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# Assessing the Project-Based Learning Strategies in Learning Mathematics Among College Students at Mindanao State University-Sulu

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**Index Terms:**

project-based learning strategies, learning mathematics, college students, interest, motivation, academic engagement

**Abstract.** This study assessed the extent of Project-Based Learning (PBL) strategies in mathematics learning among college students at Mindanao State University–Sulu. A descriptive–correlational research design was used, comprising 100 purposively selected students from the College of Science and Mathematics. The study examined PBL strategies in terms of interest and motivation, collaboration and teamwork, confidence and participation, and academic engagement, while considering respondents' demographic profiles, including age, gender, year level, and course. The Findings revealed that most respondents were 20 years old and above, equally distributed by gender and year level, with the majority enrolled in BS Mathematics. Results showed that students agreed on the effective implementation of PBL strategies across all four dimensions. No significant differences were found when respondents were grouped according to age, gender, and course; however, significant differences emerged across year levels, indicating variations in students' experiences with PBL as they progressed academically. Moreover, significant positive correlations ranging from moderate to high were observed among the four PBL dimensions, suggesting that these components are interrelated and mutually reinforcing. The conclusions of this study suggest that school administrators of Mindanao State University–Sulu may support faculty development programs focused on strengthening PBL implementation. At the same time, mathematics teachers may further integrate project-based and collaborative activities to enhance engagement and confidence. Students may actively participate in project-based tasks to maximize learning benefits, and future researchers may explore longitudinal or experimental studies further to examine the impact of PBL on mathematics learning outcomes.

## Introduction

Education in the 21st century underwent a major transformation as nations prepared learners for a rapidly evolving global economy. International assessments such as the Programme for International Student Assessment (PISA) continued to reveal persistent challenges in mathematics performance worldwide. In the 2022 cycle, Filipino students ranked among the lowest in mathematics, underscoring concerns about instructional effectiveness and conceptual understanding (Organization for Economic Co-operation and Development [OECD], 2023). These results highlighted the urgent need for innovative teaching approaches that developed not only computational proficiency but also higher-order thinking, collaboration, and problem-solving skills.

In the Philippines, the Commission on Higher Education (CHED) and the Department of Education (DepEd) implemented learner-centered, outcomes-based reforms that encouraged active, inquiry-driven pedagogy (DepEd, 2023; CHED, 2024). One such approach, Project-Based Learning (PBL), emphasized student-centered learning by engaging learners in extended, authentic tasks that promoted deeper understanding, motivation, and real-world application of knowledge (Thomas, 2000; Krajcik & Blumenfeld, 2006). Despite these educational reforms, lecture-based instruction remained predominant in mathematics classrooms, particularly in regions with limited resources and implementation challenges.

These challenges were particularly evident in the Bangsamoro Autonomous Region in Muslim Mindanao (BARMM), where schools and universities often faced diverse learner needs and constrained resources. At Mindanao State University–Sulu (MSU–Sulu), mathematics educators continuously explored strategies that enhanced students' engagement, comprehension, and retention of mathematical concepts (Alih & Sakandal, 2022). However, empirical studies on Project-Based Learning within MSU–Sulu remained limited. Most existing research focused on general education or urban settings, leaving a gap in understanding how PBL strategies function in provincial and culturally diverse environments (Barrios, 2021; Morales, 2020). Moreover, demographic variables (age, gender, year level, and course) and their effects on students' experiences and perceptions of PBL have not been widely researched.

To address these gaps, the present study, titled "Assessing the Project-Based Learning Strategies in Learning Mathematics Among College Students at Mindanao State University–Sulu," aimed to evaluate the extent and perceived impact of PBL by operationalizing it across four interrelated dimensions. Interest and motivation were captured by authentic, real-world projects that sparked curiosity, sustained effort, and cultivated intrinsic value in learning mathematics (Bell, 2010; Han, Capraro, & Capraro, 2015). Collaboration and teamwork emphasized the social construction of knowledge as students planned, communicated, negotiated roles, and collectively solved problems, thereby deepening understanding through shared inquiry (Krajcik & Blumenfeld, 2006). Confidence and participation referred to learners' self-efficacy and willingness to contribute—explaining solutions, asking questions, presenting outputs, and engaging in peer feedback—which tended to strengthen through authentic problem-solving experiences (Thomas, 2000; Alih & Sakandal, 2022). Lastly, academic engagement pertained to sustained attention, perseverance, and higher-order thinking as students applied mathematical concepts in meaningful contexts (Barrios, 2021; Morales, 2020). Together, these dimensions provided a comprehensive framework for assessing how PBL strategies influenced college students' attitudes, behaviors, and performance in mathematics at MSU–Sulu.

The results of the study were to be useful to various stakeholders. For students, the research illuminated pathways for developing problem-solving and collaborative competencies. For teachers, the results informed course design and encouraged the adoption of interactive, meaningful learning activities. For administrators, the findings guided professional development initiatives and policy formulation in support of innovative teaching practices. Finally, this research was expected to contribute to the growing literature on Project-Based Learning strategies for learning mathematics in the context of BARMM and similar higher education institutions.

*Research Questions*

This research paper was done to evaluate the Project-Based Learning (PBL) strategies in the learning of mathematics among college learners of Mindanao State University-Sulu. In particular, it attempted to respond to the following questions:

1. What is the demographic profile of the respondents in terms of:
   1.1. Age;
   1.2. Gender;
   1.3. Year level; and
   1.4. Course?

2. What is the extent of Project-Based Learning strategies in learning mathematics among college students at Mindanao State University–Sulu in terms of:
   2.1. Interest and Motivation;
   2.2. Collaboration and Teamwork;
   2.3. Confidence and Participation; and
   2.4. Academic Engagement?

3. Is there a significant difference in the extent of Project-Based Learning strategies in learning mathematics among college students at Mindanao State University–Sulu when the data are grouped according to:
   3.1. Age;
   3.2. Gender;
   3.3. Year level; and
   3.4 Course?

Is there a significant correlation among the sub-categories subsumed under the extent of Project-Based Learning strategies in learning mathematics among college students at Mindanao State University–Sulu?

## Methodology

This section delineates the systematic procedures employed for data collection and analysis. It encompasses the research design, research locale, participants, sampling methods, data collection techniques, research instruments, measures of validity and reliability, and the statistical analysis of the data.

*Research Design*

This study utilized a descriptive-correlational research design to evaluate the effectiveness of Project-Based Learning (PBL) strategies in mathematics among college students. The objective is to investigate the relationships among four dimensions of PBL and various demographic factors, as well as to compare PBL scores across different demographic groups, including age, gender, year level, and course. As noted by Lunenburg (2010), the descriptive aspect offers a detailed and systematic representation of students' PBL experiences; the correlational aspect assesses the strength and direction of relationships without manipulation, while the comparative component tests differences among groups. Data were gathered through a structured questionnaire during the School Year 2025–2026.

*Research Locale*

The research was conducted at Mindanao State University–Sulu (MSU–Sulu), specifically within the College of Science and Mathematics located in Jolo, Sulu. The institution was founded on March 28, 1974.

*Respondents of the Study*

The study's respondents comprised 100 college students from the College of Science and Mathematics at Mindanao State University–Sulu.

| Course | Year Level | No. of Respondents |
|---|---|---|
| BS Biology | 1st Year | 10 |
| | 2nd Year | 10 |
| | 3rd Year | 10 |
| | 4th Year | 10 |
| BS Mathematics | 1st Year | 15 |
| | 2nd Year | 15 |
| | 3rd Year | 15 |
| | 4th Year | 15 |
| Total | | **100** |

*Table 1. Distribution of the respondents of the Study by Section*

*Sampling Design*

This study employed a purposive sampling technique. The selected respondents were college students enrolled in mathematics courses at the College of Science and Mathematics, Mindanao State University–Sulu, who had direct exposure to Project-Based Learning during SY 2025–2026.

*Data Gathering Procedure*

The researchers obtained a letter of permission from the Dean's Office of Graduate Studies to launch the questionnaire. After securing the letter of permission from the Dean's Office of Graduate Studies, the researcher will immediately proceed to seek the letter of approval from the Mindanao State University-Sulu Chancellor. After receiving approval from the concerned authority at Mindanao State University-Sulu to administer the instrument, the researcher presented the approved letter to the Dean of the College of Science and Mathematics at Mindanao State University-Sulu to inform her that data collection for the study would commence. The coordinator then agreed and permitted the researcher to administer the instruments to the listed sample respondents.

*Research Instrument*

A survey questionnaire in checklist form was used in this study and was adopted, patterned, and revised from the authors and models referenced (Silfavan, 2024; Kwon, 2025; Zhang et al., 2023; Guo & Jou, 2020; Ryan & Deci, 2000).

The questionnaire was divided into two sections. Part I consisted of questions about respondents' demographic profiles. Part II consisted of four constructs: Interest and Motivation (6 items), Collaboration and Teamwork (6 items), Confidence and Participation (6 items), and Academic Engagement (6 items). The students were required to give their agreement on each item based on the five-point Likert scale: 5 – Strongly Agree; 4 – Agree; 3 – Partially Agree; 2 – Disagree; and 1 – Strongly Disagree.

*Validity and Reliability*

The instrument that was used in this study was adopted, patterned, and revised based on the authors and models referenced (Silfavan, 2024; Kwon, 2025; Zhang et al., 2023; Guo & Jou, 2020; Ryan & Deci, 2000). However, to ensure applicability to the present study and its local settings, the questionnaire was reviewed by at least two experts from among the faculty members of the Graduate Studies of Sulu State University.

*Statistical Treatment of Data*

The following statistical tools were utilized to treat the data that were gathered:

1. For Problem No. 1, which states: What is the demographic profile of the respondents in terms of age, gender, year level, and course? The statistical tools used were Frequency and Percentage.
2. For Problem No. 2, which states: What is the extent of project-based learning in mathematics among college students of Mindanao State University–Sulu in terms of Interest and Motivation, Collaboration and Teamwork, Confidence and Participation, and Academic Engagement?
3. The statistical tools used were Weighted Mean and Standard Deviation.
4. For Problem No. 3, which states: Is there a significant difference in the extent of project-based learning in mathematics among college students of Mindanao State University–Sulu when the data are grouped according to age, gender, year level, and course? The statistical tools used were the T-test for gender and course, and Analysis of Variance (ANOVA) for the remaining profile variables to determine significant differences.
5. For Problem No. 4, which states: Is there a significant correlation among the sub-categories under the extent of project-based learning in mathematics among college students of Mindanao State University–Sulu? The statistical tool used was the Pearson Product-Moment Correlation to determine the significant correlation among variables.

To quantitatively determine the extent of Project-Based Learning (PBL) in mathematics among college students at Mindanao State University–Sulu, the researcher used a five-point Likert Scale table as follows:

| Point | Scale value | Interpretation |
|---|---|---|
| 5 | 4.5 – 5.00 | Strongly Agree |
| 4 | 3.5 – 4.49 | Agree |
| 3 | 2.5 – 3.49 | Partially Agree |
| 2 | 1.5 – 2.49 | Disagree |
| 1 | 1 – 1.49 | Strongly Disagree |

*Table 2. Likert's Scale Table*

*Ethical Considerations*

Upholding ethical standards was essential to maintain the reliability, validity, and integrity of the research process. All data collected for analysis and interpretation were strictly in accordance with recognized ethical guidelines.

Specifically, the researcher observed the following ethical protocols in the conduct of the study:

1. Informed Consent – Participants were fully informed about the study's purpose, procedures, and scope. Their voluntary participation was sought through a signed consent form, and they were free to withdraw at any time without penalty.

2. Confidentiality and Anonymity – The identity of the participants and the institutions involved was kept strictly confidential. No identifying information will appear in any report, presentation, or publication related to this study.

3. Voluntary Participation – Participation in the study was entirely voluntary. No form of coercion, pressure, or undue influence was used to obtain participation.

4. Integrity of Data – The researcher ensured that all data were gathered, recorded, analyzed, and reported accurately and truthfully. Fabrication, falsification, or misrepresentation of data was strictly avoided.

5. Respect for Persons – The researchers upheld participants' rights, dignity, and well-being, ensuring their views and experiences were valued throughout the research process.

6. Beneficence and Non-Maleficence – The study was conducted with the intent to benefit participants and the community, ensuring that no harm—physical, psychological, or social—comes to those involved.

7. Compliance With Institutional Guidelines – The conduct of this research adhered to the ethical policies and procedures of the School of Graduate Studies, Sulu State University (SSU), as well as relevant national and international ethical standards for educational research.

8. Ethical Clearance – Before administering the survey questionnaire, the researcher secured official Ethical Clearance from the Research Ethics Committee or the authorized body of Sulu State University (SSU) to ensure that the study met all institutional and professional ethical requirements.

## Results and Discussion

This section presents the analysis and interpretation of the data gathered in the study. It provides insights into the extent of Project-Based Learning (PBL) strategies in mathematics among college students at Mindanao State University–Sulu, College of Science and Mathematics. Specifically, it describes the respondents' demographic profile by age, gender, year level, and course.

Furthermore, the section examines the extent of PBL strategies in mathematics across the dimensions of interest and motivation, collaboration and teamwork, confidence and participation, and academic engagement. It also analyses the significant differences in the extent of PBL strategies across demographic groups and determines the significant relationships among the four PBL dimensions.

The findings presented in this section serve as the basis for the study's discussion, conclusions, and recommendations. All presentations, analyses, and interpretations are based on appropriate scoring procedures and statistical treatments applied to the data, aligned with the study's research questions.

*1. What is the demographic profile of the respondents in terms of: 1.1. Age, 1.2. Gender, 1.3. Year level, and 1.4. Course?*

Table 3 presents the demographic profile of students at Mindanao State University–Sulu based on age. The data show that of 100 respondents, 3 students (3.0%) are 17 years old or younger, 32 students (32.0%) are in the 18–19 age group, and 65 students (65.0%) are 20 years old or older. These results indicate that the majority of the respondents fall within the 20 years old and above category, comprising more than half of the sample. This distribution suggests that most participants belong to an older age group, which is typical of college students and reflects a relatively mature learner population at Mindanao State University–Sulu.

| Age | Number of respondents | Percent |
|---|---|---|
| 17 years old and below | 3 | 3.0% |
| 18-19 years old | 32 | 32.0% |
| 20 years old and above | 65 | 65.0% |
| **Total** | **100** | **100%** |

*Table 3. Demographic Profile of Students at Mindanao State University-Sulu by Age*

*1.2 In terms of Gender*

Table 4 presents the demographic profile of students at Mindanao State University–Sulu by gender. The data shows that among 100 respondents, 50 students (50.0%) are male, and 50 students (50.0%) are female. These findings indicate an equal distribution of male and female respondents in the study. This balanced representation suggests that both groups are equally represented, enabling a fair comparison and analysis of Project-Based Learning strategies in mathematics across genders.

| Gender | Number of respondents | Percent |
|---|---|---|
| Male | 50 | 50.0% |
| Female | 50 | 50.0% |
| **Total** | **100** | **100%** |

*Table 4. Demographic Profile of Students at Mindanao State University-Sulu by Gender*

*1.3 In terms of Year Level*

Table 5 presents the demographic profile of students at Mindanao State University–Sulu based on year level. The data show that out of 100 respondents, 25 students (25.0%) are in the first year, 25 students (25.0%) are in the second year, 25 students (25.0%) are in the third year, and 25 students (25.0%) are in the fourth year. These findings indicate an equal distribution of respondents across all year levels. This balanced representation ensures that students from each year level are equally included in the study, allowing for a fair comparison and analysis of Project-Based Learning strategies in mathematics across year levels.

| Year Level | Number of respondents | Percent |
|---|---|---|
| First Year | 25 | 25.0% |
| Second Year | 25 | 25.0% |
| Third Year | 25 | 25.0% |
| Fourth Year | 25 | 25.0% |
| **Total** | **100** | **100%** |

*Table 5. Demographic Profile of Students at Mindanao State University-Sulu by Year Level*

*1.4 In terms of Course*

Table 6 presents the demographic profile of students at Mindanao State University–Sulu based on the course. The data show that of 100 respondents, 40 students (40.0%) are enrolled in BS Biology, while 60 students (60.0%) are enrolled in BS Mathematics. These findings indicate that the majority of respondents are from the BS Mathematics program, accounting for more than half of the sample.

| Course | Number of respondents | Percent |
|---|---|---|
| BS Biology | 40 | 40.0% |
| BS Mathematics | 60 | 60.0% |
| **Total** | **100** | **100%** |

*Table 6. Demographic Profile of Students at Mindanao State University-Sulu by Course*

*2.What is the extent of Project-Based Learning strategies in learning mathematics among college students at Mindanao State University–Sulu in terms of:2.1. Interest and Motivation, 2.2. Collaboration and Teamwork, 2.3. Confidence and Participation; and2.4. Academic Engagement?*

*2.1 In the context of Interest and Motivation*

Table 7 presents the extent of Project-Based Learning (PBL) strategies in learning mathematics among college students at Mindanao State University–Sulu in terms of interest and motivation. The data reveal a total weighted mean of 3.95 with a standard deviation of 0.61, corresponding to an overall rating of "Agree." This indicates that students generally perceive Project-Based Learning as effective in enhancing their interest and motivation in learning mathematics.

Among the indicators, the highest-rated statements are "I feel motivated to learn mathematics when involved in project-based activities" and "The project-based tasks make mathematics lessons more interesting and meaningful," both with a

mean of 4.19, interpreted as "Agree." These findings suggest that authentic, activity-based projects effectively stimulate students' motivation and make mathematics learning more engaging. On the other hand, the lowest-rated statement, "I am more persistent in completing mathematics projects compared to regular tasks," obtained a mean of 3.74, which is still interpreted as "Agree." This indicates that while persistence is positively influenced, it is less pronounced than other aspects of motivation.

Overall, the results imply that Project-Based Learning enhances students' enthusiasm, enjoyment, and willingness to participate in mathematics-related tasks. These findings are supported by Belland, Kim, and Hannafin (2020), who emphasized that PBL environments significantly improve students' intrinsic motivation by providing meaningful and real-world learning experiences that foster autonomy and relevance. Likewise, Rahmatullah et al. (2023) found that students exposed to project-based mathematics instruction exhibit higher levels of motivation and sustained engagement, driven by greater personal involvement in learning activities.

| | Statements | Mean | SD | Rating |
|---|---|---|---|---|
| **1** | I feel motivated to learn mathematics when involved in project-based activities. | 4.19 | .849 | Agree |
| **2** | The project-based tasks make mathematics lessons more interesting and meaningful. | 4.19 | .677 | Agree |
| **3** | I am eager to participate when mathematics projects are assigned. | 3.77 | .897 | Agree |
| **4** | PBL helps me enjoy learning mathematics more than traditional lectures. | 3.80 | .853 | Agree |
| **5** | I am encouraged to study mathematics independently because of project-based activities. | 3.98 | .738 | Agree |
| **6** | I am more persistent in completing mathematics projects compared to regular tasks. | 3.74 | .824 | Agree |
| | **Total Weighted Mean** | **3.9450** | **.60722** | **Agree** |

*Legend:* (5) 4.50-5.00=Strongly Agree; (4) 3.50-4.49=Agree; (3) 2.50- 3.49=Partially Agree; (2) 1.50- 2.49=Disagree; (1) 1.00- 1.49=Strongly Disagree

*Table 7. Extent Project-Based Learning Strategies in Learning Mathematics in Terms of Interest and Motivation*

*2.2 In the context of Collaboration and Teamwork*

Table 8 presents the extent of Project-Based Learning (PBL) strategies in mathematics learning among college students at Mindanao State University–Sulu, focusing on collaboration and teamwork. The data show a total weighted mean of 4.11 with a standard deviation of 0.54, corresponding to an overall rating of "Agree." This indicates that students generally perceive Project-Based Learning as effective in promoting collaboration and teamwork in mathematics learning.

Among the statements, the highest-rated item is "Project-based tasks allow me to work effectively with my classmates," with a mean of 4.24, interpreted as "Agree," suggesting that PBL provides opportunities for productive peer interaction. This is followed by "I learn better when I collaborate with others on mathematical problems" (Mean = 4.13), indicating that collaborative problem-solving enhances students' understanding of mathematical concepts. The lowest-rated statement, "I am comfortable sharing responsibilities in group projects," had a mean of 4.05, which falls within the "Agree" range, indicating that students are generally at ease working in shared roles.

Overall, the findings imply that Project-Based Learning fosters positive peer interaction, shared responsibility, and cooperative problem-solving among students. These results are consistent with Serin's (2023) study, which found that project-based learning significantly enhances students' collaboration and communication skills in mathematics classrooms.

| | Statements | Mean | SD | Rating |
|---|---|---|---|---|
| **1** | Project-based tasks allow me to work effectively with my classmates. | 4.24 | .653 | Agree |
| **2** | I actively contribute ideas when our group works on mathematics projects. | 4.11 | .723 | Agree |
| **3** | PBL develops my communication and teamwork skills. | 4.06 | .763 | Agree |
| **4** | I learn better when I collaborate with others on mathematical problems. | 4.13 | .747 | Agree |
| **5** | I am comfortable sharing responsibilities in group projects. | 4.05 | .833 | Agree |

| | | | | |
|---|---|---|---|---|
| **6** | PBL helps me appreciate the value of cooperation in solving problems. | 4.07 | .832 | Agree |
| | **Total Weighted Mean** | **4.1100** | **.54444** | **Agree** |

*Legend:* (5) 4.50-5.00=Strongly Agree; (4) 3.50-4.49=Agree; (3) 2.50- 3.49=Partially Agree; (2) 1.50- 2.49=Disagree; (1) 1.00- 1.49=Strongly Disagree

*Table 8. Extent Project-Based Learning Strategies in Learning in Terms of Collaboration and Teamwork*

*2.3 In the context of Confidence and Participation*

Table 9 presents the extent of Project-Based Learning (PBL) strategies in mathematics learning among college students at Mindanao State University–Sulu, in terms of confidence and participation. The data show a total weighted mean of 3.96 with a standard deviation of 0.57, corresponding to an overall rating of "Agree." This indicates that students generally perceive Project-Based Learning as effective in enhancing their confidence and active participation in mathematics classes.

Among the indicators, the highest-rated statement is "I am confident in expressing my ideas during project-based mathematics discussions," with a mean of 4.04, suggesting that PBL encourages students to openly articulate their mathematical thinking. This is followed by "I feel capable of presenting the results of our mathematics projects to others" (Mean = 3.99), reflecting increased confidence in public presentation and communication. The lowest-rated statement, "I am not afraid to make mistakes when participating in project-based activities," obtained a mean of 3.89, which is still interpreted as "Agree." This indicates that PBL fosters a supportive learning environment where students feel comfortable participating, even when mistakes are possible.

Overall, the findings suggest that Project-Based Learning positively influences students' self-confidence, independence, and willingness to engage in mathematical tasks. These results are consistent with Almulla's (2020) study, which found that PBL enhances students' confidence and self-efficacy by encouraging active engagement in problem-solving and presentation activities.

| | Statements | Mean | SD | Rating |
|---|---|---|---|---|
| **1** | I am confident in expressing my ideas during project-based mathematics discussions. | 4.04 | .803 | Agree |
| **2** | PBL has increased my self-assurance in handling mathematical problems. | 3.96 | .724 | Agree |
| **3** | I feel capable of presenting the results of our mathematics projects to others. | 3.99 | .847 | Agree |
| **4** | I am not afraid to make mistakes when participating in project-based activities. | 3.89 | .875 | Agree |
| **5** | My participation in mathematics has improved since using PBL. | 3.95 | .833 | Agree |
| **6** | I can work independently when needed in project-based mathematics tasks. | 3.94 | .722 | Agree |
| | **Total Weighted Mean** | **3.9617** | **.57338** | **Agree** |

*Legend:* (5) 4.50-5.00=Strongly Agree; (4) 3.50-4.49=Agree; (3) 2.50- 3.49=Partially Agree; (2) 1.50- 2.49=Disagree; (1) 1.00- 1.49=Strongly Disagree

*Table 9. Extent Project-Based Learning Strategies in Learning in Terms of Confidence and Participation*

*2.4 In the context of Academic Engagement*

Table 10 presents the extent of Project-Based Learning (PBL) strategies in mathematics learning among college students at Mindanao State University–Sulu, in terms of academic engagement. The data show a total weighted mean of 4.06 with a standard deviation of 0.63, corresponding to an overall rating of "Agree." This indicates that students generally perceive Project-Based Learning as effective in sustaining their academic engagement in mathematics classes.

Among the indicators, the highest-rated statement is "I focus more during mathematics classes that use project-based learning," with a mean of 4.15, suggesting that PBL helps students maintain attention and concentration during mathematics instruction. This is followed by "The feedback from my teacher helps me improve in project-based tasks" (Mean = 4.12), highlighting the importance of teacher guidance and feedback in enhancing students' engagement and performance. The lowest-rated statements are "I complete assigned mathematics projects on time" and "I find myself more

engaged and attentive during mathematics projects," both with a mean of 3.99, which are still interpreted as "Agree." This indicates consistent student involvement and responsibility in completing academic tasks.

Overall, the findings suggest that Project-Based Learning promotes sustained attention, timely task completion, deeper exploration of mathematical concepts, and meaningful application of knowledge. These results are supported by Karantonis and Heffernan (2023), who found that PBL enhances students' cognitive, behavioral, and emotional engagement through authentic learning tasks.

| | Statements | Mean | SD | Rating |
|---|---|---|---|---|
| **1** | I focus more during mathematics classes that use project-based learning. | 4.15 | .716 | Agree |
| **2** | I complete assigned mathematics projects on time. | 3.99 | .810 | Agree |
| **3** | PBL encourages me to explore topics beyond what is discussed in class. | 4.06 | .839 | Agree |
| **4** | I find myself more engaged and attentive during mathematics projects. | 3.99 | .927 | Agree |
| **5** | The feedback from my teacher helps me improve in project-based tasks. | 4.12 | .891 | Agree |
| **6** | PBL motivates me to connect mathematical concepts with real-life situations. | 4.07 | .742 | Agree |
| | **Total Weighted Mean** | **4.0633** | **.63333** | **Agree** |

*Legend:* (5) 4.50-5.00=Strongly Agree; (4) 3.50-4.49=Agree; (3) 2.50- 3.49=Partially Agree; (2) 1.50- 2.49=Disagree; (1) 1.00- 1.49=Strongly Disagree

*Table 10. Extent Project-Based Learning Strategies in Learning Mathematics in Terms of Academic Engagement*

*3. Is there a significant difference in the extent of Project-Based Learning strategies in learning mathematics among college students at Mindanao State University–Sulu when the data are grouped according to:3.1. Age, 3.2. Gender, 3.3. Year level, and 3.4 Course?*

*3.1 According to Age*

Table 10 presents differences in the extent of Project-Based Learning (PBL) strategies in learning mathematics among college students at Mindanao State University–Sulu, grouped by age. The table shows the F-values and significance values (Sig.) for the four dimensions of PBL, namely Interest and Motivation, Collaboration and Teamwork, Confidence and Participation, and Academic Engagement.

For Interest and Motivation, the computed F-value is 0.353 with a Sig. value of 0.703, which is higher than the alpha level of 0.05. This indicates that there is no significant difference in students' interest and motivation toward mathematics when using PBL strategies, regardless of age.

In terms of Collaboration and Teamwork, the results reveal an F-value of 2.032 and a Sig. value of 0.137, which is likewise greater than 0.05. This suggests that students' experiences in collaboration and teamwork during project-based mathematics activities do not significantly vary across age groups.

For Confidence and Participation, the obtained F-value is 0.117 with a Sig. value of 0.889, indicating no significant difference among age groups. This implies that students' confidence in expressing ideas and participating in project-based mathematics tasks is consistent across ages.
Similarly, Academic Engagement shows an F-value of 0.025 and a Sig. value of 0.976, which is also above the alpha level of 0.05. This result indicates that students' levels of focus, involvement, and engagement in project-based mathematics learning do not differ significantly by age.

Overall, the findings reveal that age does not significantly influence the extent of Project-Based Learning strategies in learning mathematics across all four dimensions. Therefore, the null hypothesis that there is no significant difference in the extent of Project-Based Learning strategies in learning mathematics among college students at Mindanao State University–Sulu, when grouped by age, is accepted.

| Sources of Variation | | Sum of squares | df | Mean Square | F | Sig. | Description |
|---|---|---|---|---|---|---|---|
| Interest and Motivation | Between Groups | .264 | 2 | .132 | .353 | .703 | Not Significant |
| | Within Groups | 36.239 | 97 | .374 | | | |
| | Total | 36.503 | 99 | | | | |
| Collaboration and Teamwork | Between Groups | 1.180 | 2 | .590 | 2.032 | .137 | Not Significant |
| | Within Groups | 28.166 | 97 | .290 | | | |
| | Total | 29.346 | 99 | | | | |
| Confidence and Participation | Between Groups | .079 | 2 | .039 | .117 | .889 | Not Significant |
| | Within Groups | 32.469 | 97 | .335 | | | |
| | Total | 32.548 | 99 | | | | |
| Academic Engagement | Between Groups | .020 | 2 | .010 | .025 | .976 | Not Significant |
| | Within Groups | 39.690 | 97 | .409 | | | |
| | Total | 39.710 | 99 | | | | |

*Note.* * Significant at alpha 0.05

*Table 10. Difference in the Extent of Project-Based Learning Strategies in Learning Mathematics when the Data are Grouped According to Age*

*3.2 According to Gender*

Table 11 presents differences in the extent of Project-Based Learning (PBL) strategies in learning mathematics among college students at Mindanao State University–Sulu, grouped by gender. The table shows the mean scores, mean differences, t-values, and significance values (Sig.) for the four PBL dimensions: Interest and Motivation, Collaboration and Teamwork, Confidence and Participation, and Academic Engagement.

For Interest and Motivation, male students obtained a slightly lower mean score (Mean = 3.90, S.D. = 0.65) compared to female students (Mean = 3.99, S.D. = 0.57), with a mean difference of –0.09. The computed t-value is –0.739 with a Sig. value of 0.461, which is higher than the alpha level of 0.05. This indicates that there is no significant difference between male and female students in terms of interest and motivation toward mathematics when PBL strategies are applied.

In terms of Collaboration and Teamwork, male students recorded a mean of 4.05 (S.D. = 0.63), while female students had a slightly higher mean of 4.17 (S.D. = 0.44), resulting in a mean difference of –0.12. The t-value of –1.10 and Sig. The value of 0.273 further indicates that the difference is not significant, suggesting that both male and female students experience similar levels of collaboration and teamwork in project-based mathematics learning.

For Confidence and Participation, male students obtained a higher mean score (Mean = 4.07, S.D. = 0.59) compared to female students (Mean = 3.86, S.D. = 0.54), with a mean difference of 0.21. However, the computed t-value of 1.854 and Sig. The value of 0.067 remains above the 0.05 significance level, indicating no significant difference between genders in terms of confidence and participation.

Lastly, for Academic Engagement, male students obtained a mean of 4.02 (S.D. = 0.76), while female students had a mean of 4.11 (S.D. = 0.48), resulting in a mean difference of –0.09. The t-value of –0.682 and Sig. A value of 0.497 indicates that the difference is not significant.

Overall, the findings reveal that gender does not significantly influence the extent of Project-Based Learning strategies in learning mathematics across all four dimensions. Therefore, the null hypothesis that there is no significant difference in the extent of Project-Based Learning strategies in learning mathematics among college students at Mindanao State University–Sulu, when grouped by gender, is accepted.

| Variables | Grouping | Mean | S.D | Mean Difference | t | Sig. | Description |
|---|---|---|---|---|---|---|---|
| **Interest and Motivation** | Male | 3.900 | .64769 | -.09000 | -.739 | .461 | Not Significant |
| | Female | 3.990 | .56686 | | | | |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| **Collaboration and Teamwork** | Male | 4.050 | .62927 | -.12000 | -1.10 | .273 | Not Significant |
| | Female | 4.1700 | .44223 | | | | |
| **Confidence and Participation** | Male | 4.067 | .59190 | .21000 | 1.854 | .067 | Not Significant |
| | Female | 3.857 | .53981 | | | | |
| **Academic Engagement** | Male | 4.020 | .75716 | -.08667 | -.682 | .497 | Not Significant |
| | Female | 4.107 | .48300 | | | | |

*Note.* * Significant at alpha 0.05

*Table 11. Difference in the Extent of Project-Based Learning Strategies in Learning Mathematics when the Data are Grouped According to Gender*

*3.3 According to Year Level*

Table 12 presents differences in the extent of Project-Based Learning (PBL) strategies in learning mathematics among college students at Mindanao State University–Sulu, grouped by year level. The table shows the F-values and significance values (Sig.) for the four dimensions of PBL, namely Interest and Motivation, Collaboration and Teamwork, Confidence and Participation, and Academic Engagement.

For Interest and Motivation, the computed F-value is 13.56 with a Sig. value of .000, which is lower than the alpha level of 0.05. This indicates a significant difference in students' interest and motivation toward mathematics when using PBL strategies across year levels.

Similarly, Collaboration and Teamwork yielded an F-value of 7.204 with a Sig. value of .000, indicating a significant difference among year levels. This suggests that students' collaborative experiences and teamwork in project-based mathematics activities vary significantly by year level.

For Confidence and Participation, the results show an F-value of 7.746 with a Sig. value of .000, which also signifies a significant difference. This implies that students' confidence in expressing ideas and participating in project-based mathematics tasks differs significantly across year levels.

Lastly, Academic Engagement recorded an F-value of 8.558 with a Sig. value of .000, indicating a significant difference among year levels. This result suggests that their year level influences students' focus, involvement, and engagement in project-based mathematics learning.

Overall, the findings reveal that year level significantly influences the extent of Project-Based Learning strategies in learning mathematics across all four dimensions. Therefore, the null hypothesis that there is no significant difference in the extent of Project-Based Learning strategies in learning mathematics among college students at Mindanao State University–Sulu, when grouped by year level, is rejected.

| Sources of Variation | | Sum of squares | df | Mean Square | F | Sig. | Description |
|---|---|---|---|---|---|---|---|
| Interest and Motivation | Between Groups | 10.865 | 3 | 3.622 | 13.56 | .000* | Significant |
| | Within Groups | 25.638 | 96 | .267 | | | |
| | Total | 36.503 | 99 | | | | |
| Collaboration and Teamwork | Between Groups | 5.392 | 3 | 1.797 | 7.204 | .000* | Significant |
| | Within Groups | 23.953 | 96 | .250 | | | |
| | Total | 29.346 | 99 | | | | |
| Confidence and Participation | Between Groups | 6.343 | 3 | 2.114 | 7.746 | .000* | Significant |
| | Within Groups | 26.204 | 96 | .273 | | | |
| | Total | 32.548 | 99 | | | | |
| Academic Engagement | Between Groups | 8.379 | 3 | 2.793 | 8.558 | .000* | Significant |
| | Within Groups | 31.331 | 96 | .326 | | | |
| | Total | 39.710 | 99 | | | | |

*Note.* * Significant at alpha 0.05

*Table 12. Difference in the Extent of Project-Based Learning Strategies in Learning Mathematics when the Data are Grouped According to Year Level*

Table 12.1 presents the results of a Post Hoc Analysis using Tukey's test to determine the pairwise differences in the extent of Project-Based Learning (PBL) strategies in learning mathematics among college students at Mindanao State University – Sulu when grouped according to year level. The analysis reveals significant differences across year levels in terms of Interest and Motivation, Collaboration and Teamwork, Confidence and Participation, and Academic Engagement.

Interest and Motivation: First Year vs Second Year shows a mean difference of 0.68667, which is significant at the 0.05 level (Sig. = .000), indicating that First Year students exhibit significantly higher interest and motivation than Second Year students. Second Year vs Third Year yields a mean difference of –0.42667 (Sig. = .022), suggesting that Third Year students have significantly higher interest and motivation than Second Year students. Likewise, Second Year vs Fourth Year shows a mean difference of –0.88000 (Sig. = .000), indicating that Fourth Year students demonstrate significantly higher interest and motivation than Second Year students. Lastly, Third Year vs Fourth Year records a mean difference of –0.45333 (Sig. = .013), implying that Fourth Year students have significantly higher interest and motivation than Third Year students.

Collaboration and Teamwork: First Year vs Second Year reveals a mean difference of 0.39333 (Sig. = .032), indicating that First Year students experience significantly higher collaboration and teamwork than Second Year students. Second Year vs Fourth Year shows a mean difference of –0.64667 (Sig. = .000), suggesting that Fourth Year students demonstrate significantly stronger collaboration and teamwork than Second Year students.

Confidence and Participation: Fourth Year vs Second Year presents a mean difference of 0.60667 (Sig. = .000), indicating that Fourth Year students exhibit significantly higher confidence and participation than Second Year students. Similarly, Fourth Year vs Third Year yields a mean difference of 0.61333 (Sig. = .000), showing that Fourth Year students demonstrate significantly greater confidence and participation than Third Year students.

Academic Engagement: First Year vs Second Year has a mean difference of 0.50000 (Sig. = .014), indicating that First Year students are significantly more academically engaged than Second Year students. Fourth Year vs Second Year shows a mean difference of 0.78667 (Sig. = .000), suggesting that Fourth Year students have significantly higher academic engagement than Second Year students. Lastly, Fourth Year vs Third Year records a mean difference of 0.51333 (Sig. = .011), indicating that Fourth Year students demonstrate significantly greater academic engagement than Third Year students.

Overall, the results suggest that year level plays a significant role in the extent of Project-Based Learning strategies in mathematics, with notable variations particularly between Second Year students and the other year levels.

| Dependent Variable | (I) Grouping by Year Level | (J) Grouping by Year Level | Mean Difference (I-J) | Std. Error | Sig. |
|---|---|---|---|---|---|
| **Interest and Motivation** | First Year | Second Year | .68667* | .14617 | .000 |
| | Second Year | First Year | -.68667* | .14617 | .000 |
| | | Third Year | -.42667* | .14617 | .022 |
| | | Fourth Year | -.88000* | .14617 | .000 |
| | Third Year | Fourth Year | -.45333* | .14617 | .013 |
| **Collaboration and Teamwork** | First Year | Second Year | .39333* | .14128 | .032 |
| | Second Year | Fourth Year | -.64667* | .14128 | .000 |
| **Confidence and Participation** | Fourth Year | Second Year | .60667* | .14777 | .000 |
| | | Third Year | .61333* | .14777 | .000 |
| **Academic Engagement** | First Year | Second Year | .50000* | .16158 | .014 |
| | Fourth Year | Second Year | .78667* | .16158 | .000 |
| | | Third Year | .51333* | .16158 | .011 |

*Note.* * The mean difference is significant at the 0.05 level

*Table 12.1. Multiple Comparison in the Extent of Project-Based Learning Strategies in Learning Mathematics when the Data are Grouped According to Year Level*

*3.4 According to Course*

Table 13 presents differences in the extent of Project-Based Learning (PBL) strategies in learning mathematics among college students at Mindanao State University–Sulu, grouped by course. The table shows the mean scores, mean differences, t-values, and significance values (Sig.) for the four PBL dimensions: Interest and Motivation, Collaboration and Teamwork, Confidence and Participation, and Academic Engagement.

For Interest and Motivation, BS Biology students obtained a mean score of 3.92 (S.D. = 0.72), while BS Mathematics students recorded a slightly higher mean of 3.96 (S.D. = 0.52), resulting in a mean difference of −0.05. The computed t-value of −0.356 with a Sig. value of 0.723, which is greater than the 0.05 alpha level, indicates that the difference is not significant.

In terms of Collaboration and Teamwork, BS Biology students posted a mean of 4.13 (S.D. = 0.56), compared to 4.10 (S.D. = 0.54) for BS Mathematics students, with a mean difference of 0.03. The t-value of 0.286 and Sig. The value of 0.775 likewise indicates that there is no significant difference between the two groups.

For Confidence and Participation, BS Biology students obtained a mean score of 3.90 (S.D. = 0.64), which is slightly lower than that of BS Mathematics students (Mean = 4.00, S.D. = 0.53), yielding a mean difference of −0.10. However, the computed t-value of −0.877 and Sig. The value of 0.383 indicates that the difference is not significant.

Lastly, for Academic Engagement, both BS Biology and BS Mathematics students recorded nearly identical mean scores (4.06), with a negligible mean difference of −0.00139. The t-value of −0.011 and Sig. The value of 0.991 further confirms that there is no significant difference between the two groups.

Overall, the findings reveal that the course does not significantly influence the extent of Project-Based Learning strategies in learning mathematics across all four dimensions. Therefore, the null hypothesis that there is no significant difference in the extent of Project-Based Learning strategies in learning mathematics among college students at Mindanao State University–Sulu, when grouped by course, is accepted.

| Variables | Grouping | Mean | S.D | Mean Difference | t | Sig. | Description |
|---|---|---|---|---|---|---|---|
| **Interest and Motivation** | BS Biology | 3.917 | .72304 | -.04722 | -.356 | .723 | Not Significant |
| | BS Mathematics | 3.964 | .52174 | | | | |
| **Collaboration and Teamwork** | BS Biology | 4.129 | .55916 | .03194 | .286 | .775 | Not Significant |
| | BS Mathematics | 4.097 | .53879 | | | | |
| **Confidence and Participation** | BS Biology | 3.900 | .64029 | -.10278 | -.877 | .383 | Not Significant |
| | BS Mathematics | 4.003 | .52570 | | | | |
| **Academic Engagement** | BS Biology | 4.063 | .60233 | -.00139 | -.011 | .991 | Not Significant |
| | BS Mathematics | 4.064 | .65820 | | | | |

*Note.* * Significant at alpha 0.05

*Table 13. Difference in the Extent of Project-Based Learning Strategies in Learning Mathematics when the Data are Grouped According to Course*

*4. Is there a significant correlation among the sub-categories subsumed under the extent of Project-Based Learning strategies in learning mathematics among college students at Mindanao State University–Sulu?*

Table 14 presents the correlations among the subcategories subsumed under the extent of Project-Based Learning (PBL) strategies in learning mathematics among college students at Mindanao State University–Sulu. The computed Pearson correlation coefficients (r) indicate statistically significant relationships at the 0.01 level for all pairs of variables, based on a sample of 100 respondents.

The degrees of correlation among the subcategories are as follows:

1. A high positive correlation is observed between Interest and Motivation and Collaboration and Teamwork (r = 0.684, Sig. = 0.000), suggesting that students who demonstrate higher interest and motivation in project-based mathematics activities also tend to exhibit stronger collaboration and teamwork skills.

2. A high positive correlation is found between Interest and Motivation and Confidence and Participation (r = 0.629, Sig. = 0.000), indicating that increased interest and motivation are strongly associated with greater confidence and active participation in mathematics learning.

3. A high positive correlation is likewise observed between Interest and Motivation and Academic Engagement (r = 0.659, Sig. = 0.000), implying that motivated students are more likely to be academically engaged during project-based mathematics instruction.

4. A high positive correlation exists between Collaboration and Teamwork and Confidence and Participation (r = 0.545, Sig. = 0.000), suggesting that collaborative learning experiences enhance students' confidence and willingness to participate in mathematics-related tasks.

5. A high positive correlation is also noted between Collaboration and Teamwork and Academic Engagement (r = 0.598, Sig. = 0.000), indicating that effective teamwork is strongly linked to sustained academic engagement in project-based mathematics activities.

6. A moderate positive correlation is observed among Confidence, Participation, and Academic Engagement (r = 0.436, Sig. = 0.000), suggesting that increased confidence and participation are moderately associated with higher levels of academic engagement.

Overall, the findings indicate that all subcategories—Interest and Motivation, Collaboration and Teamwork, Confidence and Participation, and Academic Engagement—are significantly interrelated, with moderate to high positive correlations among pairs. This suggests that improvements in one dimension of Project-Based Learning are likely to positively influence the other dimensions. Therefore, the null hypothesis that there is no significant correlation among the subcategories of the extent of Project-Based Learning strategies in learning mathematics among college students at Mindanao State University–Sulu is rejected.

| Variables | | Pearson *r* | Sig. | N | Description |
|---|---|---|---|---|---|
| Dependent | Independent | | | | |
| Interest and Motivation | Collaboration and Teamwork | .684** | .000 | 100 | High |
| | Confidence and Participation | .629** | .000 | 100 | High |
| | Academic Engagement | .659** | .000 | 100 | High |
| Collaboration and Teamwork | Confidence and Participation | .545** | .000 | 100 | High |
| | Academic Engagement | .598** | .000 | 100 | High |
| Confidence and Participation | Academic Engagement | .436** | .000 | 100 | Moderate |

*Note.* **Correlation coefficient is significant at alpha .01
Correlation Coefficient Scales Adopted from Hopkins, Will (2002):
0.0-0.1 = Nearly Zero; 0.1-0.3 = Low; 0.3-0.5 = Moderate; 0.5-0.7 = High; 0.7-0.9 = Very High; 0.9-1 = Nearly Perfect.

*Table 14. Correlations among the Sub-categories Subsumed Under the Extent of Project-Based Learning Strategies in Learning Mathematics*

## Summary of Findings

The following are findings of this study:

1. For Research Question Number 1: On the demographic profile of student-respondents: Among the 100 college student respondents at Mindanao State University–Sulu, the majority are 20 years old and above, with male and

female students equally represented. The respondents are evenly distributed across all year levels, and most are enrolled in the BS Mathematics program.

2. For Research Question Number 2: On the extent of Project-Based Learning strategies in learning mathematics among college students at Mindanao State University–Sulu: The student-respondents generally agreed that Project-Based Learning (PBL) strategies are effectively implemented in learning mathematics across the dimensions of interest and motivation, collaboration and teamwork, confidence and participation, and academic engagement. Students reported that project-based activities made mathematics lessons more meaningful and engaging, encouraged active peer collaboration, and enhanced their confidence in expressing ideas and participating in class. They also indicated that PBL sustained their focus, promoted timely task completion, and helped them connect mathematical concepts to real-life situations.

3. For Research Question Number 3: On differences in the extent of Project-Based Learning strategies in learning mathematics among college students at Mindanao State University–Sulu when data are grouped according to respondents' demographic profile: The findings reveal that no significant differences were observed in the extent of Project-Based Learning (PBL) strategies used in learning mathematics across age, gender, and course groups. This indicates that students across these demographic categories experienced PBL strategies similarly. However, a significant difference was found when the data were grouped according to year level. The results show that students' levels of interest and motivation, collaboration and teamwork, confidence and participation, and academic engagement in project-based mathematics learning vary significantly across year levels.

4. For Research Question Number 4: On correlation among the sub-categories subsumed under the extent of Project-Based Learning strategies in learning mathematics among college students at Mindanao State University–Sulu: The findings indicate significant positive relationships among the subcategories of Project-Based Learning (PBL) strategies in learning mathematics: interest and motivation, collaboration and teamwork, confidence and participation, and academic engagement. The correlations range from moderate to high, suggesting that improvements in one dimension of PBL are associated with improvements in the other dimensions. These results imply that the key components of Project-Based Learning are interrelated and mutually reinforcing, collectively contributing to more effective mathematics learning among college students.

## Conclusions

The study concludes that:

1. The demographic profile of the respondents reflects a typical college student population, with most students aged 20 years old and above, equally represented by gender, evenly distributed across year levels, and predominantly enrolled in BS Mathematics. This profile suggests that the respondents are developmentally and academically prepared to engage in learner-centred approaches such as Project-Based Learning. Studies confirm that college students demonstrate greater readiness for active and collaborative learning as they mature academically (Karantonis & Heffernan, 2023; Guo & Jou, 2020).

2. The findings indicate that Project-Based Learning strategies are effectively implemented in mathematics instruction, as evidenced by positive student responses across interest and motivation, collaboration and teamwork, confidence and participation, and academic engagement. This supports research showing that PBL enhances engagement and motivation by promoting authentic and meaningful learning experiences (Belland et al., 2020; Shih et al., 2024).

3. The study concludes that there are no significant differences in the extent of Project-Based Learning strategies across age, gender, and course. However, significant differences are observed across year levels, indicating that students' engagement with PBL increases as they progress academically.

4. The results show significant positive relationships among interest and motivation, collaboration and teamwork, confidence and participation, and academic engagement, indicating that these dimensions of Project-Based Learning are interrelated. This supports research asserting that effective PBL environments function holistically, where motivation, collaboration, and engagement mutually reinforce learning outcomes (Serin, 2023; Belland et al., 2020).

*Recommendations*

This study recommends the following:

1. Curriculum developers may more explicitly incorporate Project-Based Learning approaches into the mathematics curriculum to ensure alignment with learner-centered and outcomes-based education frameworks.

2. School administrators of Mindanao State University–Sulu may support mathematics instructors by providing continuous professional development focused on the effective design and implementation of Project-Based Learning strategies, particularly those that enhance collaboration, student engagement, and confidence across different year levels.

3. Mathematics teachers at Mindanao State University–Sulu may integrate well-structured project-based activities that emphasize real-life applications of mathematical concepts, encourage peer collaboration, and promote active student participation, while providing timely and constructive feedback.

4. College students of Mindanao State University–Sulu may actively participate in project-based and collaborative learning activities to further develop their problem-solving skills, confidence, and academic engagement in mathematics learning.

5. Future researchers in mathematics education may conduct further studies using experimental, comparative, or longitudinal designs to examine the long-term effects of Project-Based Learning on mathematics achievement and to explore its applicability in other academic disciplines or educational contexts.

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## Competing Interests Statement

The authors declare that there are no conflicts of interest, whether financial or personal, that may have influenced the outcomes or interpretations of this work.

## Data Availability Statement

This article does not involve the creation or analysis of new datasets. All materials used in the study were sourced from previously published works, as indicated in the references; therefore, data sharing is not applicable.

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## Appendices

No appendices are attached to this study.