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Enhancing Students' Mathematics Performance Through Contextualized Instruction and Technology Integration

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ABSTRACT

Enhancing the mathematics performance of students remains a challenge for mathematics teachers. To address this challenge, this study explored the effect of a contextualized instruction and technology integration approach in mathematics employing a parallel groups pretest-posttest experimental design. A content-validated, researcher-made 60-item multiple-choice test was the primary instrument used in this study. A split-half reliability test was conducted to ensure the internal consistency of the test items. Normality check of the data gathered from the control and experimental groups, consisting of 35 Grade 10 students each, was done using the Shapiro-Wilk test before the conduct of different statistical tests to test the hypotheses of the study. Results showed that both groups demonstrated considerable improvement in their mathematics performance after the intervention. Moreover, the results of the comparison of the posttest scores of the two groups revealed that the experimental group performed significantly better than their peers in the control group. Thus, contextualizing instruction and integrating technology in teaching mathematics can be a promising approach to improving students' learning and achievement. This finding underscores the critical need for teachers' professional development focusing on effective pedagogical use of technology to facilitate active learning and contextualized instruction to promote meaningful learning among students.

Keywords: *contextualized instruction, technology integration, mathematics performance*

Introduction

One of the 21st-century skills every student must possess is critical thinking, especially in a society driven by technology and with the advent of artificial intelligence in the educational landscape. Critical thinking among students can be developed through mathematical problem-solving, which is taught as early as the elementary grades. Fostering students' conceptual understanding of the fundamentals of mathematics is crucial for them to perform well in the subject and to improve their critical thinking skills.

Mathematics is widely accepted as a foundational subject essential for academic achievement and future success, which is why student performance in mathematics continually receives attention worldwide. However, there's been a global decline in students' academic performance in mathematics (OECD, 2023). The Philippines is among the countries that scored poorly on these large-scale international mathematics assessments. It ranked 76th out of 79 participating countries in 2018 and 77th out of 81 in 2022, placing Filipino students among the lowest-performing groups. In 2018, the average math score for Filipino students was 353 points, significantly less than the global average of 489 points. There was no significant improvement in 2022, as scores increased by just two points, from 353 to 355, still far below the 472-point global average. Comparing Filipino students to their international counterparts, it is clear that many are falling behind in their mathematics education and lack sufficient mathematical abilities. The Department of Education views these dismal results as a wake-up call for all education stakeholders to collaborate toward a common goal: providing every student with a quality education. Given this persistent challenge, various pedagogical innovations have been explored to improve mathematics outcomes.

Over the years, different teaching and learning approaches and strategies have been explored to improve students' mathematics performance, such as differentiated instruction, flipped classroom, and online game-based learning (Aribbay et al., 2024; Bal, 2023; Egara & Mosimege, 2024; Hidayat et al., 2024). Another such strategy is the incorporation of contextualized instruction in teaching mathematics, which makes learning more relevant and interactive. Contextualized instruction or contextual teaching and learning, as defined by Main (2024), is "an instructional approach that aims to provide students with a meaningful and relevant education by making connections between the curriculum and real-life situations." Recently, Mahmuti et al. (2025) found that students' mathematics achievement can be enhanced through contextualized instruction. In addition, secondary-level mathematics teachers emphasized the benefit of contextualized teaching in fostering student engagement and understanding (Calo, 2025).

Furthermore, technology integration in the mathematics classroom has also become a necessity because it facilitates active learning and addresses the needs of today's digital learners. Moreover, it can help create an effective learning environment (Serin, 2023). Technology integration is an approach to teaching that makes use of digital tools and applications to facilitate an effective learning experience among students. A study by Canonizado (2024) revealed that technology-aided approaches in teaching mathematics in the elementary grades are positively correlated with learners' motivation, giving emphasis on the impact of supplementing instruction by using technology to activate learning.

From the studies cited above, specific teaching and learning approaches and strategies were examined to gauge students' performance and motivation in mathematics. A study by Kurt and Sezek (2021) explored the effect of multiple intelligences, problem-based learning, peer instruction, and a combination of these methods on students' engagement and scientific process skills. They concluded that a combined method addresses the limitations of both methods. Moreover, Jong et al. (2023) investigated inquiry-based and direct instruction on student learning. They posited that a smart combination of these approaches is often most effective. A study by Boehm-Fischer and Beyer (2024) showed that peer teaching reduces academic procrastination in blended learning using a flipped classroom design. A qualitative study by Grab (2025) exploring the role of artificial intelligence (AI) applications for culturally responsive teaching concluded that AI promotes inclusivity in education through the facilitation of a personalized learning approach by catering to the diverse needs of students.

These recent studies present a knowledge gap regarding the effect of combining teaching approaches on students' performance in mathematics. While there are separate studies validating the educational significance of both contextualized instruction and technology integration in mathematics, there is no study combining these approaches, specifically within the Philippine education context. Consequently, the researchers aimed to fill this gap, with in mind that this combined approach can transform the learning environment, maximizing relevance, student engagement, and conceptual understanding simultaneously. Exploring this area can potentially identify relevant, effective, and applicable instructional methodologies to address the declining performance in both academic and international assessments. Hence, this study was conducted to investigate how effectively combining contextualized instruction and technology integration makes math more relevant and improves student learning. More specifically, this study endeavored to determine if there a significant difference between the performance of students before and after the intervention under the Traditional Teaching Approach (TTA) and the Contextualized Instruction and Technology Integration Approach (CI&TIA), as well as a significant difference between the performance of the students under TTA and CI&TIA after the intervention.

The idea of combining the aforementioned approaches is fundamentally supported by two learning theories: social constructivism and situated learning theory. Contextualized instruction primarily lies in constructivism, which suggests that learners actively construct new knowledge based on their past and current experiences. This knowledge construction is further emphasized by Vygotsky's social constructivism (1978), which stresses the importance of social interaction and a relevant cultural context. Contextualized instruction aligns with constructivism by anchoring abstract mathematical concepts and problems into real-life situations, thereby making mathematics more engaging and relevant.

Contextualized instruction also aligns with Situated Learning Theory (SLT), developed by Lave and Wenger (1991), which posits that learning is a social process and is most effective when knowledge and skills are applied in real-world situations. The current study also draws on the Technological Pedagogical Content Knowledge (TPACK) framework, developed by Mishra and Koehler (2006). In particular, the proposed study focuses on the intersection of pedagogical knowledge (contextualized instruction) and technological knowledge (technology integration) – the Technological Pedagogical Knowledge (TPK). The intersection represents the knowledge that teachers need to know about how technology plays an important role in the teaching and learning process and how technological tools can effectively support the theoretical processes of social constructivism and situated learning. Technology integration meaningfully enhances these processes by facilitating cognitive engagement, promoting collaboration, and addressing the needs of today's digital learners. Delving into TPK, this research aimed to investigate how technology integration enhances contextualized instruction in improving students' performance.

Methods

Research Design

This research utilized an experimental quantitative study design, specifically the Parallel Groups Pretest-Posttest Experimental Design. The researchers implemented the contextualized instruction and technology integration approach (CI&TIA) with one group and the traditional teaching approach (TTA) with the other group. Students under the traditional teaching approach were taught without using any digital tools or applications, and lessons were not contextualized. This design enabled testing the efficacy of using contextualized instruction and technology integration in the teaching of mathematics while holding constant potential confounding variables and reducing bias.

Participants and Locale of the Study

The research participants in this study were composed of two intact sections of Grade 10 students from a national high school in Tumauini, Isabela, Philippines. These students were enrolled during the School Year 2024-2025. The researcher was assigned to teach two sections of Grade 7 students and two sections of Grade 10 students during that same school year. The two sections of Grade 10 students were purposively chosen because they were considered more digitally and technologically exposed than the Grade 7 students. Each section consisted of 35 students, resulting in a total of 70 participants in the study. The randomization of the participants in the two groups was carried out at the class level, following the sectioning procedure of the school at the beginning of the school year, where students are assigned to classes prior to any intervention being planned.

Data Gathering Instrument

To gather the necessary data, the researchers developed a mathematics achievement test. An initial 100-item multiple-choice test was constructed based on a Table of Specification intentionally made for the study, covering all the learning competencies during the second quarter. Pilot testing was then conducted on 40 Grade 10 students over two consecutive days (50 items per day) in one of the national high schools in Cabagan, Isabela, Philippines, to generate good items. After the item analysis, forty (40) items were rejected. The remaining sixty (60) items underwent content validation by three experts and were revised based on their feedback. To assess the validity and item quality, the 60-item test was pilot-tested on 49 Grade 11 students in a senior high school within the same municipality, as suggested by one of the expert evaluators. Subsequently, reliability testing of the test was performed using the split-half method, yielding a Spearman-Brown adjusted reliability coefficient of 0.93, which indicates high reliability.

Data Gathering Procedures

After ensuring the validity and reliability of the mathematics achievement test, approval from the school principal was secured through a letter to conduct the study. A pretest was first administered to establish the equality of the two groups. One group was randomly assigned to receive the contextualized instruction and technology integration approach, while the other group received the traditional teaching approach. The experimentation was conducted by one of the researchers for eight (8) weeks from October 23, 2024, to December 12, 2024. After which, both groups took the posttest, which was constructed parallel to the pretest, to assess changes in their performance in mathematics.

Several steps were taken to enhance the internal validity and minimize the impact of extraneous variables. Both groups were taught by the same teacher to ensure consistency in the delivery of instruction, classroom management, and the explanation of the content. Instructional time, pacing, and sequence of lessons were identical between the control and experimental groups. The learning materials were aligned with the same competency standards, and both groups completed the pretest and posttest under the same test conditions. These measures helped to reduce variability not related to the intervention and to ensure that differences in student performance could not be attributed to differences in teacher behavior, class time, or test administration procedures. With these safeguards in place and the two groups showing comparable baseline performance, the cognitive gains observed in the experimental group can be reasonably attributed to the contextualized instruction and integration of the technologies.

Data Analysis

Before the conduct of various statistical tests, a normality check on the data gathered from the pretest and posttest scores was performed using the Shapiro-Wilk normality test. To test the hypothesis regarding the difference in performance of students in both groups before and after the intervention, the researchers used paired-samples *t*-tests. On the other hand, a Mann-Whitney *U*-test was used to determine if the experimental group performed differently from the control group after the intervention. A nonparametric test was used since the posttest scores of both groups follow a non-normal distribution.

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Ethical Considerations

The researchers fully oriented the participants regarding the experimental study and the data gathering procedure. Informed consent was provided to the participants, who were informed that there was no coercion or forced participation. In response to this concern, the respondents freely signed the consent letter as a manifestation of their willingness to participate. Moreover, to ensure the confidentiality of the data, the names of the participants were not disclosed; instead, codes were used to present the data in the research report. Also, the same technique was used in storing the data, which will be shredded after five (5) years if there are no complaints.

Results and Discussion

This section presents a comprehensive analysis and interpretation of the results, highlighting the potential benefits of combining contextualized instruction with technology integration in mathematics education, particularly in enhancing student performance. Tables are included to aid in understanding the discussion.

Before the start of the experiment, pretest data obtained from both groups were analyzed. A Shapiro-Wilk normality test revealed that the pretest scores of the experimental group (*SW = 0.973, p = 0.536*) and the control group (*SW = 0.978, p = 0.691*) were approximately normally distributed. Subsequently, a test of comparison between the pretest scores using a paired samples *t*-test showed no significant differences between the two groups ($t(34) = 1.76, p = 0.09$). This result establishes that the two groups began at an equivalent baseline or had equal ability before the intervention.

Table 1. Paired Samples t-test Result of the Pretest and Posttest Scores of the Control Group

Test	N	M	SD	t(34)	p	Cohen's d	(95%) CI
Pretest	35	16.14	3.87	-11.73	0.000**	2.11	[-12.87, -9.07]
Posttest	35	27.11	6.23				

***Highly Significant at 0.01 level of significance (two-tailed)*

A paired-samples *t*-test was performed to analyze the mathematics performance of the control group. Before conducting the test, a Shapiro-Wilk normality test was performed on the difference between the pretest and posttest scores. Results showed that the paired differences were approximately normally distributed (*SW = 0.970, p = 0.439*). As shown in Table 1, the students' mean score before the intervention (*M = 16.14, SD = 3.87*) increased by 10.97 points after the intervention (*M = 27.11, SD = 6.23*). With an effect size of 2.11, the magnitude of this difference in scores is very large. This indicates that, on average, students' posttest scores were approximately 11 points higher than their pretest scores. Moreover, the very large effect size shows that the average student after the intervention performs better than 98.26% of the students who took the pretest. The table also indicates a statistically significant difference ($t(34) = -11.73, p < 0.01$) in students' mean scores after the intervention. The above results show that teaching mathematics in the traditional way is still an effective approach to improve mathematics achievement and should not be discarded. This outcome is similar to previous findings highlighting the benefits of traditional teaching approaches in terms of student learning and academic gains (Stockard et al., 2018; Manaud and Aggabao, 2024). These consistent findings suggest that teaching mathematics using traditional approaches is effective in enhancing student performance.

Table 2. Paired Samples t-test Result of the Pretest and Posttest Scores of the Experimental Group

Test	N	M	SD	t(34)	p	Cohen's d	(95%) CI
Pretest	35	14.57	3.86	-23.66	0.000**	2.12	[-21.56, -18.15]
Posttest	35	34.43	5.21				

***Highly Significant at 0.01 level of significance (two-tailed)*

A paired-samples *t*-test was also performed to analyze the mathematics performance of the experimental group. Following a similar procedure, a normality test on the paired differences between the pretest and posttest scores revealed an approximately normal distribution (SW=0.954, p=0.151). As presented in Table 2, the mean score of the experimental group increased by 19.86 after exposure to a contextualized instruction and technology integration approach. This significant increase in the mean score is supported by a very large Cohen's *d* effect size of 2.12. This implies that the experimental group scored, on average, approximately 20 points higher in their posttest. Moreover, the very large effect size indicates that the average student after the intervention performs better than 98.3% of the students who took the pretest. Results from the table also show a considerable improvement in the posttest scores of students exposed to contextualized instruction and technology integration approach ($t(34) = -23.66$, $p<0.01$). The above results provide compelling evidence that contextualized instruction and technology integration as a combined approach to teaching can effectively enhance mathematics achievement. This finding aligns with that of Bottge and Cho (2013) and Mahmuti et al. (2025) that contextualized instruction can significantly enhance student achievement in mathematics and that integrating technology in teaching has a generally positive effect on improving mathematics achievement (Cheung and Slavin, 2013; Tan et al., 2021).

Table 3. Mann-Whitney U-test Result Between the Posttest Scores of the Control and Experimental Groups

Groups	N	Mean	Median	SD	U	z	p-value	r
Control (TTA)	35	27.11	26	6.23				
Experimental (CI&TIA)	35	34.43	33	5.21	177	-5.12	0.000**	0.71

***Highly Significant at 0.01 level of significance (two-tailed)*

To evaluate the effectiveness of the contextualized instruction and technology integration approach on students' mathematics performance, a Mann-Whitney *U*-test was conducted. This statistical test thoroughly examined the posttest scores of both control and experimental groups. The Mann-Whitney *U*-test was chosen because the Shapiro-Wilk normality test revealed non-normal distribution patterns for the posttest scores of both the control group ($SW = 0.861$, $p < 0.001$) and the experimental group ($SW = 0.915$, $p < 0.05$). The results, shown in Table 3, revealed a significant difference in posttest scores between the experimental group ($Md = 33$, $n = 35$) and the control group ($Md = 26$, $n = 35$), with $U = 177$, $z = -5.12$, and $p < 0.01$. Furthermore, the effect size was found to be large ($r = 0.71$). This means that the scores of the two groups after the intervention vary widely, which suggests that the intervention led to a much stronger outcome for the experimental group compared to the control group. It is also important to note that the pretest mean score of the control group is higher than that of the experimental group. Conversely, the posttest mean score of the former is lower than that of the latter. This is a clear indication that students under the contextualized instruction and technology integration approach demonstrated better performance than their peers in the other group. This result indicates that combining contextualized instruction with technology use in teaching was more effective than traditional teaching. This finding affirms the study of Jong et al. (2023), which suggests that a teaching approach is most effective and supports student learning when supplemented with an instructional strategy.

The better performance of the experimental group, as evidenced by their mathematics achievement, is deeply rooted in educational psychology theories. By relating mathematics to the real world and translating it to a local context, which makes it relevant and fosters discovery learning, contextualized instruction and technology integration approach aligns with Vygotsky's constructivism as it brings abstract concepts into the students' Zone of Proximal Development. The strong performance of the experimental group is also supported by Lave and Wenger's situated learning theory because it moves the learning process from abstract knowledge to legitimate peripheral participation, making mathematics more meaningful and relevant. These processes are then amplified by the positive effects of integrating technology in teaching.

Conclusion and Future Works

The results of the study call for a pedagogical change in mathematics education, advocating a shift towards modern, hybrid, and student-centered approaches that move beyond sole reliance on traditional instruction. However, mathematics teachers should not discard foundational practices like direct instruction, but rather integrate them into modern methods such as contextualized instruction and technology integration to deepen understanding, foster critical thinking, and maximize student learning outcomes. The findings acknowledge the potential benefits of rationally combining teaching methodologies to foster student learning and improve mathematics performance. Thus, this combined approach of teaching mathematics is recommended. Moreover, mathematics teachers are encouraged to periodically attend trainings or seminars to broaden their technological, pedagogical, and content knowledge to effectively integrate real-world context and digital tools in their teaching. Given the limitations of the study, particularly in its short-term implementation, further studies could explore its long-term effects by conducting a longitudinal study. Researchers may also consider its impact on students' engagement, attitude towards mathematics, and other affective factors. A similar study may also be conducted to verify the generalizability of the intervention's effectiveness by considering different geographical settings or other subject areas. Furthermore, a qualitative investigation or mixed-method research can be conducted to validate the empirical findings of the study.

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Conflict of Interest

The authors declare that there are no conflicts of interest regarding the publication of this paper.

Artificial Intelligence (AI) Declaration Statement

The researchers declare the use of Artificial Intelligence (AI) tools, such as Grammarly, QuillBot, ChatGPT, and Gemini, to enhance the overall readability of the paper. All the ideas and content were originally composed and collectively written by the researchers. These AI tools were used solely to refine and polish sentence structure to ensure correct grammar, clarity, and coherence. The authors assume full responsibility for the originality, accuracy of the results, and academic integrity of this research.