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A basis for calculus supplementary workbook to enhance the problem-solving skill using study buddy method

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Abstract

This study investigates the development of "A Basis for Calculus Supplementary Workbook to Enhance Problem-Solving Skills Using the Study Buddy Method." The workbook is designed to improve students' problem-solving abilities in calculus through collaborative learning. The Study Buddy method groups students to solve calculus problems together, promoting active engagement, peer teaching, and collaborative discussion. These interactions are expected to improve comprehension and long-term retention of calculus concepts.

A mixed-method approach was employed, combining pre- and post-tests to measure problem-solving improvement and qualitative surveys to capture student feedback on the Study Buddy method. The results show that students using the workbook experienced significant gains in their problem-solving skills compared to those using individual study methods. Furthermore, the Study Buddy method encouraged deeper understanding through peer explanations, shared problem-solving strategies, and collaborative learning experiences.

The findings suggest that the Study Buddy method, supported by the supplementary workbook, is an effective strategy for enhancing problem-solving skills in calculus. This resource provides educators with a structured tool to integrate collaborative learning in the calculus curriculum. The study concludes with recommendations for further workbook development based on student performance and feedback.

Keywords: Study Buddy; Supplementary Workbook; Peer Learning; Problem-Solving; Calculus

1. Introduction

Calculus, often viewed as the gateway to higher mathematical areas, requires not only a thorough comprehension of its fundamentals but also a developed problem-solving skill set. It is one of the major subjects of the Bachelor of Secondary Education major in Mathematics from the first year up to the third year. Most students struggle with calculus because they do not study regularly after classes, cannot focus in class, have gaps in their math knowledge, and believe that learning calculus is a waste of time.

Regardless of the educational level, mathematics is one of the disciplines that is considered difficult in the educational system. They encountered issues and challenges for a variety of reasons, including the intricacy of math and the difficulty involved in manipulating symbols and doing computations. A few of these included not being able to perform fundamental math operations and skills, remember information, organize several steps, and respond to unusual inquiries. Their anxieties and self-efficacy, as well as their past experiences, attitudes, personalities, dispositions, and learning behaviors and styles, all played a part in their challenges.

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In an effort to address these challenges, this research explores a novel and effective approach: the Study Buddy Method. By adding a collaborative and interactive learning framework, this approach aims to transform how students learn and understand calculus.

Laguna University has implemented the study buddy method, a collaborative learning strategy, and calculus provides various challenges that frequently necessitate multiple viewpoints to unravel, this strategy utilizes the power of collaboration to improve problem-solving proficiency. The Study Buddy Method encourages students to work in pairs or small groups, creating a setting where they can jointly address challenging issues and investigate various problem-solving techniques. In summary, the calculus workbook will serve as a spark for the active participation of the established study buddy of the Bachelor of Secondary Education (BSEd) major in Mathematics students at Laguna University.

2. Material and methods

2.1 Research Instrument

In this study, the researchers constructed their own pre-test, post-test, and questionnaire. The meticulously prepared questionnaire aims to collect data and facts from a group of individuals (Acharya, 2018). The pre-test evaluated BSEd Mathematics students' problem-solving abilities prior to utilizing the Calculus Workbook. It consists of 40 questions, 19 with 10 for each lesson topic: 1: Real Numbers, Inequalities, and Absolute Values; 2: Coordinate Plane; 3: Functions; 4: Conic Sections. The post-test assessed problem-solving abilities after utilizing the calculus workbook. It consists of 20 items centered on the lesson topic with the lowest mean level. In addition, the questionnaire identified the mean level of BSEd Math students' assessment of the Calculus Workbook as a supplementary tool to Enhance the Problem-Solving Skill using Study Buddy Method at Laguna University using a five-point Likert scale to rate. It ranges from 4 (Strongly Agree), 3 (Agree), 2 (Disagree), and 1 (Strongly Disagree).

2.2 Data Gathering Procedure

After the validation of the instrument, the researcher received authorization to proceed with data collection for the study. This involved selecting mathematics students at Laguna University to participate as respondents. The researcher examined the list of respondents within the study's scope in order to determine the total population. Subsequently, the researcher created an initial exam that was conducted online using Google Meet with the respondents in order to determine the current level of the students' problem-solving skills or to collect data. The Calculus Workbook was based on the results of the initial test of the selected participants.

3. Results and discussion

This chapter presents the results, analysis, and interpretation of data gathered from the answers to the questionnaires distributed. These are presented in tabular form in accordance with the specific questions posited in the statement of the problem.

Table 1 Mean Level of the Problem-solving Skills of the students in Calculus in terms of Pre-test

Lesson topic	Controlled group	Verbal interpretation	Experimental group	Verbal interpretation
Part 1: Real Numbers, Inequalities and Absolute Values	5.48	Average	5.54	Average
Part 2: Coordinate Plane	4.48	Average	4.75	Average
Part 3: Functions	3.19	Average	1.54	Low
Part 4: Conic Sections	2.96	Low	3.54	Average
OVERALL MEAN	4.03	Average	3.84	Average

Legend: 7.01 – 10.00 High, 3.01 - 7.00 Average, 0.00 - 3.00 Low;Mean Interpretation of Garcia & Lawsin, 2017

For part 1, the mean for the controlled group is 5.48, while the mean for the experimental group is slightly higher at 5.54; both are interpreted as average. Moving on to part 2, the mean for the controlled group is 4.48, compared to 4.75 for the experimental group, with both also being interpreted as average. In contrast, in part 3, the mean for the controlled group is 3.19, which is interpreted as average, while the experimental group has a significantly lower mean of 1.54, interpreted as low. Lastly, in the final part, the mean for the controlled group is 2.96, which is interpreted as low, whereas the experimental group's mean is 3.54, considered average.

Since the lowest overall mean level of all the topics in pre-test is part 3: Functions. Then, it served as a basis for determining which topic should be focused on. Calculus problem-solving needs students to assess, evaluate, and synthesize data, tLehis technique promotes the development of critical thinking abilities, allowing students to approach problems logically and reasonably.

According to Sitorus et al. (2019), students' understanding of problem-solving plays a crucial role in their mathematics learning outcomes. This implies that even if students achieve satisfactory results in assessments, their basic problem-solving abilities might still be insufficient, particularly for those with a lower average performance level, potentially limiting their overall mathematical proficiency.

According to Qiu and Lee (2020), the experimental group showed lower pre-test scores, indicating potential for growth through the instructional intervention. This setup allows researchers to clearly link any subsequent improvements in the post-test to the effectiveness of the intervention. This method is frequently applied in educational research, particularly when assessing the efficacy of teaching strategies in specific areas such as functions, and it underscores the necessity for a balanced assessment prior to intervention to ensure accurate measurements of progress.

Table 2 Mean Level of the Problem-solving Skills of the students in Calculus in terms of Post-test for Controlled Group

Lesson topic	Controlled group	Verbal interpretation	Experimental group	Verbal interpretation
Part 3: Functions	4.24	Average	6.48	Average

Legend: 7.01 – 10.00 High**,** 3.01 - 7.00 Average, 0.00 - 3.00 Low; Mean Interpretation of Garcia & Lawsin, 2017

In table 2, it presents the mean scores of controlled group and experimental group of students in their post-test which both interpreted as an average level. A study by Mkhastwha (2020) showed that students' quantitative reasoning skills significantly affect their ability to solve related rates of change problems in calculus. The research found that students performing at an average level often had foundational weaknesses, as demonstrated by their lower mean scores in prerequisite courses. This indicates a need for targeted interventions to enhance their problem-solving skills. Additionally, the average mean level of students in the calculus workbook further illustrates these weaknesses, emphasizing the importance of providing better instructional support.

Table 3 Validity Level of Calculus Workbook

Level of Validity of the Calculus Workbook	Validity	Verbal Interpretation
Lesson Objectives	K=0.41	Moderate Agreement
Content	K=0.31	Fair Agreement
Presentation and Usefulness	K=0.41	Moderate Agreement

Legend: $<$ 0 Poor Agreement, 0.0 − 0.20 Slight Agreement, 0.21 − 0.40 Fair Agreement, 0.41 − 0.60 Moderate Agreement, 0.61 − 0.80 Substantial Agreement, 0.81 − 1.0 Almost Perfect Agreement; Interpretation of Fleiss' kappa (κ) (from Landis and Koch 1977)

The table presents the validity level of the Calculus Workbook as evaluated by five master teachers. In terms of meeting lesson objectives, the workbook was assessed using the Kappa statistic (K), yielding a value of 0.41, which is verbally interpreted as indicating "moderate agreement." For the content evaluation, the validity level was 0.34, reflecting a "fair agreement." Lastly, regarding its presentation and usefulness, the workbook received a validity score of 0.41, again corresponding to "moderate agreement."

According to DepEd (2022), moderate agreement on the lesson objectives in calculus workbooks refers to a general consensus, but with notable differences among educational materials on what these objectives should be. This suggests that while educators agree on many core concepts, there is still variability in how these objectives are presented, which can affect student understanding. Furthermore, some research highlights how differences in the presentation of

mathematical objectives, such as those found in calculus workbooks, can lead to inconsistencies in the effectiveness of instruction, ultimately impacting learners' mastery of the subject.

Similarly, according to Moosavizadeh (2023), the term "fair agreement" in the context of calculus workbooks typically refers to a moderate consensus among educators regarding the content and pedagogical strategies presented in these materials. This implies that while there is general agreement on certain aspects of the curriculum, some discrepancies may exist, which can affect how concepts are conveyed to students. In this sense, a fair agreement indicates that while there are shared understandings of key objectives and methodologies, there remains room for diversity in interpretation and implementation across different educational resources.

As noted by Renault (2022), the phrase "moderate agreement" regarding calculus workbooks typically suggests that while there is some level of consensus about how lesson objectives are presented, there are still variations. These differences can, in turn, affect how clearly objectives are communicated, potentially impacting student comprehension and engagement with the material. Thus, this variability can apply to both the presentation of calculus concepts and the perceived usefulness of the workbooks in reinforcing these concepts.

Table 4 Mean Level of Controlled Group and Experimental Group of the Students

	T-Value	**P-Value**	**Verbal Interpretation**
Controlled Group	T=1.32	P=.1993	There is no significant difference between the pre-test and post-test of the controlled group after study buddy.
Experimental Group	T=9.75	P=0	There is a significant difference between the pre-test and post-test of the experimental group after using the Calculus workbook in Study Buddy.

Significant data on the positive influence of study interventions on academic achievement was obtained from the analyses done on the controlled and experimental groups. The statistical analysis in the controlled group showed a T-value of 1.32 and a matching P-value of 0.1993. This result implies that there was no noticeable increase in academic performance from the intervention, since there is no significant change between the pre-test and post-test scores of the controlled group after their use of study buddies.

In relation to the study buddy method without the intervention of a workbook, Zachary O'Brien (2021) discusses the effectiveness of interventions through a pre-test and post-test design. When a control group shows no significant difference between these scores, it often indicates that the intervention—in this case, the study buddy system—may not have had a measurable impact. A statistical method commonly used to interpret such findings is the paired samples t-test, where the null hypothesis suggests no significant difference between the two sets of scores.

If the p-value exceeds 0.05, this supports the null hypothesis, implying that any observed differences are likely due to chance rather than the study buddy system's effectiveness. O'Brien's study utilized gain scores to evaluate differences between student groups, and in cases where no significant changes are found, it may suggest that the intervention, like the study buddy method, did not produce the anticipated improvements.

On the other hand, the experimental group showed a significantly different result when using the Calculus textbook within the study buddy framework. According to Quantifying Health (2023), if the experimental group receiving the intervention demonstrates a statistically significant improvement in post-test scores compared to their pre-test scores, it indicates that the intervention had a meaningful effect. Studies using this approach have shown significant differences in outcomes between pre- and post-tests, supporting the effectiveness of the intervention. This design controls for internal validity threats like maturation and testing effects, thus offering more reliable cause-and-effect conclusions. Similarly, applying this method with a calculus workbook as part of a study buddy intervention could lead to significant improvements in students' understanding and performance in calculus, enhancing the validity of the findings.

On the whole, the findings indicate that although the conventional study buddy method failed to produce significant improvements in academic achievement, the integration of the Calculus workbook into the study buddy structure greatly enhanced learning outcomes. This emphasizes the value of developed and organized study interventions in promoting learning as well as the possible effectiveness of integrating specialized learning resources into study support systems. Further studies may go deeper into the particular processes that support the efficacy of those interventions and their greater implications for instructional strategies.

Table 5 Mean Level of Overall Rating of the Calculus Workbook among the Students of BSEd Mathematics

	Mean	**SD**	**Verbal Interpretation**
Overall Rating of the Calculus Workbook among the Students of BSED Mathematics	3.17	0.05	High

Legend: 1.00 – 2.00 Low, 2.01 – 3.00 Moderate, 3.01 – 4.00 High; Mean Interpretation of Sumber;Taib, 1996

The table 5 presents the mean overall rating of the calculus workbook among the students of BSEd Mathematics which has the mean of 3.17, which is interpreted as high.

Workbooks empower students to take charge of their learning journey. They allow students to progress at their own pace, providing a sense of autonomy and building self-confidence. As students conquer each section of the workbook, they gain a tangible measure of their achievements, fostering a positive learning environment.

Giangan and Gurat (2022) highlights the term "high verbal interpretation" in relation to students' overall rating of a Calculus workbook suggests that students perceive the workbook as effective and useful for their learning. In a study on the academic performance of STEM students, a Likert scale analysis showed that students had a positive perception of learning Calculus, even though the correlation between perception and performance wasn't significant. This indicates that while students rated the workbook highly, their positive perceptions didn't necessarily predict higher academic results.

4. Conclusion

Reject the null hypothesis; thus, there is a significant difference in problem-solving skill improvement between students who use the Study Buddy method with a calculus supplementary workbook and those who do not utilize any supplementary materials.

Compliance with ethical standards

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Disclosure of conflict of interest

The authors declare no conflict of interest.

Statement of informed consent

Informed consent was obtained from all individual participants included in the study.

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