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The role of digital tools in enhancing classroom assessment practices

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As educational technology becomes increasingly embedded in classrooms, it is crucial to understand how these tools are utilized for both formative and summative aspects of teachers' assessments in the classroom. Through a combination of surveys and semi-structured interviews, the study probes teachers' experiences with technology-enhanced assessments. The findings highlight the benefits of digital tools, such as increased student motivation, immediate feedback, and improved visualization of mathematical concepts. However, the study also reveals the challenges teachers face, including technical difficulties, inequities in access to technology, and the added workload associated with using these tools. The study contributes to a deeper understanding of how digital tools can enhance assessment practices in middle school mathematics, offering insights into the opportunities and obstacles faced by teachers in Türkiye.

Keywords: Formative assessment, summative assessment, technology-enhanced classrooms

Introduction

Digital tools have increasingly become integral to educational environments, particularly in mathematics classrooms (Hillmayr et al., 2020, Moliner et al., 2022). These tools offer various advantages that significantly enhance classroom assessment practices (see Saralar-Aras, 2022). In middle school mathematics, tools like dynamic geometry software, graphing calculators, and online platforms provide teachers with innovative ways to assess student learning.

Formative assessments, which function as improving student learning through adjusting learning environments, are enhanced through the use of digital tools by providing immediate feedback, allowing for real-time adjustments to instruction, and facilitating a more personalized learning experience (Cosi et al., 2020). Teachers can use these tools to identify student strengths and weaknesses more efficiently, enabling a targeted approach to instruction. Digital platforms also allow for continuous monitoring of student progress, making formative assessments more dynamic and responsive to individual student needs. Summative assessments, traditionally used to evaluate student learning at the end of an instructional period (Brookhart, 2001), are also transformed by digital tools (Newhouse, 2014). These tools can automate scoring, offer diverse question types, and provide more detailed analytics, allowing teachers to better understand student outcomes. Furthermore, the visualization capabilities of digital tools help students get better understanding of tasks which facilitates more accurate assessment of their knowledge. However, while digital tools offer numerous benefits for assessment, they also come with challenges (Onasanya & Ajamu, 2024). Issues such as inequity in access to technology, technical difficulties, and the potential for misuse must be addressed to fully harness the potential of digital tools in classroom assessments.

Literature review

Introduction to educational technology in mathematics education

The integration of digital tools in mathematics education has significantly transformed teaching and assessment practices over the past few decades. As early as the 1990s, educational researchers began to explore the potential of technology to enhance learning, with a particular focus on its applications

in mathematics (Kaput, 1992). Today, educational technologies such as dynamic geometry software, graphing calculators, and online platforms have become integral components of middle school mathematics classrooms. These tools provide interactive and accessible ways to deepen students' understanding of mathematical concepts while offering new avenues for both formative and summative assessments.

Formative assessment and digital tools

Formative assessment is an ongoing process used by teachers to monitor student learning, provide feedback, and adjust instruction to improve student understanding and performance throughout a lesson or unit (Cosi et al., 2020). It is a critical component of effective teaching, providing teachers with ongoing insights into student learning and guiding instructional decisions (Black & Wiliam, 2018). Digital tools have been shown to enhance formative assessment practices by enabling immediate feedback, which is essential for adjusting teaching strategies in real-time (Shute, 2008). In addition, dynamic geometry software like GeoGebra allows students to visualize and manipulate geometric concepts, facilitating deeper engagement and understanding (Hohenwarter & Jones, 2007). Teachers can use these tools to create interactive tasks that make students' thought processes visible, aiding in assessment by providing insights into students' reasoning and understanding. By observing students' actions and choices within the software, teachers can gather valuable data that reflects student comprehension, thereby enhancing formative assessment.

Research suggests that when teachers use digital tools for formative assessments, they can more effectively identify student strengths and areas for improvement (Nicol & Macfarlane-Dick, 2006). Furthermore, online platforms and educational apps enable continuous monitoring of student progress, allowing for a more personalized approach to learning. This capability aligns with the growing emphasis on differentiated instruction in mathematics education, where teachers tailor their teaching strategies to meet the diverse needs of students (Tomlinson, 2014).

Summative assessment and digital tools

Summative assessments, aimed at evaluating student learning at the conclusion of instructional periods, have been notably transformed by digital tools. Traditionally confined to paper-based tests, which are often time-intensive to administer and score (Brookhart, 2001), summative assessments now benefit from digital tools that offer automated scoring, diverse question formats, and in-depth analytics, enabling nuanced insights into student performance (Onasanya & Ajamu, 2024). For example, tools like graphing calculators and software such as GeoGebra empower students to engage with complex mathematical problems, allowing educators to assess higher-order thinking skills that are difficult to capture through traditional assessments.

Moreover, integrating digital tools in summative assessments fosters alignment with learning objectives, enabling teachers to design tasks that more authentically mirror real-world applications of mathematics (Hillmayr et al., 2020). The visualization capabilities of these tools aid in deepening students' comprehension of abstract mathematical concepts, thus enhancing the accuracy of knowledge assessments (Clements & Sarama, 2011). Consequently, digital summative assessments not only streamline scoring and expand task diversity but also contribute to a more meaningful evaluation of student understanding.

Challenges in the use of digital tools for assessment

While digital tools offer numerous benefits for formative and summative assessments, their use also presents several challenges. One of the primary concerns is inequity in access to technology, which can exacerbate existing educational inequalities. In middle school mathematics classrooms, not all students may have access to the necessary devices or internet connectivity, creating barriers to effective assessment (Warschauer & Matuchniak, 2010). Additionally, technical difficulties, such as software glitches or connectivity issues, can disrupt the assessment process, leading to frustration for both teachers and students (Inan & Lowther, 2010).

Another challenge is the potential for digital tools to increase the workload for teachers. The implementation of technology-enhanced assessments requires significant time and effort, including learning how to use the tools, creating digital assessment tasks, and interpreting the data generated by these tools (Ertmer & Ottenbreit-Leftwich, 2010). Moreover, managing large groups of students in a technology-enhanced environment can be difficult, particularly when trying to ensure that all students are actively engaged and on task (Sawyer, 2006).

In the context of middle school mathematics in Türkiye, the role of digital tools in enhancing classroom assessment practices is multifaceted (Cumhur & Çam, 2021; Özpınar, 2020). It involves balancing the benefits of immediate feedback and personalized learning with the challenges of accessibility and teacher preparedness. As digital tools continue to evolve, their role in classroom assessments will likely expand, offering new opportunities to enhance student learning outcomes. In this context, we looked at the following research question: How do middle school mathematics teachers in Türkiye perceive the role of digital tools in enhancing classroom assessment practices?

Methods

Research design

This study was designed as a qualitative research project with some quantitative elements and conducted in two phases. In the first phase, 16 middle school mathematics teachers completed an online survey. Participants were purposively selected to ensure diversity in regional representations across Türkiye and included experienced teachers with at least five years of teaching experience. 13 teachers had over 10 years of experience while 3 had between 6 to 10 years.

The survey aimed to gain comprehensive insights into teachers' use of technology for assessment purposes focusing on five aspects: (1) the digital tools used for assessment; (2) examples of their preferred practices; (3) challenges and limitations faced; (4) professional development support received and (5) teachers' anticipations for future development of technology in assessment. It involved both close-ended and open-ended questions. To show the idea of it, a sample question from the survey was "Could you share an example of an effective and/or innovative classroom practice where you used digital technologies for assessment?". The close-ended questions gathered demographic information, identified the type of digital tools used, and assessed the frequency of their use, and inquired about professional development sessions attended that can assist their use of technology for assessment. The open-ended questions asked teachers to provide detailed responses

about their preferred practices, the challenges they encountered and their anticipations regarding the future technologies in assessment. The survey was administered electronically via Google Forms.

In the second phase, 6 teachers were selected for semi-structured interviews from the 16 who completed the survey. Selection was based on two criteria: first, these teachers demonstrated more frequent or varied responses compared to others; second, they represented diversity in gender and geographical area they teach in. The interview protocol was carefully designed to gain deeper insights into their experiences with digital tools in classroom assessment. The interviews were audio-recorded and transcribed for qualitative analysis.

Data analysis

A thematic analysis (Braun & Clarke, 2022) was employed to identify recurring patterns in terms of the opportunities and challenges in teachers' integration of digital technologies into classroom assessment practices. As the first step, teachers' reported assessment practices were categorised based on whether they related to formative or summative aspects, using the "implementation by teacher" component of the classroom assessment model proposed by Black and Wiliam (2018, p. 556). The formative aspects were categorised according to the five formative assessment strategies outlined by Wiliam and Thompson (2007, p. 63): "(1) clarifying and sharing learning intentions and criteria for success, (2) engineering effective classroom discussions and tasks that elicit evidence of learning, (3) providing feedback that moves learners forward, (4) activating students as instructional resources for one another, and (5) activating students as the owners of their own learning". The summative aspects were categorised according to teachers' aim of evaluating what students have learned typically by assigning a final grade, score, or a combination of both (Black and Wiliam, 2018). Subsequently, the recurring patterns in the benefits and challenges associated with each type of assessment were identified.

Findings

This section presents the role of digital technologies in enhancing the participant teachers' classroom assessment practices, focusing on both formative and summative aspects. Teachers' responses underscored the complexity of the issue, linking benefits and challenges to technology itself, its use in assessment more broadly, or specifically in mathematics assessment. Before going into detail, it is useful to first outline the technologies used by the participant teachers which were technological tools for classroom assessment, including online test makers/platforms (Quizizz, Kahoot, Google Forms, Padlet, and Canva), mathematics software packages (GeoGebra and Cabri), digital books and a learning management system provided by the Ministry of National Education (namely, EBA).

The findings suggest that digital technologies significantly enhance formative assessment in mathematics lessons, despite some challenges. Teachers demonstrated adaptability in addressing issues such as students' limited access to technological devices and internet connectivity during formative assessments. They found it easier to switch to alternative plans and blend digital tools with traditional teaching techniques for formative purposes. However, the impact of digital technologies on summative assessment practices appears more limited due to the challenges involved. Issues such as unequal access to technological devices and reliable internet made it difficult for teachers to fully

integrate digital tools into summative assessments like digital tests and coursework projects that require the use of digital technologies. Although teachers were thoroughly probed about their use of digital tools for both formative and summative assessments, their responses were more detailed regarding formative practices. When discussing the integration of digital tools, teachers provided more comprehensive insights into the opportunities within formative assessment, while they viewed potential benefits for summative assessment as less feasible under current conditions. The following two sub-sections will present an overview of the opportunities and challenges reported by teachers.

Benefits of the use of digital technologies for effective classroom assessment

Teachers identified several opportunities that digital tools offer for enhancing classroom assessment practices. The recurring opportunities identified in teachers' responses include increased student participation, efficient use of time, easier visualization of abstract mathematical concepts, convenient access to a wide range of mathematics tasks, and provision of detailed analytics. In Table 1, the first column presents these opportunities, the second column includes teachers' responses as evidence to support these identified patterns and the third column presents the aspects of classroom assessment that were linked to these practices.

Table 1: Teacher-reported opportunities of digital technologies in classroom assessment practices

The benefits	Example supporting evidence	Link to the elements of classroom assessment
Increased student participation	Digital tools help create a stress-free learning environment. Digital games increase students' motivation. Digital tools make it easy to capture students' attention. Digital games and online competitions facilitate peer feedback.	Providing feedback that moves learners forward Activating students as instructional resources for one another Activating students as the owners of their own learning
Efficient use of time	Digital tools provide immediate feedback. Digital technologies facilitate immediate access to a variety of mathematics tasks. Digital tools enable automated marking.	Engineering effective classroom discussions and tasks that elicit evidence of learning Providing feedback that moves learners forward Summative aspects
Easier visualization of mathematical concepts	Digital tools enhance the visualization of abstract mathematics concepts such as absolute value, and geometrical concepts like 3D shapes.	Engineering effective classroom discussions and tasks that elicit evidence of learning Summative aspects
Convenient access to a wide range of assessment tasks	Digital tools provide interactive mathematics tasks. Digital tools and online resources facilitate project-based learning.	Clarifying and sharing learning intentions and criteria for success Engineering effective classroom discussions and tasks that elicit evidence of learning Summative aspects
Provision of detailed analytics	Digital tools provide detailed analysis of students' mistakes.	Formative use of summative tests Summative aspects

Challenges with the use of digital technologies for classroom assessment

While digital tools offer various opportunities to enhance classroom assessment practices, teachers also reported several challenges in using them. These recurring challenges, along with example teacher responses as supporting evidence, are outlined in Table 2.

Table 2: Teacher-reported challenges of using digital tools in classroom assessment practices

The challenges	Example supporting evidence	Link to the elements of classroom assessment
Additional workload	<p>Teachers may need extra preparation to learn how to use specific digital technologies.</p> <p>Developing digital tools that align with learning intentions can be time-consuming.</p> <p>Additional instructions might be required for students and parents.</p> <p>Teachers might need contingency plans for unexpected technical issues.</p>	<p>Summative aspects</p> <p>All five formative assessment strategies</p>
Limited access	<p>Some useful software requires payment.</p> <p>Students might have limited access to technological devices and reliable internet connections.</p>	<p>Summative aspects</p> <p>All five formative assessment strategies</p>
Limited features of existing tools and resources	<p>Readily accessible digital or online materials may not meet the specific needs of students.</p> <p>Available tasks might provide limited opportunities for open-ended and long-answer questions, which are necessary to assess higher-order learning.</p>	<p>Summative aspect</p> <p>All five formative assessment strategies</p>

These challenges can potentially limit the implementation of formative assessment strategies and the effectiveness of teachers' summative assessments. However, teachers seem to manage them more effectively in formative contexts through flexible adaptations. The limited flexibility in using digital technologies for summative assessment appears to stem from the specific demands of summative assessment, which require a higher level of accuracy and fairness in obtaining and interpreting students' scores or grades.

For instance, during interviews, two teachers expressed a preference for digital assessments due to their convenience of scoring exams. However, they noted that this is not feasible under current conditions. One teacher highlighted issues with students' access to technological devices and the potential for unstable internet connections at school. She suggested that allowing students to complete tests outside of school, where they might have better access, could lead to inequities and make it difficult to monitor for cheating. Another teacher pointed out the challenges related to the types of questions that digital technology can automatically assess. He mentioned that relying on digital tests for summative assessment would predominantly limit him to short-answer and multiple-choice questions, which could undermine a comprehensive interpretation of students' learning.

Discussion

The findings suggest that integrating digital technologies has significant potential to enhance teachers' classroom assessment practices, both in formative and summative aspects. Consistent with existing literature, the results indicate that teachers perceive digital technologies as enhancing feedback practices by facilitating immediate feedback (Shute, 2008), visualizing abstract mathematical concepts (Hohenwarter & Jones, 2007), and effectively eliciting student learning while motivating active engagement (Nicol & Macfarlane-Dick, 2006). However, despite the literature highlighting the benefits of digital technologies for summative assessment (Onasanya & Ajamu, 2024), it appears that teachers in this study may have been hesitant to adopt these technologies for summative purposes, potentially due to concerns about meeting the rigid requirements for accurate and fair grading. This difference between teachers' tendency to use digital technology seems to stem from the issues with students' equal access to digital technologies (Warschauer & Matuchniak, 2010) and technical difficulties (Inan & Lowther, 2010).

Conclusion and suggestions for future research

This study has demonstrated that digital technologies offer significant benefits for enhancing classroom assessment practices. However, the challenges associated with their integration must be acknowledged. Ensuring that all students have access to adequate technology is particularly important. Additionally, advancements in educational technology should focus on developing more valid and reliable assessment tools. Future research could explore the design of digital tools that better address teachers' needs for more effective assessment practices and conduct large-scale trials of these tools.

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