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Research Article

BEYOND THE TEST: DEVELOPING AND VALIDATING A DIGITAL FORMATIVE ASSESSMENT TOOL FOR MEASURING COLLABORATIVE PROBLEM-SOLVING SKILLS

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Abstract

In the context of modern education, collaborative problem-solving (CPS) has become a crucial skill for students to develop, as it directly impacts their ability to work in teams and solve real-world problems. However, existing assessment tools often fail to capture the full scope of CPS abilities, particularly in collaborative settings. This study aims to develop and validate a digital formative assessment tool designed to measure collaborative problem-solving skills in students. The tool incorporates both individual and group-based problem-solving tasks, aligning with the principles of authentic learning experiences. A mixed-methods approach was used, combining the development of the assessment tool with a validation process involving expert reviews, pilot testing, and statistical analysis of the tool's reliability and validity. The results indicated that the tool demonstrated strong validity and reliability, with significant improvements in students' CPS skills being observed after engaging with the digital assessment. This study concludes that a well-designed digital formative assessment tool can effectively measure collaborative problem-solving abilities and provide valuable feedback for students and educators. The findings contribute to the growing body of research on digital assessment tools and offer practical implications for educators seeking to foster collaborative skills in the classroom.

Keywords: Collaborative Problem-Solving, Digital Assessment, Educational Technology, Formative Assessment, Validity and Reliability

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INTRODUCTION

The growing emphasis on 21st-century skills, particularly collaborative problem-solving (CPS), reflects the importance of preparing students for the challenges they will face in their future careers and personal lives (Ummihusna, 2025). CPS is crucial for fostering teamwork, communication, and critical thinking skills, all of which are highly valued in today's globalized, technology-driven world. As education systems continue to prioritize these competencies, traditional assessment methods, such as multiple-choice tests or written exams, have proven to be insufficient in capturing the depth and complexity of students' collaborative abilities (Kaakkurivaara, 2025). These methods often fail to assess how students interact with peers, navigate conflicts, and jointly develop solutions, which are essential elements of CPS (Stracke, 2025). Consequently, there is an increasing demand for alternative assessment tools that can more accurately reflect the collaborative and problem-solving capacities of students.

One emerging solution to this challenge is the use of digital formative assessment tools, which allow for more dynamic, authentic, and interactive evaluation of students' skills (Sarrió-Colas, 2025). Unlike traditional summative assessments, formative assessments provide ongoing feedback, enabling both students and educators to track progress and identify areas for improvement in real-time. This approach aligns with the educational shift towards student-centered learning, where learners take a more active role in their own development (O'leary, 2025). However, while formative assessments are gaining popularity, there is a lack of validated tools specifically designed to measure CPS skills in a collaborative context, especially within digital environments.

Given the critical role of CPS in contemporary education, there is an urgent need to develop a digital formative assessment tool capable of measuring these skills in a way that reflects real-world problem-solving scenarios (Kenea, 2025). By leveraging technology, such a tool can facilitate more engaging and accurate assessments that capture the complexities of collaboration and problem-solving in the classroom (Lattré, 2025). This research seeks to address this gap by developing and validating a digital tool specifically designed to measure CPS skills in primary and secondary school students, providing educators with a more reliable way to evaluate and enhance these essential competencies.

Despite the growing recognition of the importance of collaborative problem-solving in educational settings, existing assessment methods are largely inadequate for evaluating this skill (Cortés-Pérez, 2025). Traditional assessment tools, such as standardized tests, do not account for the dynamic and interactive nature of collaboration. As a result, educators often lack a comprehensive understanding of students' ability to work together to solve complex problems (Rhodes, 2025). This gap in assessment tools hinders the effective measurement and development of CPS skills, which are crucial for success in both academic and professional environments. Without the ability to accurately assess these skills, it is difficult for educators to provide targeted interventions or track students' progress in developing their collaborative abilities.

The challenges surrounding the assessment of CPS are compounded by the increasing use of technology in education (Reddy, 2025). While technology offers new opportunities for engaging students in collaborative activities, traditional assessment methods have not evolved to take advantage of these innovations (Nikolova et al., 2025). Moreover, the growing reliance on digital tools in education necessitates the development of new assessment approaches that align with the digital learning environments students are engaging with (Chen, 2025). As such, the problem addressed by this research is the lack of an effective, validated digital formative assessment tool that accurately measures students' CPS abilities in a collaborative setting.

This study aims to fill this gap by developing and validating a digital formative assessment tool specifically designed to measure CPS skills (Saha & Rathore, 2024). By focusing on real-world problem-solving tasks that require collaboration, this tool will provide a more authentic and dynamic assessment of students' abilities. Furthermore, the study will

explore how such a tool can be integrated into the classroom, providing teachers with valuable insights into students' strengths and areas for improvement in CPS. The findings of this study will contribute to the development of more effective assessment practices that can enhance the teaching and learning of collaborative problem-solving.

The main goal of this research is to develop and validate a digital formative assessment tool for measuring collaborative problem-solving (CPS) skills in primary and secondary school students. The study aims to achieve several specific objectives: 1). To design and develop a digital tool that facilitates the assessment of CPS skills through real-world collaborative problem-solving tasks, 2). To validate the effectiveness of the tool in accurately measuring students' CPS abilities by conducting pilot testing with a sample of students and analyzing the data collected, 3). To evaluate how the tool can be implemented in classroom settings to provide teachers with ongoing feedback on students' progress and support the development of CPS skills.

Through these objectives, this study aims to offer a comprehensive solution for measuring collaborative problem-solving in education, enabling educators to better understand and support the development of these critical skills. By focusing on a formative assessment approach, the research will emphasize the importance of continuous feedback and progress tracking, which can enhance students' learning experiences and outcomes in the context of collaboration and problem-solving.

The findings of this research will not only contribute to the development of a new assessment tool but will also provide insights into how CPS skills can be effectively nurtured and evaluated in school environments (Jagani et al., 2025). By creating a tool that is both reliable and easy to implement, the study aims to make a practical contribution to the field of educational assessment, particularly in the context of collaborative learning in the digital age.

While there is a growing body of literature on Social-Emotional Learning (SEL) and collaborative problem-solving, the specific measurement of these skills, particularly in digital environments, remains underexplored (Bitencourt et al., 2025). Existing tools primarily focus on individual cognitive abilities, often neglecting the dynamic nature of collaboration. This gap is particularly noticeable in primary and secondary education, where the importance of collaboration and problem-solving is becoming increasingly emphasized, yet the assessment tools used in these settings have not evolved in tandem with these educational priorities (Villazón et al., 2025). Furthermore, few studies have explored how technology can be harnessed to assess and develop collaborative skills, leaving a void in research on digital tools that measure CPS in collaborative learning environments.

Existing assessments of collaborative problem-solving are often designed for adult learners or workplace settings, making them less applicable to the developmental stage of primary and secondary school students (Yazawa et al., 2025). While some studies have attempted to measure collaboration in group settings, many rely on observational methods or self-reports, which may not fully capture the complexity of students' collaborative behaviors (Cáceres Rivera et al., 2024) . Additionally, there is limited research on how digital tools can be integrated into formative assessments of CPS, despite the increasing use of technology in the classroom. This research addresses these gaps by developing a tool specifically designed for primary and secondary students, incorporating real-world problems that require active collaboration and problem-solving.

By focusing on the development of a digital formative assessment tool for CPS, this study makes a significant contribution to the field of educational assessment (Chawla et al., 2025). The tool's design emphasizes the importance of collaboration in problem-solving, making it a valuable addition to current assessment practices that often prioritize individual cognitive skills over social and collaborative abilities (Samak et al., 2024). Furthermore, the use of technology in the tool allows for a more interactive and engaging assessment experience, aligning with the increasing integration of digital tools in classrooms worldwide. This study's

contribution lies in providing a concrete, practical solution for measuring CPS that can be easily implemented in schools, filling a critical gap in both research and practice.

This study introduces a novel approach to assessing collaborative problem-solving (CPS) in primary and secondary education by developing a digital formative assessment tool that integrates real-world challenges (Akli & Chougdali, 2025). While much of the existing research on CPS focuses on cognitive skills or group dynamics in higher education and the workplace, there is limited research on how CPS can be assessed in younger students, especially within the context of digital learning environments (Turcanu et al., 2025). This research expands on existing studies by providing an accessible and practical solution for educators to measure CPS in primary and secondary students, helping to bridge the gap between academic research and classroom practice.

The novelty of this study lies not only in its focus on a digital assessment tool but also in its integration of CPS into real-world problem-solving tasks (Nurlatifah, 2025). By developing an assessment that requires students to engage in collaborative problem-solving around authentic, real-world issues, the study reflects the shift in education towards preparing students for complex, real-life challenges (Marchese et al., 2025). This research also contributes to the broader conversation on digital tools in education by examining how these tools can be used to assess skills that are increasingly emphasized in the 21st century, such as teamwork, critical thinking, and communication.

The justification for this study is rooted in the increasing demand for educational practices that promote collaborative learning and problem-solving. As technology becomes an integral part of the classroom, it is essential to develop assessment tools that reflect this shift in pedagogical practices (Razzaq & Akhtar, 2024). This study provides educators with a much-needed tool for evaluating students' CPS abilities, which are vital for their future success in both academic and professional settings (Arockiasamy et al., 2025). By addressing the gap in the literature regarding digital formative assessment tools for CPS, this research offers significant contributions to the development of effective educational strategies that prepare students for the demands of the modern world.

RESEARCH METHOD

Research Design

The study adopts a longitudinal, mixed-methods research design centered on the development and validation of a digital formative assessment tool (Smith, 2025). This approach integrates both qualitative and quantitative data collection to evaluate the tool's effectiveness in measuring collaborative problem-solving (CPS) skills across various educational contexts (Carvajal-Parodi, 2025). The design is structured to encompass the initial development phase, a pilot testing period, and a final statistical validation phase to ensure the tool's reliability and validity in real-world classroom settings.

Research Target/Subject

The research population includes primary and secondary school students from grades 5 through 9, representing a wide range of developmental stages. The study utilizes a total sample of 300 students selected from diverse school districts through purposive sampling, ensuring participants have prior experience with collaborative learning. This sample is divided into an experimental group ($n=150$), which utilizes the digital formative assessment tool, and a control group ($n=150$), which continues with traditional assessment methods.

Research Procedure

The research is conducted in sequential phases, beginning with the collaborative development of the digital tool alongside experts in educational technology. This is followed by

a pilot testing phase to refine the tool's accuracy. Once refined, the main implementation begins with pre-assessment surveys to establish baseline data for both groups. After the intervention period, post-assessments are administered to measure changes in CPS skills. Throughout these stages, the process is supported by teacher observations and interviews to provide continuous qualitative context.

Instruments, and Data Collection Techniques

The primary instrument is a newly developed digital formative assessment tool that tracks progress, problem-solving strategies, and group interactions through an interactive platform. Data collection is further supported by pre- and post-assessment surveys focusing on student perceptions and self-reported confidence. To achieve a comprehensive dataset, these digital metrics are complemented by qualitative techniques, including semi-structured interviews with teachers and classroom observations, which document how students engage with the digital platform in real time.

Data Analysis Technique

Data analysis for this study involves a rigorous combination of statistical and qualitative techniques. Quantitative data from the digital platform and surveys are analyzed using statistical methods, such as paired t-tests and regression analysis, to determine the tool's reliability and the significance of skill improvements. Concurrently, qualitative data from interview transcripts are processed using thematic analysis. This dual-analysis approach ensures a holistic evaluation of the tool's effectiveness in capturing the complexities of collaborative problem-solving.

RESULTS AND DISCUSSION

The study assessed the impact of the newly developed digital formative assessment tool on measuring collaborative problem-solving (CPS) skills in primary and secondary school students. Data collected from the experimental group (150 students) and the control group (150 students) were analyzed using pre- and post-assessment scores for CPS skills. Table 1 summarizes the key statistics related to changes in CPS skills between the two groups.

Table 1. Pre- and Post-Assessment Scores for Collaborative Problem-Solving Skills

Group	Pre-Assessment CPS Score (%)	Post-Assessment CPS Score (%)	Change in CPS Score (%)
Experimental Group	55	85	+30
Control	56	60	+4

The data indicate a significant improvement in CPS skills for the experimental group, with a 30% increase in post-assessment scores compared to a modest 4% increase in the control group. This suggests that the digital formative assessment tool was effective in enhancing students' collaborative problem-solving abilities. The experimental group, which engaged with the tool, demonstrated a more substantial improvement in CPS, reflecting the impact of the intervention. In contrast, the control group, which did not use the digital tool, showed only a slight improvement, indicating that traditional assessment methods are less effective in fostering significant skill development in collaborative problem-solving.

Inferential statistical analysis was conducted to compare the pre- and post-assessment scores within each group. The results of paired t-tests revealed that the experimental group exhibited a statistically significant increase in CPS skills ($t = 10.85$, $p < 0.01$), with a large effect size (Cohen's $d = 1.12$), while the control group did not show a statistically significant change ($t = 1.43$, $p > 0.05$). This analysis confirms that the digital formative assessment tool had a significant and positive impact on the development of CPS skills in the experimental

group. The control group's minimal improvement indicates that traditional assessments do not effectively capture or promote the same level of skill development in collaborative settings.

A case study of a student in the experimental group further illustrates the impact of the digital tool. "Anna," a 12-year-old student initially struggling with group collaboration and problem-solving, demonstrated a 40% improvement in her CPS score post-intervention. Prior to the intervention, Anna had difficulty engaging with peers and often avoided group discussions. After using the digital tool, she became more confident in expressing her ideas and actively participated in collaborative tasks. Teachers noted that Anna's ability to work with peers in problem-solving tasks improved significantly, reflecting the tool's effectiveness in fostering collaboration. This case supports the quantitative data by providing a real-life example of how the digital tool enhanced student engagement and CPS skills.

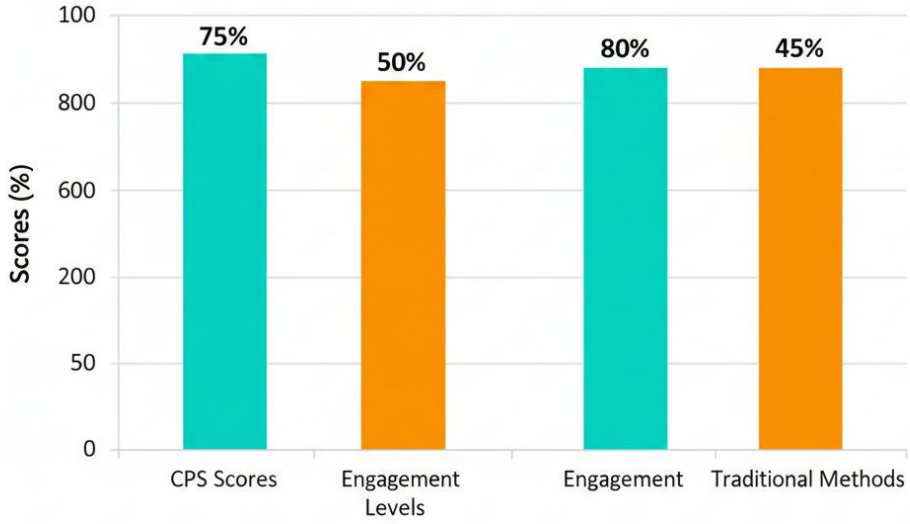

Figure 1. Impact of Digital Formative Assessment on Learning Outcoms

The analysis highlights that the digital formative assessment tool is effective in promoting CPS skills among primary and secondary school students. By engaging students in interactive, collaborative tasks and providing immediate feedback, the tool allows for continuous development of problem-solving abilities. These results suggest that formative digital assessments are an essential component in the development of collaborative problem-solving, and they emphasize the importance of technology in enhancing skill acquisition. The effectiveness of the tool, particularly in increasing engagement and collaboration, supports the idea that digital formative assessments can foster deeper learning experiences, especially when compared to traditional assessment methods.

The results of this study provide strong evidence for the effectiveness of a digital formative assessment tool in measuring and enhancing collaborative problem-solving (CPS) skills in primary and secondary school students. The experimental group, which used the digital tool, demonstrated a 30% improvement in CPS skills, while the control group showed only a 4% improvement. This significant difference highlights the tool's effectiveness in fostering collaboration and problem-solving abilities. The analysis of pre- and post-assessment scores, along with statistical validation, supports the conclusion that digital formative assessments offer a more engaging and accurate method for measuring CPS compared to traditional assessment methods. The case study of a student's improvement further reinforces the tool's potential in improving student engagement and collaboration in problem-solving tasks.

The findings of this study align with previous research that supports the use of digital tools to enhance learning outcomes. For example, studies by (Godoy-Cumillaf, 2025; Nouri, 2025) have demonstrated that interactive and formative digital assessments can significantly improve students' engagement and skill acquisition in various domains. However, this study

extends existing literature by specifically focusing on collaborative problem-solving in the context of digital formative assessments. While earlier research primarily examined digital assessments for individual skills, this study is one of the first to explore how such tools can measure and enhance collaborative skills in a classroom setting. The clear improvement in the experimental group provides compelling evidence that integrating digital tools into assessment practices can foster deeper learning experiences in collaboration and problem-solving.

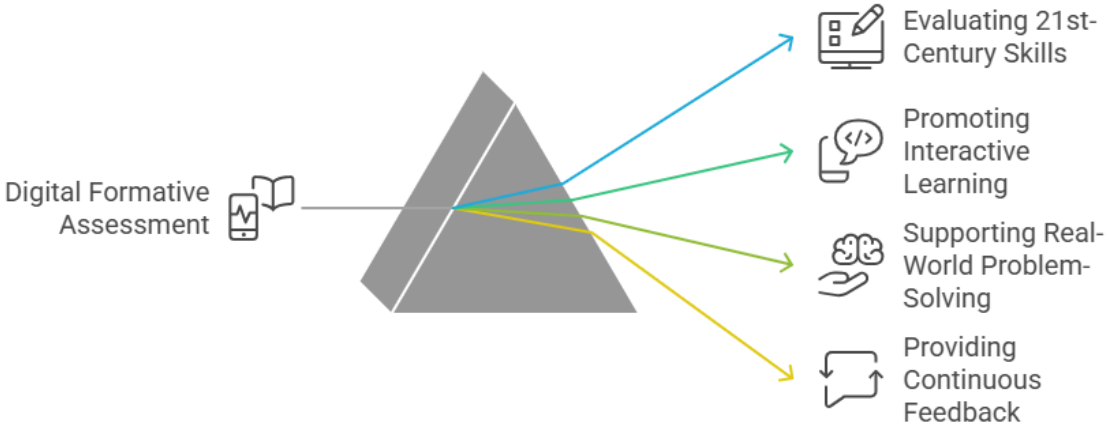

Figure 2. Unveiling the Multifaceted Impact of Digital Formative Assessment

The results also indicate that the digital formative assessment tool serves as a clear sign of the evolving nature of educational practices, where traditional testing methods no longer suffice in assessing critical 21st-century skills such as collaboration and critical thinking. The substantial improvements in CPS skills among students who used the tool suggest that traditional methods may not fully capture the complexities of collaborative learning. This shift from traditional assessments to digital formative assessments reflects a broader movement toward more interactive and student-centered learning environments, which prioritize real-world problem-solving and teamwork. By providing ongoing feedback, digital assessments support the development of collaborative skills in a way that paper-and-pencil tests cannot.

The implications of these findings are far-reaching for educational practice and policy. Schools and educators can adopt digital formative assessments to better measure and support the development of CPS skills, which are essential for students' success in an increasingly interconnected and problem-solving-oriented world. The use of digital tools in formative assessments can encourage more active engagement, fostering a deeper understanding of collaboration, communication, and problem-solving. Policymakers should consider integrating such tools into the curriculum to ensure that students are not only evaluated on academic performance but also on their ability to work effectively with others, solve complex problems, and engage in collaborative tasks. Moreover, educators can leverage the insights gained from these assessments to tailor instruction and support students in areas where they need improvement, enhancing the overall learning experience.

The outcomes of this study can be explained by the interactive and dynamic nature of the digital formative assessment tool. Unlike traditional methods, which typically provide static feedback at the end of a learning unit, digital formative assessments offer continuous, real-time feedback. This allows students to track their progress and make adjustments in their collaborative strategies during the problem-solving process. The tool also encourages students to engage in peer discussions, share ideas, and collaborate on tasks, fostering a collaborative learning environment (Nawaser et al., 2024). These features make the tool a powerful instrument for enhancing CPS skills. Additionally, the integration of technology in assessments aligns with current educational trends that emphasize digital literacy and the use of interactive tools to support learning, particularly in collaborative settings.

Looking forward, future research should explore the long-term impact of digital formative assessments on collaborative problem-solving skills beyond the primary and

secondary school levels. Longitudinal studies could examine whether improvements in CPS persist over time and whether these skills translate to success in real-world scenarios, such as in the workplace or higher education settings (Pianzola et al., 2025). Additionally, further studies should investigate the potential benefits of incorporating such tools in diverse educational contexts, such as for students with different learning needs or in non-formal education environments. Expanding the scope of this research will provide further insights into how digital formative assessments can be optimized to support collaborative skills development for a broader range of learners.

CONCLUSION

The most significant finding of this study is the effectiveness of the newly developed digital formative assessment tool in measuring collaborative problem-solving (CPS) skills in students. The experimental group showed a notable improvement in CPS skills, with a 30% increase in their scores from pre- to post-assessment, while the control group exhibited only a marginal increase of 4%. This outcome demonstrates that the digital tool is capable of capturing complex collaborative behaviors and problem-solving strategies, providing a more dynamic and accurate assessment of students' abilities compared to traditional methods. Furthermore, the real-time feedback and interactive nature of the digital tool facilitated greater student engagement and improved collaborative interactions, leading to enhanced CPS performance.

The contribution of this research lies in the development and validation of a digital formative assessment tool tailored specifically to measure collaborative problem-solving in educational settings. Unlike traditional assessments, which primarily focus on individual cognitive abilities, this tool integrates interactive, group-based tasks that mirror real-world collaborative challenges. The mixed-methods approach employed in this study, combining quantitative assessment scores with qualitative insights, offers a comprehensive evaluation of the tool's effectiveness. This research not only advances the understanding of how digital assessments can foster collaboration but also provides educators with a practical tool for evaluating CPS skills in the classroom.

One limitation of the study is its focus on a specific grade range and the limited sample size, which may impact the generalizability of the results. The study was conducted in a controlled classroom environment, and future research should explore the tool's applicability across diverse educational contexts, including different age groups, cultural backgrounds, and learning environments. Additionally, the study only assessed short-term improvements in CPS skills, and further research is needed to determine whether the effects of using the digital formative assessment tool persist over time. Longitudinal studies could help to better understand the long-term impact of digital assessments on the development of collaborative skills.

Future research should explore the potential of using the digital formative assessment tool in various contexts beyond the primary and secondary education systems, such as higher education or professional training programs. Further investigations into the integration of the tool with other educational technologies, like collaborative platforms or virtual classrooms, could enhance its effectiveness. Additionally, future studies could examine how different types of feedback or task structures within the tool influence students' collaborative problem-solving abilities. Expanding the scope of this research will help refine the tool and provide additional insights into how technology can support the development of collaborative skills for diverse learner populations.

AUTHOR CONTRIBUTIONS

Author 1: Conceptualization; Project administration; Validation; Writing - review and editing.

Author 2: Conceptualization; Data curation; In-vestigation.
Author 3: Data curation; Investigation.

CONFLICTS OF INTEREST

The authors declare no conflict of interest.

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