considering specific digital tools. Our results confirm the suggestion of Olando and Attward (2016) that preservice teachers have some relevant experiences with different digital tools, while also suggesting that more experiences are needed.

Teacher educators can build on this awareness of connecting technological knowledge about different digital tools to both content knowledge and pedagogical knowledge as had been suggested by Handel et al. (2013). The differences between preservice and inservice teachers' evaluations of the digital tools suggest that courses need to provide opportunities for both groups to have experiences as learners and teachers. As well, inservice teachers may need more opportunities to engage with different digital tools as part of their professional development.

The survey results show that preservice and inservice teachers are less confident in their views of the usefulness of different digital tools for differentiated mathematics teaching and in multilingual classrooms than when they consider the usefulness of different digital tools for learning mathematical content. However, the reasons behind some of their evaluations is not clear, with little indication of what makes them consider particular tools as suitable for certain groups of students, learning specific mathematical content. More research is needed to better understand teachers' reasons for judging the usefulness of the different digital tools for different groups of students.

The results indicate a need to provide teacher education courses that cater for the specific needs of preservice and inservice teachers, as had been suggested by Karatas, et al. (2017). Without a broadening of the teacher education, teachers may not gain the necessary professional digital competence needed to critically identify how and when to integrate digital tools into their mathematics teaching for different groups of students. Courses would, therefore, need to include not only making teachers aware of the range of digital technologies, but also support them gaining evaluation skills to determine which tools might support specific groups of students to better learn mathematics connected to their backgrounds and needs, as indicated by the TPACK component of Mishra and Koehler's (2006) model.

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