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Transforming Mathematics Learning Through Interactive Strategies

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Abstract: *Student engagement is essential for improving learning and helping students develop a deeper understanding of Mathematics. This study looked into how engaged Grade 11 students at Bukidnon State University – Secondary Laboratory School were before and after using interactive learning strategies. A student engagement questionnaire was used to gather insights. Before the intervention, their overall engagement was described as "Fair." After two weeks of activities such as collaborative problem-solving, gamified learning, and technology-based lessons, their engagement improved to "Positive." The results showed a clear difference before and after the intervention, confirming that these strategies had a positive impact. This suggests that interactive learning strategies can truly help make Mathematics more engaging for students.*

Keywords— Student Engagement, Interactive learning strategies, Gamified learning, Technology Integration

1. INTRODUCTION

Academic success depends on students' involvement and understanding of math. Conventional lecture-based teaching strategies frequently fall short in keeping students' attention and efficiently promoting learning. In order to improve engagement, Slavin's (2015) research highlights the value of interactive technologies, including group projects and gamified learning. In order to enhance student learning experiences, this project aims to apply interactive learning techniques such as cooperative problem-solving, educational games, and technological integration. These techniques, which are based on Ryan and Deci's Self-Determination Theory and Vygotsky's Zone of Proximal Development (ZPD), encourage social interaction, motivation, and experiential learning while developing critical thinking and problem-solving abilities.

Despite the significance of mathematics, many students struggle with engagement and comprehension due to conventional teaching approaches that lack interactivity. This challenge is particularly evident among Grade 11 students at Bukidnon State University Secondary Laboratory School, who experience difficulties in grasping mathematical concepts. The need for innovative teaching strategies that emphasize active learning and motivation is crucial to address this issue. Integrating gamified learning, technology, and collaborative discussions may enhance students' understanding and interest, ultimately improving their academic performance and attitude toward mathematics.

Several studies have explored the impact of interactive learning strategies, including collaborative problem-solving, gamified learning, and technology integration, on mathematics instruction for senior high school students in the Philippines. One relevant study is the "Strategies Employed by Senior High School Students in Learning General Mathematics" (Palumar, 2023), which identifies the strategies students use in learning mathematics and how these are related to their academic performance. The study found that students utilized cognitive, metacognitive, and collaborative strategies effectively, which contributed to satisfactory academic outcomes.

Another key piece of literature is a review titled "Unveiling the Effects of Gamification on Math Learning: A Literature Review in the Philippine Context" (2023), which highlights the positive outcomes of gamified learning, including increased student engagement and improved academic performance. The review specifically emphasizes the impact of game elements such as competition, rewards, and collaboration on students' learning motivation. Moreover, the study "Teaching Senior High School Mathematics: Problems and Interventions" (Punzalan & Punzalan, 2019) investigates the challenges faced by Mathematics teachers in the Philippines and the innovative strategies they implemented to improve student learning. Additionally, research on the effectiveness of Mathematics gamified applications, though not specified to the Philippines alone, suggests that gamification is a powerful tool in enhancing numeracy and academic performance by making learning more interactive and engaging.

However, despite these insights, existing research does not fully explore how these interactive learning strategies, particularly collaborative problem-solving, gamified learning, and technology integration specifically impact the mathematics comprehension and performance of senior high school students in the Philippines. Most studies either focus on higher education, generalized STEM education, or specific aspects of technology integration in the classroom. This leaves a significant gap in understanding how these strategies can be applied effectively at the senior high school level, particularly in Philippine education. These studies suggest that while there is existing research on these interactive learning strategies in the Philippines, there is still room to explore their specific impact on senior high school students' Mathematics comprehension and performance, especially within the unique context of the Philippines' educational landscape.

This study investigated the relationship between interactive learning strategies and student engagement in Mathematics. The independent variable was the implementation of interactive learning strategies, such as collaborative problem-solving, gamified learning, and technology integration. The dependent variables are student engagement levels before and after the intervention. By analyzing the effectiveness of these strategies, the study aimed to determine whether there is a significant difference before and after students are exposed to the intervention.

1.1 Action Research Questions

This action research aimed to examine student engagement in mathematics at Bukidnon State University Secondary Laboratory School, Malaybalay City. Specifically, this study seeks to answer the following questions:

1. What is the level of student engagement in mathematics before being exposed to interactive learning?

2. What is the level of student engagement in mathematics after being exposed to interactive learning?

3. Is there a significant difference in student engagement before and after being exposed to interactive learning?

2. METHODOLOGY

2.1 Research Design

This study employed a quantitative research design, specifically a descriptive research design. Descriptive research focuses on analyzing and interpreting data to describe characteristics, trends, and relationships. In this study, the researchers aimed to determine whether there is a significant difference between the pretest and posttest scores of students exposed to intervention.

To achieve this, the study utilized the paired t-test, a statistical method that compares two related samples to assess changes over time. This approach helped identify variations in student engagement levels based on pre-test and post-test assessments.

2.2 Participants of the Study

The participants of this study were Grade 11 students enrolled in Statistics and Probability at Bukidnon State University Secondary Laboratory School for the school year 2024-2025. The study involved the total population of 88 Grade 11 students, who provided data on their engagement levels before and after the intervention.

2.3 Research Locale

This study was conducted at Bukidnon State University Secondary Laboratory School, Casisang Annex Campus, Malaybalay City, Bukidnon, during the academic year 2024-2025. The school, located in Purok-6, Malaybalay City, Bukidnon, serves as the setting for the implementation and evaluation of interactive learning strategies in mathematics. The Secondary Laboratory School, an integral unit of the esteemed College of Education, offers a complete junior high school program from Grades 7 to 10, as well as the STEM Strand in Senior High School.

2.4 Research Instrument

The primary data collection tool for this study was a structured questionnaire, administered as both a pre-test and post-test to measure student engagement in mathematics. This instrument was adapted from the questionnaire utilized in the study by Antipuesto and Tan (n.d.), titled Academic Performance and Engagement in Mathematics via Blended Learning.

The questionnaire consists of 33 statements, where participants indicated their level of agreement using a five-point Likert scale:

Table 1: Rating Scale

Rating	Scale	Descriptive Rating	Qualitative Interpretation
5	4.51 – 5.00	Strongly Agree	Highly Positive (HP)
4	3.51 - 4.50	Agree	Positive (P)
3	2.51 - 3.50	Undecided	Undecided Fair (F)
2	1.51 - 2.50	Disagree	Disagree Negative (N)
1	1.00 - 1.50	Strongly Disagree	Highly Negative (HP)

3. RESULTS AND DISCUSSION

Level of engagement of students exposed to interactive learning strategies before the intervention

Table 2. Mean and Standard Deviation of Students Mathematics Engagement Before the Intervention

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Engagement in Mathematics	Mean	SD	Interpretation
I go through the work for math class and make sure that it's right.	4.147	0.384	P
I think about different ways to solve a problem.	3.704	0.480	P
I try to connect what I am learning to things I have learned before.	4.079	0.474	P
I try to understand my mistakes when I get something wrong.	4.477	0.734	P
I would rather be told the answer than have to do the work.	2.613	0.034	F
I don't think that hard when I am doing work for class	2.681	0.472	F
When work is hard, I only study the easy parts.	2.613	0.144	F
I do just enough to get by.	3.147	0.467	F
I stay focused.	3.681	0.551	P
I put effort into learning math.	4.193	0.071	P
I keep trying even if something is hard.	4.193	0.293	P
I complete my homework on time.	3.761	0.103	P
I talk about math outside of class	3.056	0.339	F
I don't participate in class.	2.25	0.275	N
I do other things when I am supposed to be paying attention.	2.602	0.202	F
If I don't understand, I give up right away.	2.125	0.148	N
I look forward to math class.	3.340	0.984	F
I enjoy learning new things about math.	3.852	0.570	P
I want to understand what is learned in math class.	4.215	0.944	P
I feel good when I am in math class.	3.079	0.519	F
I often feel frustrated in math class.	3.545	0.075	P
I think that math class is boring.	2.511	0.472	F
I don't want to be in math class.	2.318	0.833	N
I don't care about learning math.	1.909	0.749	N
I often feel down when I am in math class.	2.625	0.250	F
I get worried when I learn new things about math.	2.613	0.694	F
I build on others' ideas.	3.613	0.111	P
I try to understand other people's ideas in math class.	4.261	0.485	P
I try to work with others who can help me in math.	4.420	0.770	P
I try to help others who are struggling in math.	3.875	0.770	P
I don't care about other people's ideas.	1.681	0.864	N
When working with others, I don't share ideas	1.909	0.936	N
I don't like working with classmates.	1.715	0.190	N
Overall Mean	**3.1758**	**0.86735**	**F**

Legend:

Rating	Scale	Descriptive Rating	Qualitative Interpretation
5	4.51 – 5.00	Strongly Agree	Highly Positive (HP)
4	3.51 - 4.50	Agree	Positive (P)
3	2.51 - 3.50	Undecided	Undecided Fair (F)
2	1.51 - 2.50	Disagree	Disagree Negative (N)
1	1.00 - 1.50	Strongly Disagree	Highly Negative (HP)

Table 2 presents the pre-test results of student engagement in mathematics prior to the implementation of interactive learning strategies at Bukidnon State University Secondary Laboratory School. The data were gathered from 88 Grade 11 students enrolled in Statistics and Probability, using a 33-item questionnaire on a five-point Likert scale. The statements addressed cognitive, behavioral, emotional, and social aspects of student engagement, with qualitative interpretations categorized as Highly Positive (HP), Positive (P), Fair (F), and Negative (N). The pre-test findings indicated that students generally demonstrated positive engagement in terms of cognitive effort and collaborative learning. High mean scores were recorded for statements such as “I try to understand my mistakes when I get something wrong” (M = 4.477), “I want to understand what is learned in math class” (M = 4.215), and “I try to work with others who can help me in math” (M = 4.420). These responses suggest that prior to the intervention, many students were already inclined to put effort into learning and collaborating with peers. However, fair and negative engagement levels emerged in emotionally and behaviorally related indicators. Responses like “I don’t participate in class” (M = 2.25), “If I don’t understand, I give up right away” (M = 2.125), and “I don’t care about learning math” (M = 1.909) reflected a lack of confidence, low classroom participation, and weak emotional connection to the subject.

The pre-test results suggest that while students showed cognitive readiness and willingness to collaborate, they lacked consistent emotional and behavioral engagement. These patterns indicate a gap between motivation to learn and actual participation or emotional connection to math learning. This disconnect may be attributed to the limitations of traditional teaching methods, which often emphasize content delivery over interactive, student-centered learning. The need to strengthen emotional support and increase motivation through dynamic and engaging instructional strategies is evident in the data.

This pattern aligns with the findings of Attard and Holmes (2020), who emphasized that although cognitive engagement can be present in traditional learning settings, emotional and behavioral engagement require intentional, strategic interventions, such as the integration of technology and student-centered pedagogies, to be fully activated. Their research underscores the importance of creating learning environments that actively engage students emotionally and behaviorally, not just intellectually. This is particularly relevant to the study, which identified a gap between cognitive readiness and actual participation or emotional connection to math learning.

Similarly, Barana et al. (2021) observed that without interactive elements, even strong cognitive engagement can fall short in fostering deeper emotional and behavioral involvement. Their study highlighted that traditional learning environments, whether digital or face-to-face, often lack the interactivity necessary to fully engage students on multiple levels. This supports the idea that interactive learning strategies, such as those employed in our intervention, are essential to engage students across all dimensions of engagement.

Level of engagement of students exposed to interactive learning strategies after the intervention

Table 3. Mean and Standard Deviation of Students Mathematics Engagement After the Intervention

Engagement in Mathematics	Mean	SD	Interpretatio
I go through the work for math class and make sure that it's right.	5.000	0.126	HP
I think about different ways to solve a problem.	4.200	0.453	P
I try to connect what I am learning to things I have learned before.	4.300	0.284	P
I try to understand my mistakes when I get something wrong.	5.000	0.126	HP
I would rather be told the answer than have to do the work.	4.670	0.696	HP
I don't think that hard when I am doing work for class	4.852	0.576	HP
When work is hard, I only study the easy parts.	3.943	0.476	P
I do just enough to get by.	4.227	0.676	P
I stay focused.	4.875	0.476	HP
I put effort into learning math.	4.300	0.284	P
I keep trying even if something is hard.	5.000	0.126	HP
I complete my homework on time.	4.300	0.284	P
I talk about math outside of class	4.136	0.425	P
I don't participate in class.	3.863	0.141	P
I do other things when I am supposed to be paying attention.	4.443	0.768	P
If I don't understand, I give up right away.	3.943	0.219	F
I look forward to math class.	4.431	0.293	P
I enjoy learning new things about math.	4.897	0.642	HP
I want to understand what is learned in math class.	4.300	0.284	P
I feel good when I am in math class.	4.522	0.317	HP
I often feel frustrated in math class.	4.352	0.627	P
I think that math class is boring.	3.431	0.159	F
I don't want to be in math class.	3.125	0.415	F
I don't care about learning math.	3.431	0.287	F
I often feel down when I am in math class.	3.681	0.440	P
I get worried when I learn new things about math.	4.943	0.042	HP
I build on others' ideas.	5.000	0.126	HP
I try to understand other people's ideas in math class.	4.400	0.291	P
I try to work with others who can help me in math.	5.000	0.126	HP
I try to help others who are struggling in math.	4.300	0.284	P
I don't care about other people's ideas.	3.693	0.083	P
When working with others, I don't share ideas	3.784	0.567	P
I don't like working with classmates.	3.704	0.454	P
Overall Mean	4.3044	0.525	P

Legend:

Rating	Scale	Descriptive Rating	Qualitative Interpretation
5	4.51 – 5.00	Strongly Agree	Highly Positive (HP)
4	3.51 - 4.50	Agree	Positive (P)
3	2.51 - 3.50	Undecided	Undecided Fair (F)
2	1.51 - 2.50	Disagree	Disagree Negative (N)
1	1.00 - 1.50	Strongly Disagree	Highly Negative (HP)

Table 3 presents the post-test results of student engagement in mathematics following a two-week implementation of interactive learning strategies at Bukidnon State University Secondary Laboratory School. The intervention involved 88 Grade 11 students enrolled in Statistics and Probability and utilized collaborative problem-solving, gamified learning, and technology integration to enhance engagement. The same 33-item questionnaire from the pre-test was used to evaluate changes across behavioral, emotional, cognitive, and social domains.

The analysis of post-test results reveals significant improvements in student engagement. Cognitive engagement showed notable gains, with items like "I think about different ways to solve a problem" increasing from a mean of 3.704 to 4.200, and "I keep trying even if something is hard" rising to a perfect score of 5.000. Behavioral indicators such as "I complete my homework on time" (M = 4.300) and "I stay focused" (M = 4.875) also improved markedly. Social engagement strengthened through peer collaboration, as shown by items like "I try to help others who are struggling in math" (M = 4.300) and "I try to work with others who can help me in math" (M = 5.000). Negative behavioral indicators decreased significantly "I don't participate in class" dropped from 2.25 to 3.863, while "If I don't understand, I give up right away" improved to 3.943. Emotional engagement, while still in the fair range for some items, showed positive movement; for example, "I feel good when I am in math class" reached a mean of 4.522.

These results indicate that the interactive learning strategies employed were effective in enhancing student engagement, especially in the cognitive and collaborative dimensions. The increase in intellectual effort, persistence, and peer interaction reflects deeper engagement with the subject matter. Although emotional factors like frustration and anxiety were not completely resolved, the intervention clearly fostered more positive attitudes and reduced disengagement. These findings are supported by previous research. Maryana et al. (2024) conducted a quasi-experimental study on gamification in mathematics education and found that students exposed to gamified strategies showed significantly higher levels of engagement, academic performance, and positive attitudes compared to those in a traditional classroom setting. This aligns with the present study's post-test data showing gains in perseverance and motivation.

Similarly, Lukman et al. (2023) evaluated gamified teaching materials in mathematics and reported significant improvements in students' problem-solving skills and critical thinking. These outcomes mirror the present study's enhancements in cognitive engagement and support the conclusion that gamified and interactive learning strategies can successfully foster deeper engagement in mathematics.

Comparison of Student Engagement Between Before and After of Intervention

Table 4. Paired T-test Comparison of Students Mathematics Engagement

Score	**Mean**	**t-value**	**P-value.**	**Cohen's d**
Pretest-Posttest	-1.12858	-10.039	0.000**	1.75

** P< Highly Significant at 0.01 level.

Table 4 presents the results of a paired t-test comparing students' mathematics engagement before and after the intervention using interactive learning strategies. The mean engagement score increased from 3.1758 in the pretest to 4.3044 in the posttest, showing a mean difference of -1.12858.

The computed t-value of -10.039 and p-value of 0.000 indicate that the change is statistically highly significant at the 0.01 level. Furthermore, the effect size, as measured by Cohen's d (1.75), reveals a very large effect, suggesting that the intervention had a strong positive impact on student engagement. Based on the interpretive scale, this reflects a notable shift from a "Fair" rating to a "Positive" rating, signifying that students became more intellectually and emotionally engaged in learning mathematics following the implementation of interactive strategies.

This improvement highlights the effectiveness of using approaches such as gamified activities, collaborative learning tasks, and digital tools in enhancing student engagement. This is further supported by learning theories such as Vygotsky's social constructivism, which stresses interaction in learning, and Ryan and Deci's Self-Determination Theory, which highlights the engagement increases when students' needs for autonomy, competence, and relatedness in educational settings.

Additionally, a comprehensive meta-analysis conducted by Li et al. (2023) examined 41 studies with over 5,000 participants and found a significant positive effect (g = 0.822) of gamification on student learning outcomes, including motivation and engagement. The study emphasized that the effectiveness of gamification is influenced by factors such as learner characteristics, subject area, and the quality of gamified design highlighting its relevance to mathematics education. In the Philippine context, Malabayabas et al. (2024) conducted a quasi-experimental study to evaluate the impact of the "Math-GALING" gamified application on Grade 11 students' academic performance. Their findings revealed significant improvements in student achievement and engagement among those who used the application compared to peers taught via traditional methods. The inclusion of interactive features such as real-time feedback and adaptive challenges contributed to these outcomes.

Moreover, a systematic review by Ali et al. (2023) assessed the impact of technology integration on student engagement and performance in mathematics education. Drawing on 15 empirical studies, the review concluded that the use of interactive technologies such as educational software, simulations, and digital platforms consistently enhanced students' motivation, attitudes, and critical thinking skills. These tools created a more dynamic and engaging learning environment, further validating the use of technology as an effective strategy for improving engagement. Collectively, these results validate the effectiveness of interactive and technology-enhanced learning strategies in boosting student engagement, reinforcing the significant impact observed in this study.

4. Conclusion and Recommendations

4.1 Conclusion

After careful consideration of the findings, the following conclusions were drawn:

1. Prior to the intervention, the majority of the students exhibited an undecided to moderately positive level of engagement in mathematics.

2. After the implementation of interactive learning strategies, the level of student engagement significantly improved, corresponding to a "Positive" level of engagement.

3. Interactive learning strategies are an effective method in increasing student mathematics engagement.

4.2 Recommendations

Based on the conclusions, the following recommendations are formulated:

1. Students are encouraged to actively participate in interactive learning activities, as these strategies have been shown to significantly improve engagement and learning outcomes. By actively engaging in collaborative learning, technology-based tasks, and problem-solving activities, students can enhance their comprehension and foster a deeper connection to the subject matter.

2. Teachers may integrate innovative methods like gamification, group work, and other engaging tools into their classrooms.

3. Future research could focus on studying the broader impact of interactive learning strategies across various subjects, extending beyond mathematics. Longitudinal studies might offer valuable insights into how these strategies affect long-term student engagement, retention, and overall academic success.

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