Digital Tools in Mathematics Classrooms: Norwegian Primary Teachers' Experiences

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Abstract

This article explores the integration of digital tools in Norwegian primary school mathematics classrooms, focusing on teachers' experiences. With the increasing use of technology in education, digital tools have the potential to enhance mathematics instruction by enabling personalised learning, increasing student engagement, and offering dynamic ways to visualise mathematical concepts. However, these tools also present challenges, such as the potential for student distraction and a lack of teacher confidence in using technology effectively. Using a collective case-study approach, we conducted semi-structured interviews with eleven mathematics teachers to examine how digital tools impact student learning, instructional practices, and the nature of mathematics education. The findings reveal both the potential of digital tools to foster differentiated learning and their limitations, including concerns about over-reliance on technology and difficulties in maintaining classroom focus. This study contributes to the ongoing conversation about digitalisation in education, offering insights into the practical realities teachers encounter and recommendations for optimising the use of digital tools in mathematics classrooms.

Keywords: digital tools, teachers' experiences, didactical tetrahedron, Norway

Introduction

The growing integration of digital tools into education has gathered considerable attention worldwide, particularly as technology assumes an increasingly central role in classroom practices. The Nordic countries of Norway, Sweden, Denmark, and Finland have been frontrunners in adopting digital tools for education, with government policies strongly advocating for technology integration in daily teaching (Olofsson et al., 2021). In Norway, which is the focus of the present paper, this emphasis is reflected in policy documents such as the mathematics curriculum (Kunnskapsdepartementet, 2019) and the national strategy for digital competence and infrastructure in kindergartens and schools (Kunnskapsdepartementet, 2023). As indicated by recent findings from the Programme for International Student Assessment – PISA (OECD, 2023), Norwegian students use digital tools more frequently than their peers in any other country. This is perhaps unsurprising given that over 90% of students in years 1 to 10 (ages 6 to 16) are provided with digital devices by their school districts (Amdam et al., 2024). However, Norwegian teachers' levels of professional digital competence vary significantly. Also, despite the growing body of Norwegian literature examining the digital competence of prospective teachers (e.g., Tveiterås & Madsen, 2022), practising teachers (e.g., Folkman et al., 2023), and teacher educators (e.g., Lindfors et al., 2021) from a general education perspective, far less work has been undertaken specifically within the context of mathematics education.

This study focuses on the experiences of primary school teachers in Norway as they contend with this evolving digital landscape in relation to school mathematics. Teachers are instrumental to the success of digitalisation initiatives, as they bear the responsibility of incorporating technology into their instructional methods and ensuring it supports rather than detracts from student learning. The effectiveness of digital tools is thus closely linked to how teachers perceive and use them. If teachers lack confidence in these tools or view them more as distractions than assets, the potential benefits of technology may not be fully realised (Loong & Herbert, 2018). Therefore, understanding teachers' experiences is essential for evaluating the actual impact of digital tools on mathematics education.

Three key questions guide our work, focusing on teachers' experiences and perspectives. Each question should be read as beginning with "According to teachers, …"

- RQ1: In what ways do digital tools impact students in the mathematics classroom?
- RQ2: In what ways do these tools affect teachers and their teaching practices?
- RQ3: In what ways do digital tools reshape the nature of mathematics as a subject?

The work presented here is significant for its potential to inform teachers, policymakers, and researchers about the practical realities of integrating digital tools into mathematics education. While the theoretical benefits of digitalisation are widely acknowledged, a deeper understanding of teachers' everyday experiences offers a more nuanced perspective on how technology affects teaching and learning. This study focuses on the views of those directly involved in the classroom, aiming to provide practical recommendations for optimising the use of digital tools in mathematics education. In the following pages, we first review relevant academic literature to provide context for the study. Then, we outline the research methodology, key findings, discussion, and implications.

Digital Tools in Mathematics Education

Meirbekov et al. (2022) describe digital tools as resources and services used in the educational process to develop key competencies such as critical thinking. These tools include online platforms that enable the creation of tests, logical tasks, real-time collaboration, and the visual presentation of information. In the context of mathematics education, Loong and Herbert

(2018) broaden the definition to encompass both physical devices and digital learning resources, such as tablets, computers, and educational games. For the purposes of this article, we use the term ‘digital tools’ to refer to both technological devices and learning software. The use of digital tools has grown significantly, particularly in mathematics classrooms, where traditional methods are increasingly supplemented or replaced by tablets, smartboards, and computers (Kunnskapsdepartementet, 2023). These tools, including tablets and software such as GeoGebra[1], Excel, computer algebra systems (CAS), and various dynamic geometry software, support students with complex operations and enhance their understanding of concepts. This shift enables students to explore and manipulate mathematical ideas that were previously difficult to visualise without the use of technology (Swensen, 2014).

Research on integrating digital tools in Norwegian schools and beyond stresses both their potential benefits and the obstacles they may present. One advantage lies in adaptive learning platforms that tailor activities according to students’ progress, offering personalised support in subjects such as mathematics (Swensen, 2014; Viberg et al., 2023). Digital resources open up possibilities for deepening conceptual understanding. For instance, software like GeoGebra enables students to explore geometric and algebraic ideas interactively, fostering stronger engagement and insight (Kunnskapsdepartementet, 2019; Swensen, 2014). Meanwhile, adaptive platforms respond to students’ progress by adjusting task difficulty and providing immediate feedback, allowing each learner to work at a level that challenges them appropriately (Kunnskapsdepartementet, 2023; Viberg et al., 2023). In addition, digital tools can significantly increase student engagement. Educational games and interactive simulations are particularly effective at capturing students’ interest, making learning mathematics more enjoyable and immersive. When learners are more engaged, they are more likely to participate actively in lessons and perform better academically (Deater-Deckard et al., 2013; Fadda et al., 2022).

Despite these promising attributes, studies highlight challenges that can compromise the potential of digital tools. One recurring concern is distraction, as devices may lure students into non-academic activities and undermine concentration on mathematical tasks (Klette et al., 2018). While these tools offer opportunities for interactive learning, they also present temptations for students to disengage from the lesson, for example by browsing social media or playing games (Bergdahl et al., 2020). This challenge mirrors international findings, where teachers grapple with similar issues in tech-rich classrooms (e.g., Hennessy et al., 2007; Loong & Herbert, 2018; McCulloch et al., 2018). In addition, many teachers, in Norway and elsewhere, feel ill-prepared to harness technology fully, often reverting to traditional methods due to insufficient training and limited confidence (Kunnskapsdepartementet, 2023; Madsen, 2020; Munthe et al., 2022). Some also remain cautious about overreliance on technology, stressing the importance of pen-and-paper methods in developing core mathematical skills (Kunnskapsdepartementet, 2019; Marpa, 2021). Finally, many teachers hold beliefs that an overreliance on technology may weaken students’ abilities to perform basic calculations and solve problems independently of digital aids (Beck, 2016).

Theoretical Framework: The Didactical Tetrahedron

Traditionally, educational theory has concentrated on the interaction between three core components: the teacher, the student, and the content (Mølstad & Karseth, 2016). These three components form the vertices of the well-known *didactical triangle*. More recently, in recognising the complexities of classroom realities, scholars have visualised these components in a three-dimensional shape (known as *the didactical tetrahedron*) by adding a fourth vertex,

[1] https://www.geogebra.org/

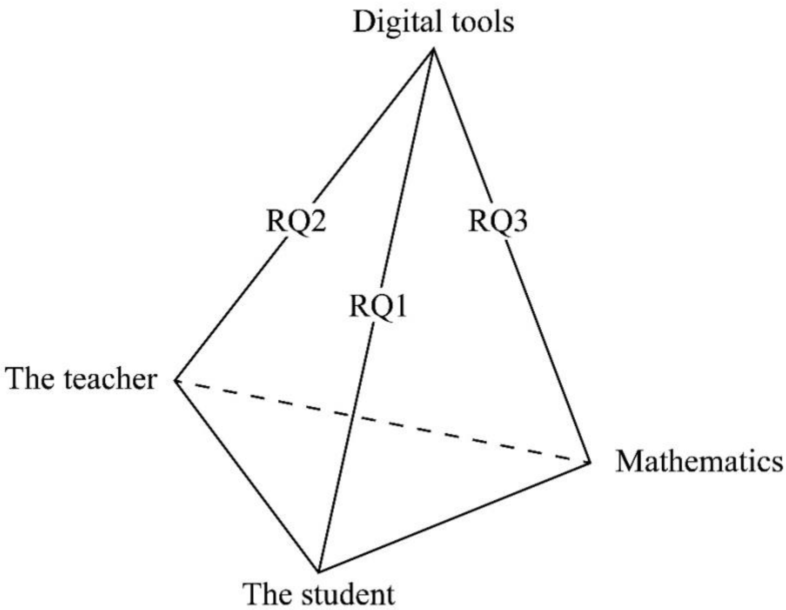
representing artefacts—namely, the materials or tools used in the classroom (see Goodchild & Sriraman, 2012; Jukić Matić & Glasnović Gracin, 2016; Rezat & Sträßer, 2012). In our work, we build on the ideas of Ruthven (2012), who encourages us to regard digital tools as a type of artefact. From this perspective, the didactical tetrahedron provides a robust and comprehensive framework for analysing how digital tools shape and transform the teaching and learning of mathematics. This approach recognises the significant role that digital tools play in mediating and reshaping relationships between teachers, students, and mathematical content. Within this expanded framework, technology is not merely a supplementary tool but an active agent that influences the nature of these interactions. For instance, technology enables teachers to present mathematical content dynamically, using tools such as dynamic geometry software to visualise abstract concepts in real time. This approach can enhance student engagement by creating more interactive and exploratory learning environments. Moreover, digital tools allow students to interact with content in novel ways, fostering deeper conceptual understanding through manipulation and experimentation.

This framework involves various relationships (Ruthven, 2012). The teacher-technology dynamic is crucial in enhancing instruction, enabling teachers to communicate content, deliver lessons, and facilitate interactive learning experiences. Teachers must continually develop their ability to manage and integrate these resources into their pedagogy. Similarly, the student-technology relationship encourages exploration, discovery, and a deeper understanding of content. Whether students engage with technology independently or under guidance, it offers them different levels of control over their learning. The content-technology interaction transforms static content into dynamic forms that can be manipulated, visualised, or simulated, greatly enriching subjects such as mathematics through tools like dynamic geometry software. Although the teacher-student relationship remains central, technology redefines this connection, positioning teachers more as facilitators who guide students through independent explorations using technological tools.

Thus, the didactical tetrahedron serves as a valuable heuristic for examining both the potential benefits and challenges posed by digital tools in mathematics education. On the one hand, it identifies opportunities for creating more student-centred, investigative learning environments. On the other, it highlights the need for teachers to adapt their pedagogical strategies to effectively integrate technology into their instructional practices. By considering technology alongside the traditional elements of the learning environment (i.e., teacher, student, content), this framework ensures a holistic approach to understanding the evolving nature of mathematics education in the digital age. Interestingly, while Ruthven (2012) provides an extensive discussion on the didactical tetrahedron and its components, he does not provide any visual representation of it. For this reason, Figure 1 provides an illustration of how we interpret Ruthven's ideas and the relevance of the framework to the research questions in this study, as outlined earlier in the introduction.

Figure 1:

The Didactical Tetrahedron (Ruthven, 2012).



This Study and Its Methods

This paper draws on data from the master's thesis of the first author, under the supervision of the second author. The study adopts a collective case-study methodology (Goddard & Foster, 2002), an approach grounded in the premise that understanding selected cases can provide deeper insights and potentially contribute to improved theorisations of a broader range of cases (Stake, 2005). Here, we focus on the collective case of a group of eleven teachers working in the same school. Nevertheless, to emphasise the importance of acknowledging individual voices, participants were encouraged to share personal experiences as primary mathematics teachers, in keeping with the narrative research approach seen in other studies (e.g., Kaasila, 2007). Narrative research seeks to explore how participants construct stories to make sense of their professional worlds, aiming to foster honesty and trust between the researcher and participants by prioritising the voices of individuals (Litchman, 2013).

Context and Participants

Despite the wide digitalisation of Norwegian schools (Amdam et al., 2024), not all schools in the country use digital tools in the same way, as their integration depends on several contextual factors. Variations arise from differences in regional and municipal funding, which influence the availability of technology and infrastructure (Rohatgi et al., 2021). Individual schools also exercise autonomy in selecting and implementing digital tools, leading to diverse approaches tailored to their specific educational goals (Ottestad, 2013). Furthermore, disparities in teacher training and digital competence create inconsistent usage patterns, with some teachers leveraging technology extensively for pedagogical purposes while others limit it to administrative tasks (Krumsvik, 2006). These variations are further amplified by differences in leadership priorities and the unique needs of each student population, resulting in a non-uniform adoption of digital tools across schools (Ottestad, 2013; Krumsvik, 2006). Despite

Norway's high ranking in digitalisation, such differences highlight the ongoing challenges of achieving equitable and effective use of technology in education (Amdam et al., 2024).

This study involved eleven teachers working in the same primary school (covering years 1-7, ages 6-13), where digitalisation has been widely embraced, in a southeastern town in Norway. Following the 2010 generalist teacher education reform (International Association for the Evaluation of Educational Achievement [IEA], 2015), primary teachers in Norway may possess one of two types of qualifications: those qualified to teach years 1-7 (exclusively primary school teachers) and those qualified to teach years 5-10 (upper primary and lower secondary teachers). In our study, we did not differentiate between these two qualification types. All participants were selected through purposive sampling. The rationale behind this selection process was to ensure that participants had direct experience in integrating digital tools into their mathematics teaching. By choosing purposive sampling, the study targeted individuals who could provide valuable insights into both the benefits and challenges of using technology in the classroom (Brinkmann & Kvale, 2015). The participants varied in terms of gender and teaching experience, ranging from early-career teachers to those with over two decades in the profession. Additionally, all participants were employed in a school that provided digital resources to students, such as iPads, in line with current practices in Norwegian schools, where digital competence is a growing priority. To maintain the anonymity of participants, the following pseudonyms are offered: Kari, Sofie, Lars, Anne, Ole, Nils, Astrid, Kåre, Sigurd, Solveig, and Ingrid. No further demographic information is provided (e.g., age, years of experience) for two reasons. First, these factors are not relevant to our work here. Secondly, since the participants work at the same school in a small town in Norway, such information may compromise their anonymity.

Data Collection

Data collection, conducted by the first author over a period of two months, was carried out through individual semi-structured interviews. This method was chosen for its flexibility, allowing participants to share their experiences in depth while providing a consistent framework for comparison across interviews (Xenofontos, 2018). Each audio-recorded interview lasted between 45 and 60 minutes, during which participants were asked about their use of digital tools, the perceived impact on student engagement, and any challenges they faced in balancing technology with traditional teaching methods. The interview guide was structured around key topics corresponding to three vertices of the didactical tetrahedron (Ruthven, 2012: the student, the teacher, and mathematics. Table 1 presents sample questions from the interview guide. Since the interviews were semi-structured, not all participants were asked the same questions, as some topics naturally emerged during the conversation. The flexible format of the semi-structured interviews enabled us to cover key topics without adhering to a strict order.

Table 1

The Interview Guide with Sample Questions

Key Topic	Sample Questions
Students' Use of Digital Tools	How often do your students use digital tools in mathematics? Can you provide specific examples? What advantages have you experienced that make digital tools beneficial for students in mathematics? What challenges have you encountered that make digital tools less useful for students in mathematics?

Teachers' Use of Digital Tools in Mathematics	How often do you use digital tools in planning and conducting lessons? Can you provide specific examples? What advantages have you experienced that make digital tools beneficial for teachers in mathematics? Do you feel you have sufficient knowledge to guide students in a digital mathematics class? Why or why not?
Digital Tools and the Subject of Mathematics Itself	From your experience, which mathematical topics benefit from the use of digital tools? Can you give specific examples? Which mathematical topics can be influenced negatively? Can you give specific examples? In what ways has technology changed mathematics as a school subject? In what ways has it not?

Data Analysis

As noted earlier, this study is based on the master's project of the first author, under the supervision of the second. Consequently, the primary data analysis was carried out by the former, with substantial input from the latter. As the master's thesis supervisor, the second author acted as a 'critical friend' (Richards & Shiver, 2020), performing member checks on the transcripts. The interview transcripts were subjected to a thematic analysis, following Braun and Clarke's (2006) six-step framework: familiarising with the data, generating initial codes, searching for themes, reviewing themes, defining and naming themes, and finally, producing a comprehensive report. This approach was selected for its robustness in identifying, analysing, and interpreting patterns within qualitative data, while also maintaining trustworthiness in qualitative research through systematic coding (Killi & Xenofontos, 2024; Nowell et al., 2017). The analysis began with a detailed reading of the transcripts to gain an overall understanding of the data. Initial codes were generated, focusing on themes such as the perceived benefits of digital tools in fostering student motivation and the challenges posed by digital distractions. Both inductive and deductive approaches were applied during the coding process. Pre-existing theories about technology in education informed some of the initial codes, while others emerged directly from the data, reflecting the participants' unique experiences. The codes were then grouped into broader categories, falling under the three vertices of the didactical tetrahedron, which served as our broader themes.

Ethical Considerations

Ethical approval for the study was obtained from the Norwegian Agency for Shared Services in Education and Research (Sikt), ensuring that the research adhered to national guidelines on the ethical treatment of human subjects. Informed consent was obtained from all participants prior to the interviews. Participants were fully briefed on the purpose of the study, their rights as participants, and the voluntary nature of their involvement. They were also informed that they could withdraw from the study at any point without any repercussions. To maintain confidentiality, and privacy in qualitative research, as Brinkmann and Kvale (2015) emphasise, participants were assigned pseudonyms, while any identifying information was removed from the transcripts and final report. The recordings and transcripts were stored securely, and only researchers could access the raw data.

Findings

This section is organised using three vertices from the didactical tetrahedron (i.e., the student, the teacher, and the subject of mathematics) and how these relate to the fourth vertex, technology, and, more specifically the use of digital tools. In doing so, we deliberately avoid quantifying how many teachers addressed an issue, as our purpose is to map, and not quantify their experiences. Readers should keep in mind that we present these findings without discussing or attempting to interpret them, as we wish to provide a more truthful depiction of teachers' own experiences. Discussion of the findings and connections to the academic literature takes place in a subsequent section.

The Student

Personalisation and Adapted Learning

Several teachers highlighted the benefits of using digital tools in mathematics to tailor instruction based on students' abilities and needs. For instance, Anne appreciates how these tools automatically adjust levels of difficulty for children. In her own words, "[m]any of these maths platforms increase in difficulty when a student is doing well. It's much easier to tailor tasks digitally instead of manually searching for appropriate exercises". Kåre agrees, pointing out that digital tools offer equal opportunities for students regardless of their background. He also emphasises their value for students with reading or writing difficulties, arguing that "[i]t's been particularly useful for children with dyslexia or dyscalculia, who can use headphones to have tasks read aloud. This makes it easier for them to understand and complete the work correctly". For Sofie (quote below), digital tools are invaluable in promoting independent learning. Instead of forcing students to complete tasks within a set time, they can work at their own pace with a variety of personalised tasks. Many platforms also provide instructional videos for additional support:

The advantage is probably that it offers many differentiation options. You can choose which level to work at, so some students can push themselves further. [...] It's very self-instructive. And especially if they make too many mistakes in a task, a video will appear to repeat the explanation, and so on. It offers different approaches and types of tasks than the book allows. [...] Kikora[2] is really good because you can choose – I can decide what they should work on, and they can also choose themselves, to some extent. And it adjusts according to their skills. You can take a longer time or less time. It's great, especially for weaker students, as they can work at their own pace without having to rush and miss the last pages of the book.

Overall, teachers agree that the use of digital tools in mathematics education offers significant advantages by providing tailored, self-paced learning experiences for students of varying abilities. From enhancing individualised instruction to supporting students with learning challenges, these tools help foster independence and ensure that all students can engage with the material at their own level and pace.

Increased Motivation

The 11 participants shared remarkably similar views on how the use of digital tools in the mathematics classroom enhances students' motivation. Ingrid, for example, highlighted how these tools offer gaming experiences that transform students' attitudes towards maths, making it less frustrating and more engaging. As she put it, "[i]t's like those tools are self-motivating, you know. It's timed, and you get a certificate and things like that. At least, I've found that students think it's motivating". Solveig echoed this view, noting how:

> [t]here are so many fun programmes that motivate. [...] It's as if they [students] are in a game, solving mathematical problems. So, it has a lot to do with motivation. [...] I've also seen students who struggle with learning their times tables. If they use a

[2] https://kikora.no/

> multiplication app, their brain somehow filters out everything to do with maths and just allows the gaming experience.

Sofie also emphasised the role of motivation, focusing on how learning from peers sustains engagement. She described how digital tools create different types of participation in the classroom: “If you have an interactive smartboard in the classroom... I used it a lot, particularly with the younger students. You could project the book and other resources, making students more involved. It’s motivating because they pay more attention when they know they might be called on. It’s fun for them to come to the front, press buttons, and interact. That can be a real motivating factor”.

The participants also mentioned that digital tools give students the chance to teach their teacher something new. As Ole explained, “Students are very knowledgeable. They’re incredibly skilled. I get a lot of help from them. They teach me a lot, and that gives them a sense of achievement, being able to teach older teachers something new”. Nils expanded on this, noting how this creates a sense of accomplishment for students: “They’re given the freedom to explore, and some of them might discover something I haven’t noticed. It becomes a shared learning experience. We learn together. I can say, ‘Wow, look at this! She’s found this answer or discovered this method.’ Then I’ll ask, ‘Can you explain how you did that?’ That’s great”.

In conclusion, the interviewees agree that digital tools in maths offer adaptations that provide all students with the same opportunities for success, regardless of ability or need. Many programmes adjust the level of difficulty based on previous answers, promoting independent work. Additionally, several teachers noted that digital learning games ignite interest, making mathematics more motivating for many students.

Negative Effects on Students

While digital tools offer many opportunities, teachers also voiced concerns about the challenges technology presents to students’ learning. A common concern is that a wide variety of online tools encourages students to click through tasks without fully engaging, often rushing to complete them by guessing. Ingrid, for example, shared her experience:

> Sometimes they just sit and click through the tasks just to move on. We see this often. If websites and apps allow it, children will progress without thinking or critically assessing their answers. When they get something wrong, some don't even bother to ask—they just keep going. [...] It’s hard to stop this behaviour because it becomes automatic, and monitoring 22 students at once to see what each is doing is impossible.

Kåre noted that notifications and lights from students’ iPads create a distracting environment and suggested that devices should be set aside for students to concentrate fully on classroom activities. He also stressed how digital tools often cause disruptions, as students’ familiarity with and interest in devices frequently pull their attention away from the task at hand:

> There are so many other things you can use an iPad for, and those distractions are always lurking in the background. It’s like having your phone on the table—you know a Snap could come in any moment, or that Messenger notification you’re waiting for could pop up. It’s the same for students with their iPads—there’s always something else tempting them. [...] It’s a massive distraction.

Similarly, Ole observed how easy internet access can lead to distractions. He believes that digital tools often divert students’ focus from important learning:

> I see individual students pushing boundaries, using the iPad or computer for things other than classwork. It's so easy for them to switch between a subject page and another site like Safari or Google without us noticing. They pretend to be working. They quickly switch back when I approach. [...] They take advantage because they know more about it than I ever will.

In summary, while digital tools offer valuable opportunities in mathematics education, teachers express concern over their potential to distract students and encourage superficial engagement. Many students rush through tasks without critical thought, often becoming distracted by the many features of their devices. Teachers also find it difficult to monitor behaviours effectively, as students can easily navigate between educational tasks and other online distractions, undermining their learning experience.

The Teacher

Adapted Teaching

As previously mentioned, digital tools offer opportunities to tailor mathematics to students' abilities and needs, providing better conditions for success within the classroom. The respondents claim that the teachers' task of adapting lessons becomes significantly easier when using digital tools during planning. For example, Ole believes that technology allows for assigning tasks directly to students, rather than spending time photocopying for each individual: "I can assign tasks directly in Skolestudio[3], for instance. It's great for adapting to each student's level and development, so I can tailor tasks according to where they are. If a student is in Year 7 but works at a Year 5 level in maths, I can give appropriate tasks without wasting time at the photocopier".

Ole has noticed this saves a lot of time, a view shared by Kåre, who adds that "as long as there's the internet, there are endless resources available". Lars also takes advantage of digital tools for creating creative lessons, as the internet offers "room to find a bit of inspiration". As he said, "[i]n maths specifically, there are so many apps and websites to find drills. I use maths puzzles as homework for those who want an extra challenge, so it's primarily a tool for me. And there are many good tips out there, so I see it as more of a tool for myself".

According to Sigurd, teachers gain a clearer overview of students' progress when working digitally, which helps them plan tailored lessons. As stated, "[i]t's useful to get an overview of all the students – results, understanding – if the programmes are designed for that. You can check how long they've worked, what they've understood. It gives me an indicator that I can match with my own perception". Ole experienced this when schools in Norway closed due to the Covid pandemic, and many teachers had to shift to digital teaching:

> Not all students can focus on a lesson in class, but digital tools can help by allowing students to receive instructions via Teams. This became very clear during the pandemic when we had to quickly switch to online teaching. Digitalisation really took off, and we had to adapt. It became much easier to give feedback directly in the text, without waiting until Friday to hand back a marked book.

All in all, as teachers argued, digital tools in education offer significant benefits by allowing teachers to tailor lessons to individual students' needs, streamline their workflow, and access a vast array of resources. Teachers find that digital platforms save time and enable them to provide quicker, more personalised feedback, which was especially valuable during the shift to online teaching. By offering better insights into students' progress, these tools support more

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[3] https://www.skolestudio.no/

effective and customised teaching, ultimately enhancing the learning experience for all students.

Administrative Work and Planning

Several participants highlight how digital tools have simplified administrative tasks. For Kari, daily life has become much easier since digitalisation, as she can now store everything in one place. With internet access, she can access all documents on her computer, phone, or iPad, no matter where she is. She explains:

> I have a much better overview of what I've covered and what I still need to cover because everything is in one document on my PC. I can also open it on my iPad or phone when I'm elsewhere. It's stored in the cloud, so I can add things wherever I am without needing to carry a book. It's made my daily life much easier.

Anne relates to this and adds that communicating with students outside school hours has also become easier:

> I also distribute the weekly plan on Teams and communicate with the students. They can ask me questions if they're unsure about something. [...] I can also acquire knowledge if there's something I'm unsure about. [...] Yes, I use it a lot. [...] There's no point in coming in on Thursday and saying you didn't understand the homework because you have the opportunity to ask me throughout the week. If they've forgotten the homework at home, they can message me, and I'll send it to them digitally. It gives them fewer excuses for not getting things done, and it significantly lightens the workload. [...] I find it practical for planning – doing things digitally and keeping them digital. Cloud storage allows me to access everything from both my iPad and PC.

Anne sees mostly advantages in using digital tools, particularly for mathematics. For her, it has been a positive contribution to planning. Kåre agrees, adding that digital tools have been helpful for assigning homework. He shares that "[t]he availability of many online resources gives us another option for assigning homework, which can be useful. It provides variety for the students and allows me to follow up in different ways, beyond just collecting and marking or reviewing in class".

Overall, the majority of teachers report that the adaptation to digital tools has made their administrative work, especially in planning for mathematics lessons, significantly easier.

Lack of Digital Competence

The participating teachers' use of digital tools in mathematics seems linked to their age. Anne, a younger teacher, feels confident using digital tools, having grown up with them. She explains, "I have sufficient competence [...] I enjoy it and probably learn most of it on my own. But it's unfortunate that it depends on personal interest." Ingrid shares a similar view, saying, "I remember some [tools] from university, but I've mostly kept up with them on my own. It hasn't been an issue for me, but I imagine older teachers find it harder".

On the other hand, Ole is one of those who rarely use digital tools in mathematics, explaining that "I'm a bit old-fashioned, you know, so I use them very rarely, really". Others of a similar age have stuck with traditional teaching methods, as this is what they feel comfortable with. Sigurd, for example, says that:

> [i]n primary school, too much goes wrong, I think. You try to show something on a screen, and it's not synchronised. There's just so much hassle, and I'm not that good with it. I'm not exactly a tech wizard. For me to use it, it has to work. When things don't work, I struggle a bit. And we have to adjust, and the kids don't have the software, or it doesn't

> come up, they make mistakes, 'what am I doing wrong.' There's just so much of that, it gets a bit … It takes up a lot of time. […] And as I said, I'm not particularly comfortable using it. I can manage, but that's about it. I feel it often takes a lot of time away from actual learning.

For Sigurd, the use of digital tools detracts from time that could otherwise be spent teaching mathematics, a feeling also shared by others. Kari, for example, mentions that many teachers have to adapt because of how fast things have progressed. For her, this takes far too long. She believes this is one reason why some teachers choose not to incorporate digital tools in their mathematics lessons:

> It's partly because progress has sped up a bit. You've been working in one way, and then suddenly you have to completely adapt. […] I think some teachers feel they don't have the time to familiarise themselves with it properly, because their day is already so full. I think some see it as more of a time thief, and sometimes they don't realise its value. If you'd invest the time, it might have made your day easier, but there's just no time or energy to start that process.

In summary, the use of digital tools in mathematics teaching seems to correlate with teachers' age and ease with technology. Younger teachers tend to embrace these tools with confidence, while older teachers often prefer traditional methods, citing difficulties with technology and the additional time required for integration. The rapid pace of technological advancement has left some teachers feeling overwhelmed, viewing the adoption of digital tools as a time-consuming challenge rather than a beneficial resource for their teaching.

The Subject of Mathematics

Effective Support for School Mathematics

The teachers provided examples of why they believe digital tools are effective for school mathematics. For Sofie, they are particularly useful for practising large quantities of tasks: "As I said, when we need to practise more. If I feel the book doesn't have enough exercises, for example, the multiplication table or geometry, I use it for practice". Similarly, Nils admits, "I've found the multiplication table to be really useful. I've used various websites and multiplication songs". Astrid shares an example from her class:

> We use it a lot for number learning. [...] Especially geometry and things like that. For example, when working with volume, you can use Minecraft[4]. It becomes clear when you ask them to build something, pretending one block in Minecraft is a cubic centimetre, and they then build a cubic decimetre. The fact that the cubic decimetre contains so many more blocks than the centimetre is difficult for some students to grasp, but it becomes clear when you're building block by block. [...] It's also a platform the kids are familiar with, and I imagine they remember it better.

Kari has also noticed that digital tools present mathematical ideas in ways a textbook cannot:

> I've looked at something called Brilliant[5], a maths app. [...] It has great visualisations for understanding mathematics, showing how things look in practice. For example, when working with fractions, it provides excellent illustrations. I'm very focused on different models like that. [...] There are also apps for number lines, which you can generate with a few clicks instead of drawing them by hand.

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[4] https://www.minecraft.net/en-us

[5] https://brilliant.org/

Overall, teachers' experiences demonstrate that digital tools enhance the subject of mathematics by offering alternative methods and visual aids that engage students in new ways. These tools not only provide more practice opportunities but also allow for clearer demonstrations of complex topics and concepts, like geometry and number learning. By using platforms familiar to students, digital tools help motivate and support students in understanding mathematical ideas, making learning more accessible and effective.

Challenges for School Mathematics

For the teachers in this study, there is no doubt that school mathematics has changed over the years. For example, Sofie claims that "we are now more focused on understanding. […] There's a bit less memorisation and more comprehension". Ole, on the other hand, argues that the fundamental understanding of mathematics is lost if one solely relies on digital tools:

> I think they will miss out on the essential basic skills required. For example, in maths, physically using a protractor. How do you place it on the paper to get the correct angle? If it's only done digitally, they will lose the basic skill of knowing what a protractor is and how to use it in the most elementary way. That will disappear.

Ole believes that physical work with pen and paper is necessary for students to achieve the desired learning outcomes in mathematics. Lars also remarks, "I do think it's unfortunate that so much has become digital, although it certainly offers opportunities. So, I think a good mix is important. Not just one or the other. […] No, it's related to hand-eye coordination. So, I would never fully abandon pen and paper". Kåre, in turn, gives an example of why he believes a combination is crucial:

> I think some students would feel less ownership if everything was done digitally. Research has also shown that holding a pencil triggers different processes in the brain compared to working digitally. So, I think it's very important to do both. Of course, we need to include the digital aspect because we live in a digital world. We can't rely only on pencils and books, but we can't go fully digital either. I think we would lose something very important. […] I believe understanding might be slightly diminished, and students would have fewer tools to work with. They wouldn't be able to just grab a grid book and sketch or make tally marks. They'd feel helpless if they found themselves without a computer one day. It could also affect their confidence and belief in their problem-solving abilities because there are always many ways to solve a problem.

For the participants, the consensus is clear: while digital tools offer significant advantages in mathematics, they cannot entirely replace the value of physical work with pen and paper. They advocate for a balanced approach, combining digital and traditional methods, to ensure that students not only thrive in a digital world but also retain essential problem-solving skills and the confidence that physical tools provide.

Discussion

The integration of digital tools in mathematics education offers both promising opportunities and significant challenges, as reflected in the experiences of the teachers interviewed. A prominent theme that emerged from the study is the potential of digital tools to enhance personalised learning. Several teachers shared examples of how these tools adjust to students' individual needs, allowing for differentiated instruction that is difficult to achieve through traditional methods. For instance, tools like Kikora automatically increase the difficulty of tasks based on student performance, enabling learners to work at their own pace. This aligns with Swensen's (2014) observations on the value of adaptive learning environments, particularly in subjects like mathematics, where student abilities vary widely. By allowing students to engage with material that matches their level of understanding, these tools foster greater independence and confidence in learners, a conclusion supported by previous research (Viberg et al., 2023).

In addition to fostering personalised learning, digital tools were reported to increase student motivation. Teachers described how the gamified aspects of many educational platforms transform mathematics from a subject, which students often find daunting into a more engaging experience. Several participants noted that students see these activities as less stressful and more like games, increasing the possibility of their active participation in lessons. This reflects the findings of Deater-Deckard et al. (2013) and Fadda et al. (2022), who argue that the interactive nature of digital tools can significantly enhance engagement, particularly when compared to more static, traditional learning methods. However, while motivation is a benefit, it is important to consider whether this heightened engagement consistently translates into deeper mathematical understanding, a question that remains open in the literature.

Despite these advantages, the study also reveals significant concerns about the capacity for distraction when using digital tools. Teachers reported that students often become preoccupied with non-educational apps and websites, and this compromises their ability to focus on mathematical tasks. This issue is particularly acute in classrooms where students have open access to the internet or a wide range of apps, leading them to browse social media or play games during lessons. These findings align with those of Klette et al. (2018), who noted that while digital tools can enhance student engagement, they also introduce new distractions that are difficult for teachers to manage. Such distractions can impede the benefits of personalised learning, as students may fail to fully engage with the material, instead rushing through tasks without fully processing their answers.

Related to the issue of distraction is the challenge of over-reliance on digital tools. Some teachers expressed concern that students, particularly those at the primary level, may become dependent on these tools for solving mathematical problems. As Ole pointed out, the frequent use of digital tools for calculations or visualisations could weaken students' grasp of basic mathematical skills. This is consistent with Swensen's (2014) suggestion that over-reliance on technology can impede the development of core competencies, such as mental arithmetic and manual problem-solving, which are essential for building a strong foundation in mathematics. While digital tools offer powerful ways to explore complex concepts, they must be integrated in ways that complement, rather than replace, traditional methods.

Teacher competence with digital tools also emerged as a critical factor influencing their integration into mathematics education. Several participants, particularly those with more years of teaching experience, indicated a lack of confidence in using technology effectively. Teachers, like Sigurd, explained how they often avoid using digital tools due to technical difficulties and additional time required to integrate them meaningfully into lessons. This challenge reflects broader trends in the literature, where insufficient training and a lack of familiarity with digital platforms are cited as major barriers to the effective use of technology in education (Madsen, 2020). For digital tools to fulfil their potential to enhance mathematics instruction, teachers must receive adequate professional development that addresses both technical skills and pedagogical strategies for integrating technology into their teaching.

Interestingly, the teachers in this study also emphasised the need for a balanced approach between digital and traditional teaching methods. While they acknowledged the value of digital tools for promoting engagement and individualised instruction, many expressed concerns that these tools alone are insufficient to develop a full range of mathematical skills. Ole's reflections on the importance of manual tasks, such as using a protractor or completing problems by hand, underline the need to retain aspects of traditional mathematics education, which promotes foundational skills that technology cannot easily replicate. This perspective aligns with the findings of Loong and Herbert (2018), who argue that a combination of digital and manual approaches is necessary to ensure that students develop both conceptual understanding and procedural fluency.

In summary, while digital tools offer considerable advantages in mathematics education – particularly in terms of personalisation and engagement – they also introduce challenges that require careful navigation. Teachers must find ways to leverage these tools without allowing them to dominate the learning process, therefore ensuring that students remain focused to develop the necessary skills to succeed in mathematics. The findings of this study suggest that ongoing professional development is key to equipping teachers with the skills and confidence to integrate digital tools effectively. Moreover, a balanced approach that incorporates both digital and traditional methods may offer the best path forward, allowing students to benefit from the innovations of technology while preserving the strengths of manual problem-solving.

Implications

While this study was conducted within the specific context of Norwegian primary schools, some of the findings can be generalised to broader contexts, while others may remain unique to the local Norwegian educational system. Norway's strong emphasis on digitalisation, as seen in government policies advocating for technology integration (Kunnskapsdepartementet, 2023), provides a context where digital tools are more prevalent than in other educational systems. This has led to particular challenges and opportunities related to access, teacher training, and student engagement, which may not be directly applicable in countries with different levels of technological infrastructure or educational priorities.

Regarding the context-specific interest of our findings, the teachers' concerns about distractions from digital tools, such as students being tempted to engage with non-educational content during class, might be particularly heightened in Norway where individual devices are widely available to students (Klette et al., 2018). Additionally, the specific platforms and tools mentioned by the teachers, such as *Kikora* and *Skolestudio*, are tailored to the Norwegian curriculum, making some of the experiences and feedback context-specific. On the other hand, from a more global perspective, the broader pedagogical challenges of integrating digital tools into mathematics instruction (such as balancing traditional methods with digital tools, fostering student motivation through gamification, and concerns over students losing foundational skills due to over-reliance on technology) are themes that resonate with international research (e.g., Loong & Herbert, 2018; McCulloch et al., 2018). These findings suggest that many of the pedagogical strategies and reflections shared by Norwegian teachers could be relevant in other educational contexts where digital tools are being integrated into classrooms.

Our study highlights implications for practice, teacher education, and policy, both within and beyond the Norwegian context. The effective use of digital tools necessitates significant investment in teacher education (Masoumi & Noroozi, 2023). Building teachers' confidence and skills in utilising these tools is essential. Initial teacher education and professional development initiatives should prioritise equipping teachers with digital pedagogical expertise through hands-on learning, encompassing both technical and instructional applications. Digital tools have the potential to enhance engagement and enable personalised learning, but striking a balance between technology and more "conventional" approaches is crucial. Integrating the strengths of digital tools, such as visualisation and adaptive learning, with analogue approaches, including the use of concrete materials and geometric drawings, can promote a deeper understanding of mathematics (Sarama & Clements, 2016). Furthermore, teachers need strategies to manage distractions in technology-enhanced classrooms. Measures such as restricting access to non-educational apps and websites can help maintain focus (Neuwirth, 2022). In addition, equitable access to quality digital tools and reliable internet infrastructure is vital (Imran, 2023). Funding must address regional disparities and include regular updates to tools, devices, and technical support. Finally, curriculum guidelines should clearly define the role of digital tools in mathematics, ensuring alignment with learning objectives and their integration with traditional methods (Livingstone, 2019).

Reflections on the Use of the Didactical Tetrahedron as a Theoretical Framework

The use of Ruthven's (2012) adaptation of the didactical tetrahedron in this study provided a comprehensive approach to analysing how digital tools shape interactions in the mathematics classroom. Incorporating technology as a fourth component within the traditional teacher-student-content triangle proved particularly useful in understanding the multifaceted impacts of digitalisation. This framework allowed us to recognise not only the potential of digital tools in enhancing instruction but also the complexity of their integration into pedagogical practices. While the application of this framework provided valuable insights within the Norwegian context, it holds broader relevance for global educational settings as well. In any educational environment where digital tools are introduced, the didactical tetrahedron can serve as a robust model for understanding the interplay between teachers, students, content, and technology. By framing technology as an active agent in the learning process, this model encourages educators and policymakers worldwide to consider not just the availability of digital tools, but how they reshape teaching strategies and learning outcomes. This perspective can guide the implementation of technology in classrooms globally, ensuring that it complements rather than disrupts the learning process. Furthermore, the framework's adaptability to various educational settings suggests that its use can transcend local specificities, offering a universal lens through which to examine the integration of digital tools. In contexts where digital tools are being introduced with varying degrees of teacher confidence or student engagement, the didactical tetrahedron helps in identifying and addressing challenges similar to those observed in the Norwegian context, such as teacher preparedness or student distraction. As educational systems around the world continue to embrace digitalisation, the didactical tetrahedron can offer a valuable framework for both researchers and educators to navigate these changes.

Limitations and Suggestions for Future Research

Overall, our findings support several previous studies in this field, contributing to the existing body of knowledge and enhancing the understanding of the topic. This strengthens the confidence in both our findings and the broader literature. However, like many qualitative studies, our research has limitations. One such limitation is that findings from a smaller number of participants may not be easily transferable to all contexts (Brinkmann & Kvale, 2015). While the aim of this study is not to generalise to the wider teacher population of Norway, we acknowledge that a larger number of participants could have provided a more diverse foundation for exploring the possibilities and challenges associated with digital tools.

On the other hand, focusing on one specific school allows us to delve deeply into how teachers there work to ensure good learning outcomes in alignment with societal developments. Although a smaller sample offers less variation, it provides detailed, context-rich insights, which are highly valuable in qualitative research. It is important to recognise that the findings from this particular school may not reflect the experiences of all teachers across Norway. Several factors, such as the municipality's economy, access to digital resources, and individual teachers' experiences with technology, could influence how digital tools are perceived and used in the classroom.

Researchers and practitioners must be mindful of various measures to ensure the quality of the research despite these limitations. Furthermore, the formulation of our research questions acknowledges that the findings will be shaped by subjective experiences, opinions, and interpretations, which is typical in qualitative studies. That said, these limitations present opportunities for further research. If there is a desire to expand this work, we suggest including a broader sample of teachers from different regions in Norway to compare findings and potentially increase the transferability of the results. Additionally, while this study focuses on teachers' perspectives, future research could explore the views of other key actors, such as students, curriculum designers, teacher educators, and parents, offering a more comprehensive understanding of the use of digital tools in mathematics.

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