Journal of Research in Mathematics, Science, and Technology Education
ISSN 3047-5163 (online) & 3047-6933 (print)
January 2026, Vol. 3, No. 1, pp. 24–36

Research Article

Effect of Diverse Assessment Methods on Undergraduate Engineering Students' Performance in Mathematics Courses

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Abstract
Assessment plays a crucial role in shaping how students engage with mathematics in engineering programs. Traditional summative examinations often emphasize rote learning rather than problem-solving or conceptual understanding. This study investigates the impact of diverse assessment methods—including online quizzes, assignments, poster presentations, viva voce, mathematical software applications, note checking, and class participation—on undergraduate engineering students' performance in mathematics courses. The objectives were to evaluate which assessment strategies most effectively enhance learning outcomes and to provide actionable insights for improving assessment practices in higher education. A quasi-experimental design was employed with a sample of second-year undergraduate engineering students enrolled in core mathematics courses. Data were collected using structured quizzes, software-based tasks, poster presentations, viva assessments, and student surveys, and analyzed using descriptive and inferential statistics. Findings revealed that interactive and technology-driven methods, such as online quizzes and mathematical software tasks, had the strongest positive influence on student performance, while passive methods like note checking showed minimal impact. Assignments and viva voce were perceived as valuable for developing analytical reasoning and verbal articulation, although they sometimes generated stress. Poster presentations were effective in enhancing communication and creativity, but received mixed responses regarding mathematical depth. These results align with educational psychology frameworks, suggesting that active engagement reduces cognitive load and enhances intrinsic motivation. The study concludes that integrating diverse and interactive assessments fosters deeper conceptual understanding, problem-solving ability, and sustained engagement among engineering students. Implications for faculty, curriculum developers, policy makers, and educational technologists are discussed, particularly in terms of redesigning assessment frameworks and supporting professional development for educators.

Keywords: Assessment Diversity, Formative Assessment, Mathematical Software, Mixed-Method Research, Online Quizzes, Poster Presentations, Student Engagement, Viva Voce

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Received
June 22, 2025
Accepted
December 5, 2025
Published
January 1, 2026

Citation: Rai, N., Thakkar, Y., & Salvi, R. (2026). Effect of diverse assessment methods on undergraduate engineering students' performance in mathematics courses. *Journal of Research in Mathematics, Science, and Technology Education, 3*(1), 24–36.

DOI: 10.70232/jrmste.v3i1.53

1. INTRODUCTION

In higher education, assessment plays a pivotal role not only in measuring student learning outcomes but also in shaping the learning experience itself. This is particularly true in mathematics, a rigorous and abstract subject that forms the foundation of engineering education. Traditional assessment practices—such as midterm and final examinations—tend to emphasize high-stakes, summative evaluations. While these methods are useful for certification purposes, they often encourage rote memorization rather than the development of conceptual mastery, critical thinking, or problem-solving skills. This misalignment between what is tested and what is educationally valuable raises an important question: Are we truly assessing what matters in mathematics education?

In recent years, educators and researchers have increasingly recognized the importance of diversifying assessment methods to support deeper learning (Carless, 2007). Continuous, formative, and innovative assessments have been shown to encourage active learning, foster critical thinking, and improve long-term retention of mathematical concepts (Nicol & Macfarlane-Dick, 2006). Among these strategies are online quizzes, assignments, poster presentations, class notes checking, viva voce, and the use of mathematical software tools. Each method offers distinct advantages. Online quizzes provide regular practice and immediate feedback, helping students monitor their progress. Assignments promote analytical and problem-solving skills, while poster presentations develop creativity and the ability to communicate complex ideas visually. Notes checking encourages discipline and consistent engagement, and viva voce tests verbal articulation and conceptual clarity. Mathematical software tools such as Scilab, R, and Python applications support visualization and application of abstract concepts, bridging the gap between theory and practice.

For engineering students, mathematics is not only an academic requirement but also a tool essential to their technical training and future careers (Wiliam, 2011). Therefore, assessment strategies in undergraduate engineering mathematics courses must serve multiple purposes. They should reinforce theoretical concepts through application, promote logical and analytical reasoning, encourage active participation, accommodate diverse learning styles, and prepare students to solve complex real-world problems.

This study aims to investigate the impact of diverse assessment methods on the performance of undergraduate engineering students in mathematics courses. By analyzing performance data and student feedback, it seeks to identify which assessment strategies are most effective in supporting academic success, conceptual understanding, and learner engagement. The findings are expected to provide evidence-based recommendations for instructors, curriculum designers, and institutions seeking to improve assessment practices in engineering education.

1.1. Literature Review

A growing body of research highlights the limitations of conventional assessment and the benefits of adopting diverse strategies in higher education. Traditional examinations, while efficient for grading large cohorts, often fail to assess reasoning processes, conceptual clarity, and the ability to apply knowledge to novel contexts (Sadler, 1989; Brookhart, 2004). In contrast, formative and integrative approaches—such as quizzes, assignments, oral examinations, and technology-based assessments—have been shown to promote deeper learning and sustained engagement (Black & Wiliam, 1998; Boud & Falchikov, 2006).

Online quizzes are particularly effective because they promote continuous learning through regular low-stakes testing and provide immediate feedback. Such feedback reduces misconceptions, supports self-regulation, and encourages students to distribute their study efforts over time (Nicol & Macfarlane-Dick, 2006; Nguyen & Kulik, 2020). Assignments, particularly problem-based tasks, extend learning by requiring higher-order reasoning, application of theory, and development of academic writing skills (Biggs, 1996; Ramsden, 2003; Biggs & Tang, 2011).

Poster presentations and visual tasks have gained attention in mathematics education for fostering creativity, communication, and synthesis of ideas (Anderson & Boud, 1996; Race, 2010). They encourage students to explain complex concepts visually and concisely, an essential skill in interdisciplinary fields. However, they can sometimes lack mathematical depth, highlighting the importance of careful design to ensure rigor.

Note checking and viva voce remain less common in mathematics but serve complementary functions. Regular monitoring of class notes promotes attentiveness, discipline, and active listening, though its effect on deeper understanding is limited unless linked to reflective practices (Entwistle & Ramsden, 1983). Oral examinations, on the other hand, provide valuable opportunities to probe conceptual understanding and verbal articulation, but they require well-defined rubrics to minimize subjectivity and stress (Rust, 2002; Srivastava, 2017).

Technology-enhanced assessments, particularly the use of mathematical software such as MATLAB, GeoGebra, Python, or Scilab, have become central to modern engineering education. They not only

improve conceptual visualization and problem-solving but also build technological competence aligned with industry expectations (Arasasingham et al., 2011; Ouyang & Stanley, 2014; Thomas & Holton, 2003). More recent studies confirm that integrating digital tools into assessments fosters autonomy, supports exploratory learning, and enhances motivation (Nguyen & Kulik, 2020).

Across the literature, a consistent theme emerges: no single assessment method is universally effective. Instead, balanced approaches that combine formative and summative, traditional and innovative, individual and collaborative strategies appear to yield the best outcomes (Bloxham & Boyd, 2007). For mathematics education in engineering, such diversity is particularly valuable, as it aligns assessment with the dual goals of building theoretical foundations and fostering applied problem-solving skills.

2. METHODS

2.1. Participants

The study was conducted with second-year undergraduate engineering students enrolled in core mathematics courses at K. J. Somaiya School of Engineering. A total of 186 students participated, selected through convenience sampling based on course enrolment. This approach was adopted because the selected cohorts were readily accessible and represented the standard profile of students undertaking compulsory mathematics courses in engineering programs. The sample consisted of 108 male students (58%) and 78 female students (42%), with an age range of 18–20 years. Participation was voluntary, and informed consent was obtained digitally at the start of the semester. The demographic composition closely reflected the broader student population of the institution, supporting the relevance and generalizability of the findings.

2.2. Instruments

A range of instruments was employed to capture different aspects of student learning and performance. Online quizzes were designed with 10–12 multiple-choice and short-answer items aligned with the course learning outcomes. Each quiz required approximately 25–30 minutes to complete and was administered weekly through the institutional learning management system. Automated scoring ensured objectivity, and reliability testing produced a Cronbach's alpha of 0.82, indicating good internal consistency.

Mathematical software tasks were also used to engage students with Scilab and Python in solving applied problems that demanded both procedural computation and conceptual analysis. Each task lasted 30–40 minutes, and scores were assigned based on accuracy, completeness, and the problem-solving approach. The reliability of these tasks was confirmed with a Cronbach's alpha of 0.86.

In addition, students were given written assignments in the form of weekly tutorials requiring approximately one hour to complete. These assignments focused on applying theoretical concepts to structured problem-solving and were evaluated using a rubric that emphasized correctness, reasoning, and clarity of presentation. Poster presentations were organized mid-semester, in which students individually or in small groups designed posters illustrating mathematical concepts or their engineering applications. Evaluation criteria included creativity, clarity of explanation, and the quality of visual presentation, with standardized rubrics ensuring transparency.

Viva voce assessments were conducted during the latter part of the semester to test conceptual clarity and verbal articulation. Each session lasted 8–10 minutes and was jointly graded by two faculty members. Inter-rater reliability for these assessments was 0.79, demonstrating acceptable agreement. In addition, students' class notes were reviewed twice in the semester to evaluate their organization, completeness, and attentiveness. Although qualitative in nature and contributing marginally to overall scores, note checking served as an incentive for maintaining engagement. Finally, class participation was assessed throughout the semester using a rubric that tracked both the frequency and quality of students' contributions during problem-solving sessions.

2.3. Procedure

The study was conducted across a 15-week semester. At the outset, students were informed about the objectives of the study and assured that participation was voluntary and non-punitive. Assessments were seamlessly integrated into regular teaching to ensure authenticity. Online quizzes were administered weekly through the learning management system, and assignments were collected every week. Software-based tasks were carried out in laboratory sessions with technical assistance available. Poster presentations were scheduled mid-semester, followed by viva voce assessments during the final weeks. Notes checking occurred twice during the semester, and class participation was continuously monitored. To minimize bias, instructors received training in scoring procedures, and anonymized identification codes were used during data entry and analysis.

2.4. Data Collection and Analysis

Both quantitative and qualitative data were collected. Quantitative data included scores from all assessment components as well as final examination results. Qualitative data were obtained from an anonymous survey conducted via Google Forms, which included both structured Likert-scale questions and open-ended items.

Descriptive statistics (mean and standard deviation) were used to evaluate performance patterns across assessment types. One-way ANOVA was conducted to compare mean scores and determine whether statistically significant differences existed between assessment methods. Post-hoc tests (Tukey HSD) were applied where appropriate. Qualitative data were analyzed using thematic analysis to identify key themes such as engagement, motivation, stress, and perceived fairness. Sentiment analysis was also conducted on open-ended responses to capture overall student attitudes toward different assessment methods.

3. RESULTS

This section presents the performance outcomes of students across different assessment methods, followed by their perceptions captured through survey responses.

3.1. Performance Outcomes

Table 1 summarizes student achievement across the seven assessment types. The highest mean scores were recorded for mathematical software tasks (M = 21, SD = 5.3) and poster presentations (M = 18, SD = 4). Online quizzes and assignments both produced a mean of 17, although assignments displayed slightly greater variability. The lowest outcome was observed in note checking, where the mean score was 4 out of 5 (SD = 1). Final examination scores yielded a mean of 30 out of 50 (SD = 10), with the widest dispersion among all assessments.

Table 1. Performance Overview by Assessment Method

Assessment Method	Maximum Marks	Mean Score	Standard Deviation (SD)
Online Quizzes	25	17	6
Assignments	25	17	7
Notes Checking	5	4	1
Viva Voce	10	7.33	1.5
Mathematical Software Task	25	21	5.3
Poster Presentation	20	18	4
End-Semester Exam	50	30	10

Figure 1 illustrates these results as average percentage scores. Mathematical software tasks and poster presentations achieved the highest mean percentages, while note checking accounted for the lowest contribution to overall performance. Final examination results displayed the greatest variability, confirming their role as high-stakes and less predictable assessments compared to continuous methods.

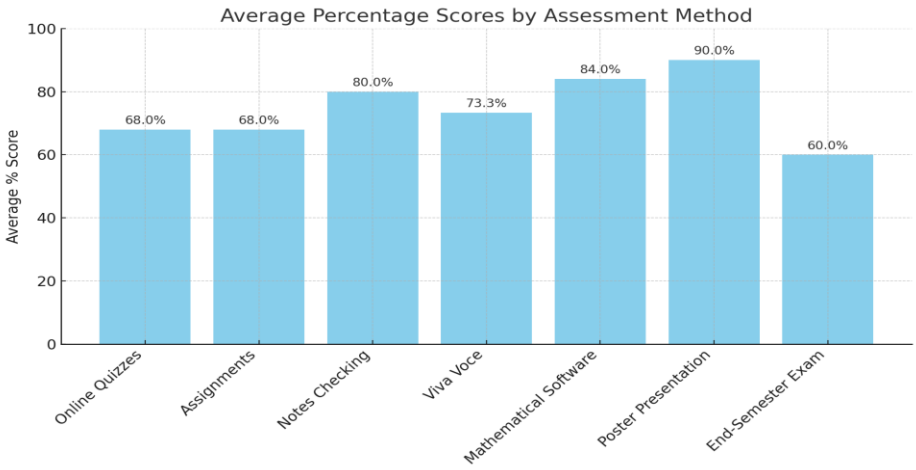

Figure 1. Average Percentage Scores by Assessment Method

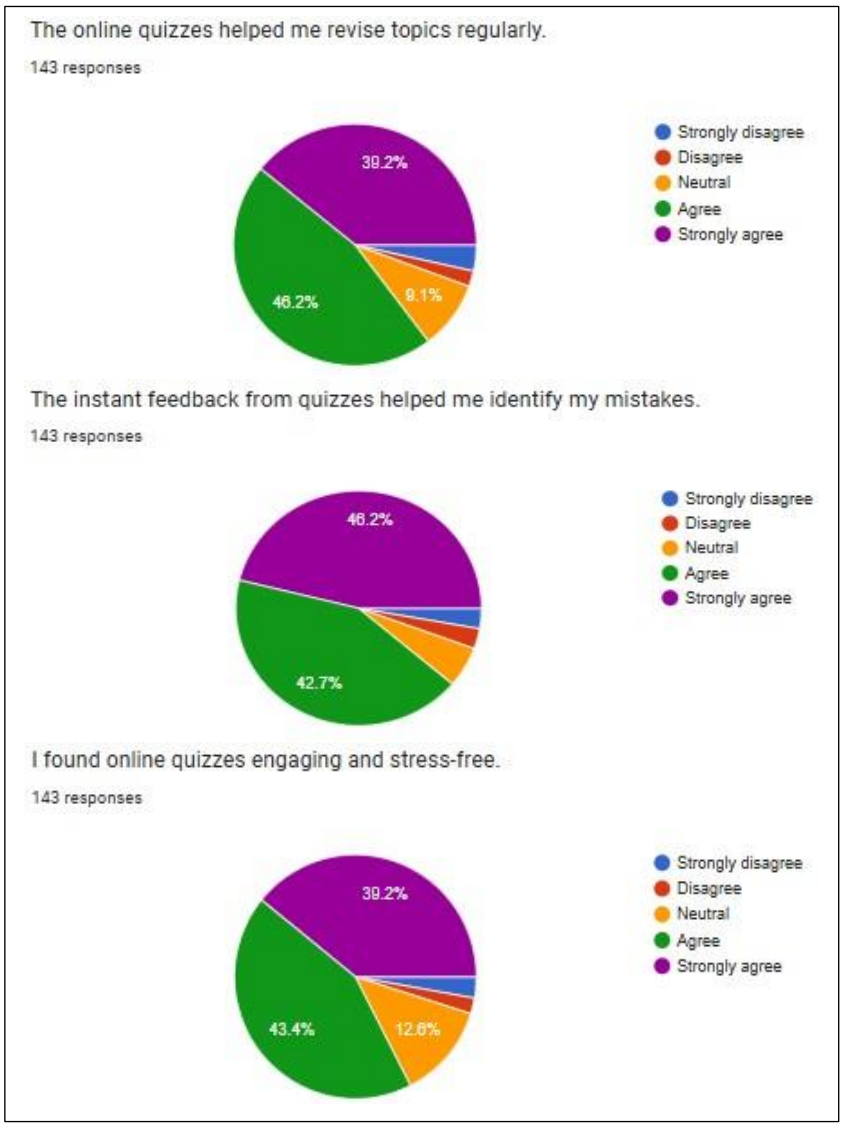

Figure 2. Students' Responses on the Effectiveness of Online Quizzes

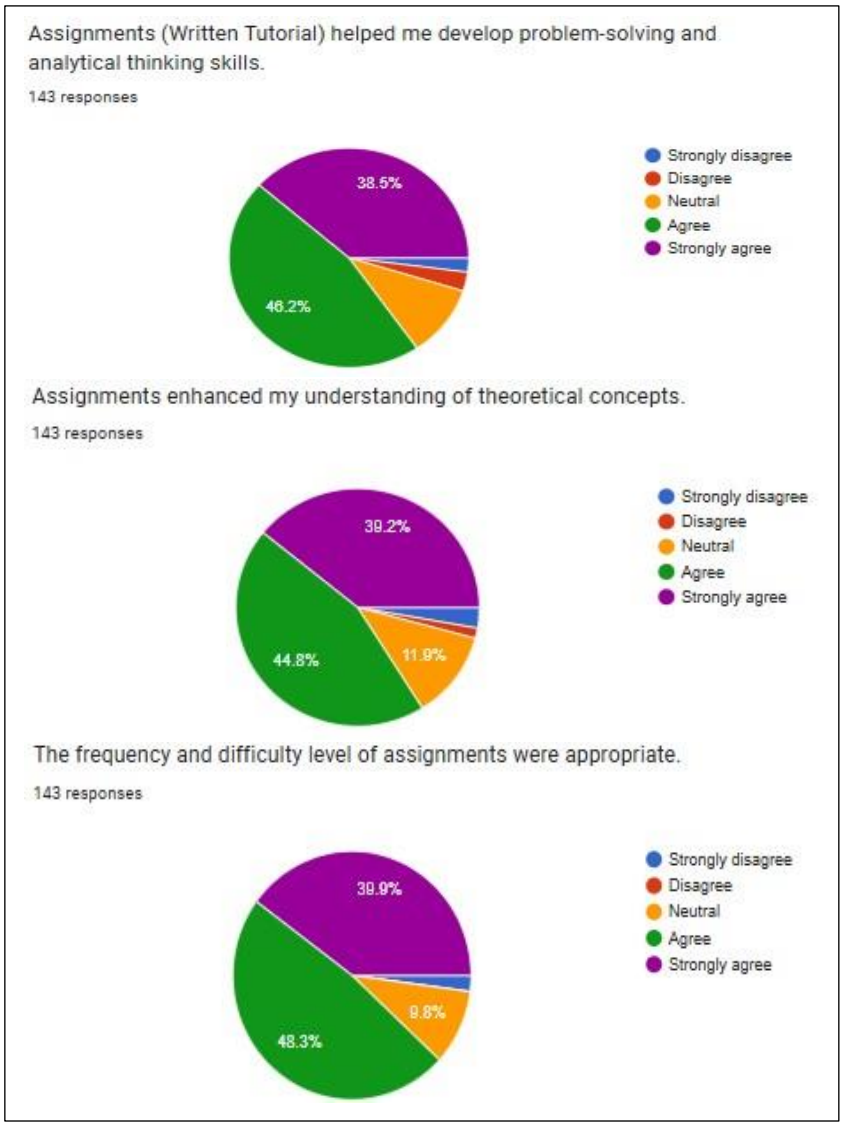

Figure 3. Students' Responses on the Effectiveness of Assignments

3.2. Student Perceptions

Survey responses provided further insight into how students experienced different assessment methods. Online quizzes were strongly endorsed, with 85.4 percent of students reporting that the quizzes supported regular revision, 89 percent valuing the instant feedback feature, and more than 80 percent describing them as a low-stress and engaging experience. Assignments were also well received, as 84.7 percent of respondents indicated that they improved analytical and problem-solving skills, while a similar proportion felt that assignments deepened their theoretical understanding. The majority also found the workload appropriate, suggesting that assignments were effective in balancing challenge with feasibility.

Poster presentations received more mixed responses. Nearly 70 percent of students acknowledged that posters enhanced their communication and presentation skills, while 62.3 percent felt they supported conceptual visualization. However, around one quarter of respondents disagreed, reflecting concerns about their relevance to mathematical rigor. A note checking, in contrast, was viewed more positively as a behavioural reinforcement tool, with 81.9 percent of students stating that it encouraged attentiveness and discipline, although some expressed neutrality regarding its contribution to academic performance.

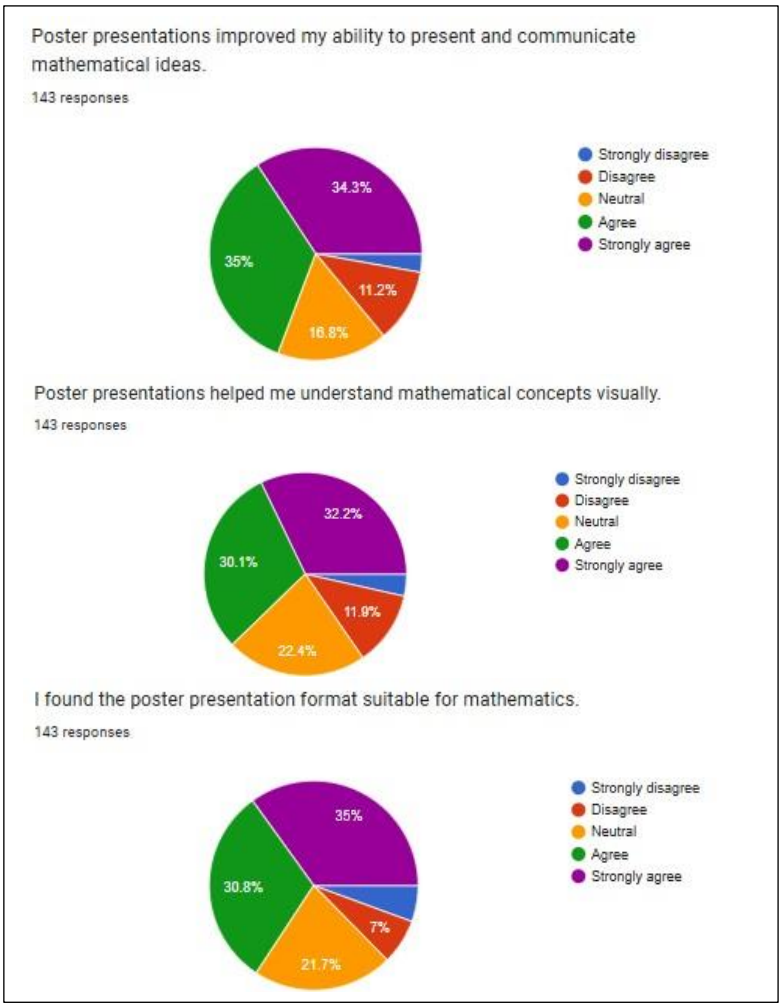

Figure 4. Students' Responses on the Effectiveness of Poster Presentation

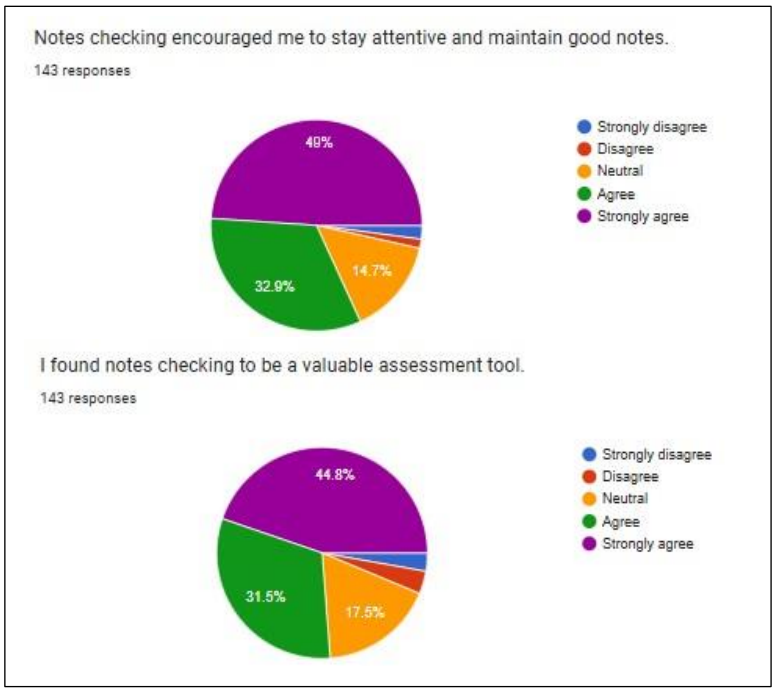

Figure 5. Students' Responses on the Effectiveness of Notes Checking

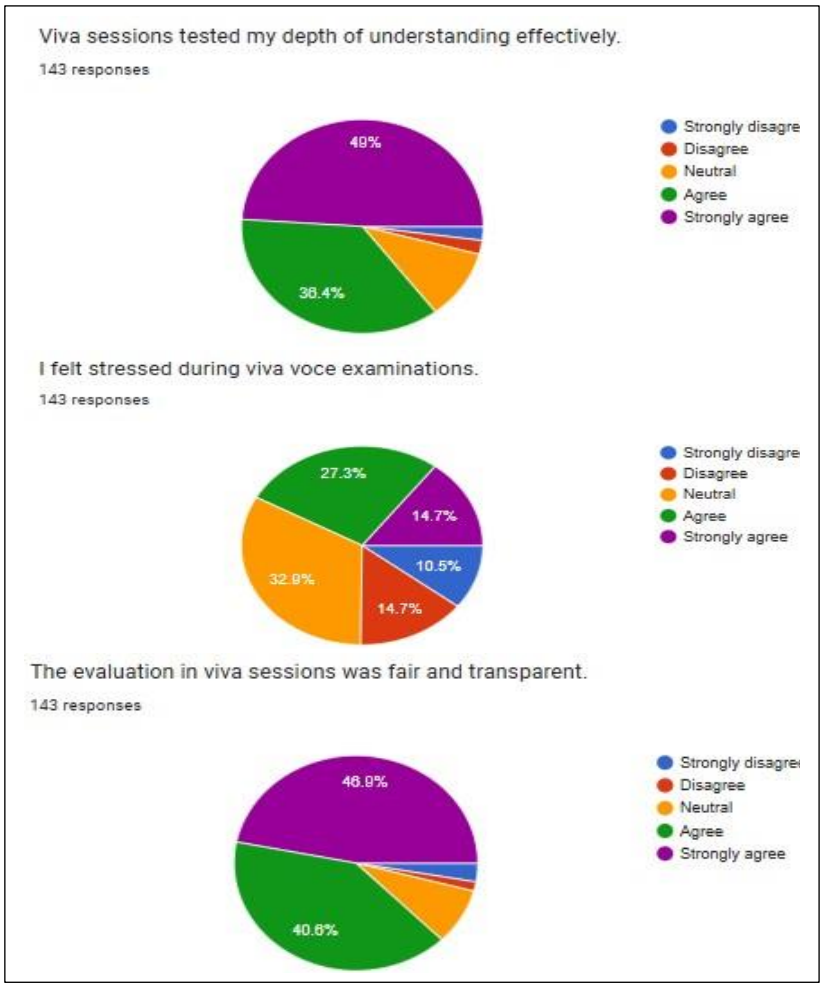

Figure 6. Students' Responses on the Effectiveness of Viva Voce

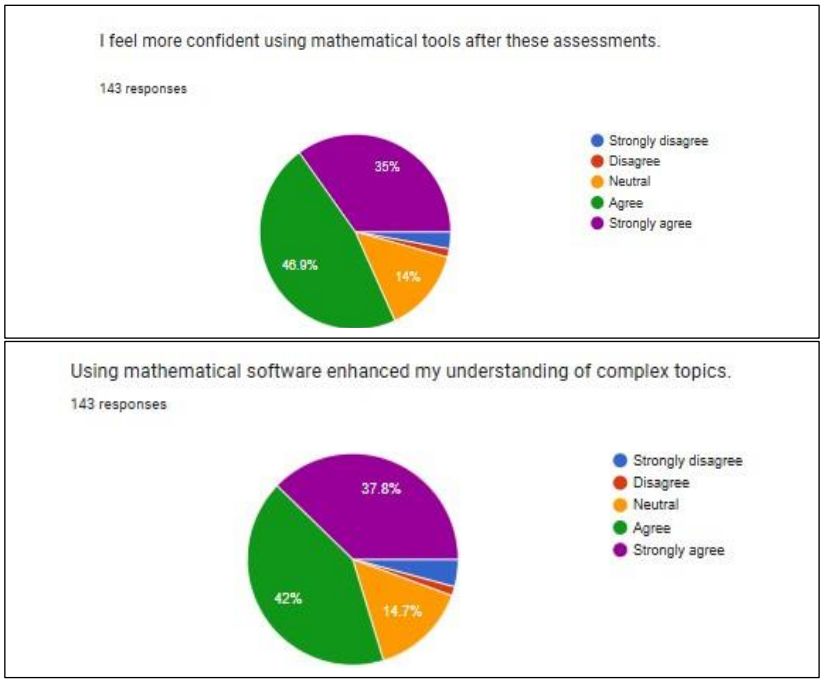

Figure 7. Students' Responses on the Effectiveness of the Software Task

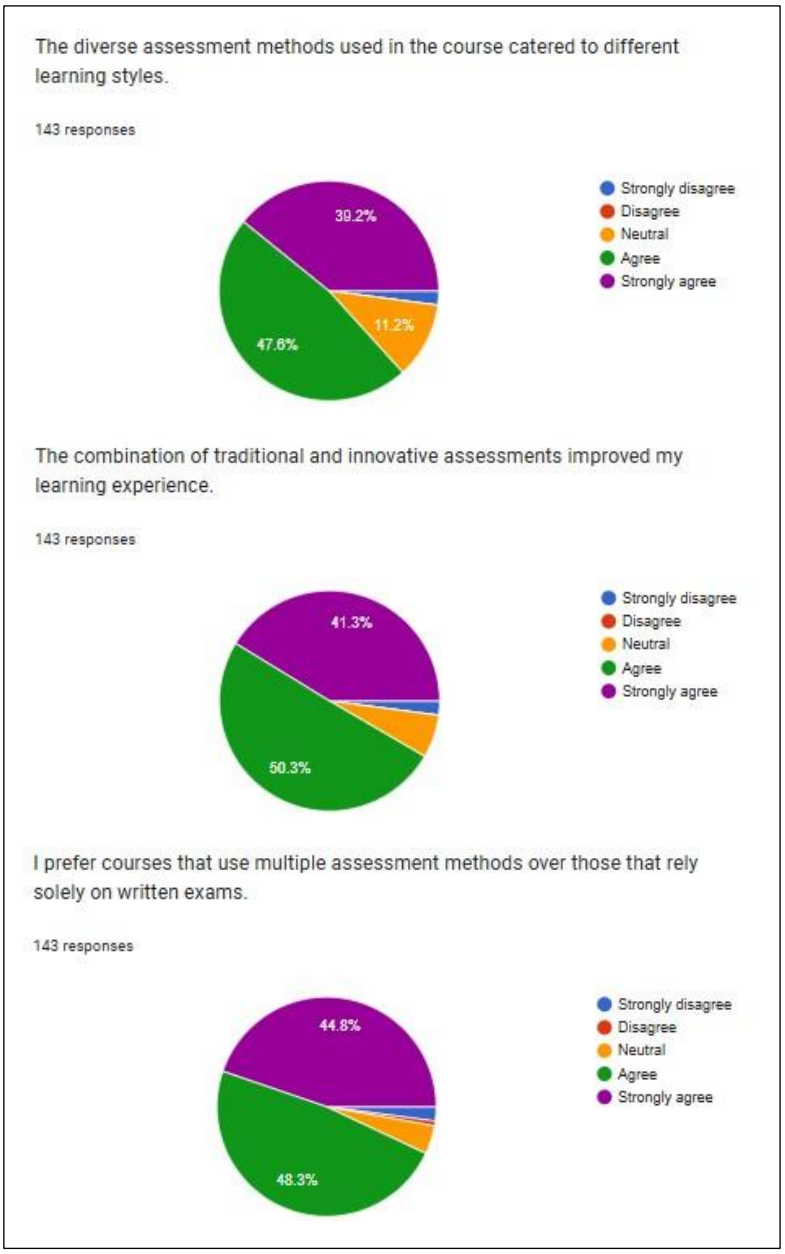

Figure 8. Students' Responses on the Overall Assessment Diversity

Viva voce assessments revealed a similarly nuanced picture. Almost 78.4 percent of students agreed that viva sessions effectively tested their conceptual understanding, and more than 80 percent rated the process as fair and transparent. At the same time, 47.6 percent reported experiencing stress, underlining the need for structured rubrics and preparation strategies. Mathematical software tasks were widely praised, with 79.8 percent of students stating that the software enhanced their grasp of complex concepts and 81.9 percent reporting increased confidence in handling computational tools.

When asked about assessment diversity as a whole, students expressed overwhelming support. More than 93 percent indicated a preference for varied assessments over single-mode evaluation, and 91.6 percent agreed that the combination of conventional and technology-driven methods enhanced their learning experience. Figures 2 through 8 provide a visual representation of these survey responses.

3.3. Sentiment Analysis of Student Feedback

In addition to structured survey items, open-ended student feedback was analyzed to capture the overall tone of responses. The analysis revealed that most comments expressed positive sentiment,

particularly regarding the role of online quizzes and mathematical software in enhancing engagement and understanding. Students frequently emphasized the value of immediate feedback in quizzes and the real-world applicability of software-based tasks as motivating features.

Neutral responses were more commonly associated with poster presentations and note checking. While some students valued poster work for encouraging creativity and communication, others questioned its relevance to mathematical depth. Similarly, notes' checking was perceived as useful for maintaining attentiveness but limited in contributing to conceptual growth.

Negative sentiments, though fewer, were primarily directed at viva voce assessments. Several students noted that the oral format increased anxiety and created a high-pressure environment, even while acknowledging its role in probing conceptual understanding.

Overall, the sentiment analysis supported the quantitative results by demonstrating student preference for interactive, technology-driven, and problem-based assessments over passive or compliance-focused methods. It also revealed nuances in student perceptions, particularly the balance between creativity and rigor in poster presentations and the stress-management challenges associated with oral assessments.

4. DISCUSSION

The results of this study reveal important differences in the effectiveness of diverse assessment methods on student performance in undergraduate mathematics courses. Technology-driven approaches such as online quizzes and mathematical software tasks consistently produced the strongest positive outcomes, while more passive strategies, such as note checking, yielded only marginal effects. Assignments and viva voce assessments contributed positively to problem-solving and communication skills, though they were sometimes associated with stress. Poster presentations, while enhancing creativity and presentation skills, received mixed evaluations regarding their mathematical depth. These findings can be better understood when viewed through the lens of educational theory and prior empirical research.

Cognitive load theory (Sweller, 1988; Sweller et al., 2011) provides one explanation for the superiority of interactive assessments. Online quizzes, by offering frequent practice with immediate feedback, reduce extraneous cognitive load and promote schema development. Similarly, mathematical software tools such as Scilab and Python allow students to focus on higher-level reasoning by offloading routine computations, thereby enhancing germane cognitive load. In contrast, note checking does little to manage cognitive load because it focuses on surface-level compliance rather than meaningful engagement.

The findings can also be interpreted using self-determination theory (Deci & Ryan, 1985, 2000), which highlights autonomy, competence, and relatedness as key drivers of intrinsic motivation. Technology-based assessments provide students with opportunities for autonomy by allowing them to work at their own pace and receive personalized feedback. Competence is reinforced when students successfully engage with problem-solving tasks and software applications, while collaborative elements of poster work and lab-based tasks enhance relatedness. Conversely, assessments like note checking are externally regulated and thus contribute little to intrinsic motivation, which may explain their limited effect on academic performance.

Formative assessment literature also supports these results. Black and Wiliam (1998) demonstrated that timely feedback significantly improves achievement, especially in subjects that build cumulatively, such as mathematics. Online quizzes and software-based tasks in this study served a formative purpose by providing continuous feedback to students and instructors alike. By contrast, viva voce assessments, although effective in probing conceptual understanding, were associated with stress for some students, reflecting challenges noted in earlier studies of oral assessment (Rust, 2002; Srivastava, 2017). Similarly, while poster presentations encouraged creativity and communication, students questioned their relevance for capturing the depth of mathematical reasoning, echoing Race's (2010) caution that such assessments need careful alignment with disciplinary objectives.

Taken together, these results emphasize the principle that the mode of engagement is as significant as the content being assessed. Engineering students benefit most from tasks that mirror the problem-solving and applied nature of their discipline. This explains why technology-enhanced and problem-based assessments yielded higher levels of both performance and student approval. The findings are consistent

with prior research in STEM education showing that blended strategies combining formative feedback, active learning, and technology integration result in stronger engagement and learning outcomes (Nguyen & Kulik, 2020; Ouyang & Stanley, 2014).

5. IMPLICATIONS OF THE FINDINGS

The findings of this study carry important implications for multiple stakeholders in higher education. For instructors, the results emphasize the need to move beyond traditional reliance on high-stakes examinations and adopt a more balanced approach to assessment. Online quizzes, assignments, and software-based tasks can be integrated into regular teaching to provide continuous feedback and foster deeper learning. At the same time, instructors should remain mindful of student stress in assessments such as viva voce and design clear rubrics, provide preparatory guidance, and ensure transparency to reduce anxiety.

For curriculum developers, the study suggests that assessment frameworks in engineering mathematics should be intentionally diversified to include both formative and summative components. Curriculum design must align assessment practices with the dual goals of fostering conceptual mastery and practical problem-solving skills. Poster presentations and collaborative tasks, though sometimes perceived as less rigorous, can still play a valuable role when thoughtfully structured to reinforce disciplinary knowledge while also cultivating creativity and communication skills that are crucial for professional practice.

At the policy-making level, institutions and accreditation bodies can use these findings to guide assessment policies that encourage innovation and flexibility. Rigid reliance on written examinations does not adequately capture the diverse competencies required of engineering graduates. Policies should therefore incentivize faculty to experiment with multiple assessment modes and provide the institutional support necessary for scaling such practices. Embedding continuous assessment practices within institutional frameworks could help ensure that diverse methods are not optional add-ons but integral components of learning.

Educational technologists also play a critical role in supporting effective implementation. The strong student response to technology-driven assessments highlights the need for reliable digital infrastructure and accessible learning management systems. Training programs can equip faculty with the skills to design and administer online quizzes, software tasks, and digital rubrics efficiently. Furthermore, collaboration between faculty and technologists can lead to the development of innovative tools that reduce grading burdens while improving feedback quality.

Finally, the implications extend to professional development initiatives. Faculty development programs should train educators not only in content delivery but also in assessment design, with a focus on strategies that promote active learning, motivation, and fair evaluation. By encouraging reflective practice, such programs can help instructors make informed choices about which assessment methods best serve their students' learning needs.

6. CONCLUSION

This study examined the effect of diverse assessment methods on undergraduate engineering students' performance in mathematics courses. By integrating traditional practices with innovative strategies such as online quizzes, mathematical software tasks, poster presentations, viva voce, note checking, and class participation, the research demonstrated that no single method is sufficient on its own. Instead, a balanced combination of assessments provides a richer and more accurate picture of student learning.

The findings revealed that interactive and technology-driven approaches were the most effective in enhancing performance and engagement. Online quizzes and mathematical software tasks supported continuous learning, reduced cognitive load, and promoted confidence in applying mathematical concepts. Assignments and viva voce contributed positively to analytical and verbal skills, although the oral format generated stress for some students. Poster presentations enhanced communication and creativity, but

received mixed evaluations regarding mathematical rigor. Note checking played a limited role, serving more as a mechanism for discipline and attentiveness than as a tool for conceptual development.

From a pedagogical perspective, these results affirm the importance of aligning assessment with principles of active learning, cognitive load management, and intrinsic motivation. They also underscore the need for professional development and institutional support to enable faculty to design and implement varied assessments effectively. For policymakers and curriculum designers, the study highlights the value of embedding assessment diversity into program structures to prepare students for both academic and professional challenges.

While the study provides valuable insights, it is not without limitations. The sample was drawn from a single institution, and the findings may not fully generalize across diverse contexts. Future research could extend the investigation to multiple institutions, disciplines, and cultural settings, while also examining the longitudinal effects of assessment diversity on retention and long-term skill development.

In conclusion, assessment diversity is not merely a pedagogical choice but a necessity in modern engineering education. By combining traditional, formative, and technology-enhanced strategies, educators can foster deeper understanding, greater engagement, and more holistic development of their students, ultimately preparing them for the complex problem-solving demands of their professional careers.

Acknowledgment. The authors acknowledge the Director of K J Somaiya School of Engineering, SVU, for his constant help and support in using the various technology-based practices to blend with teaching. The author would like to further extend their thanks to the students for being an active part of teaching learning system and participating in all the activities conducted for assessment.

Research Ethics. All procedures performed in this study involving human participants were conducted in accordance with institutional guidelines and approved by the Director and Faculty Development Committee of K. J. Somaiya School of Engineering. Participation was voluntary, and informed consent was obtained from all students.

Data Availability Statement. The datasets generated and/or analyzed during the current study are available from the corresponding author upon reasonable request.

Conflicts of Interest. The authors declare no competing interests.

Funding. The authors received no external funding for this research.

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