International Journal of Research Publication and Reviews

Journal homepage: www.ijrpr.com ISSN 2582-7421

Improving the Academic Performance in Calculus 1 Derivatives Among BSED Math 2 Students Using DerivaThon

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A B S T R A C T:

Mathematics is a foundational discipline that cultivates essential analytical and problem-solving skills. Nevertheless, many pre-service mathematics educators encounter difficulties with advanced calculus concepts, particularly differentiation techniques such as the chain rule and trigonometric differentiation. At Cataingan Municipal College, performance data revealed that 21% of the 43 students in BSED Math 2-Block A12 scored 75 or below on their Calculus 1 final exam, underscoring significant learning gaps. Many students struggled to grasp multi-step differentiation rules, resulting in poor retention and limited application of fundamental concepts. Consequently, a structured, gamified intervention was needed to address these challenges and reinforce learning. To enhance learning outcomes, the researchers implemented Deriva Thon—a gamified learning strategy designed to boost student engagement, alleviate math anxiety, and improve problem-solving skills among those challenged by differentiation. The intervention consisted of a checkpoint-based problem-solving marathon in which students worked collaboratively in groups to tackle differentiation problems of varying difficulty, earn points, and progress through successive levels. All 43 students participated, benefiting from faculty guidance and real-time validation of their solutions. Post-intervention results indicated that students' mean scores improved by 5.51 points, signifying a statistically significant enhancement in mastery of differentiation techniques. The Wilcoxon Signed-Rank Test confirmed the efficacy of DerivaThon with a p-value of less than 0.0001, demonstrating that the improvements were not attributable to chance. Moreover, thematic analysis of student reflections revealed notable increases in motivation, problem-solving confidence, and collaborative learning dynamics. These findings suggest that DerivaThon is an effective instructional model for advancing calculus proficiency and holds promise for broader integration into mathematics education curricula.

Keywords: derivatives, Calculus 1, differentiation, gamified intervention, collaborative learning, chain ruleIntroduction

Mathematics plays a crucial role in developing students' analytical, problem-solving, and logical reasoning skills, especially for Bachelor in Secondary Education (BSED) major in Mathematics students who need to master Calculus 1 as a foundation for advanced topics and future teaching careers. However, many students are still having difficulty in Calculus 1, indicating significant struggles with differentiation techniques such as the chain rule and trigonometric differentiation. These areas are particularly challenging due to their algebraic complexity and the requirement for multi-step application of rules (Tall, 1985), leading to concerns about students' grasp of fundamental calculus concepts and their readiness as future mathematics educators.

Several factors contributed to students' difficulties in learning derivatives, including the abstract nature of the concepts, a lack of foundational knowledge, and ineffective learning strategies. Internationally, studies have explored various interventions to improve calculus learning, such as technology-enhanced, inquiry-based approaches (Lai et al., 2018) and the use of dynamic software (Habre, 2000) and computer-aided assessment (Sangwin, 2007). In the Philippines, research has also focused on student-centered approaches using tools like GeoGebra (Arevalo et al., 2020), problem-based learning, and digital gamification (Medico et al., 2023), all showing positive outcomes.

To address these persistent difficulties, this study introduces DerivaThon, a gamified problem-solving approach designed to enhance students' understanding and performance in these challenging derivative areas. This intervention incorporates active learning, collaborative problem-solving, and competitive elements to create an engaging and effective learning experience. By integrating interactive methods, DerivaThon aims to deepen conceptual understanding, reinforce differentiation rules, and reduce mathematics anxiety, ultimately preparing pre-service mathematics teachers to effectively teach fundamental mathematical concepts in their future classrooms. This aligns with Philippine educational policies like DepEd Order No. 42, s. 2017, and CHED Memorandum Order No. 20, s. 2013, which emphasize student-centered learning, active engagement, and the development of holistic competencies, reinforcing the necessity of enhancing students' calculus performance for their future teaching roles.

1.1 Statement of the Problem

This action research examined the effectiveness of DerivaThon in improving the academic performance in the less learned areas of derivatives in Calculus

1 among BSED Math 2-Block A12 of Cataingan Municipal College. Through the implementation of this gamified learning strategy, specific aspects of academic performance in derivatives were identified as most improving. Further, it examined how DerivaThon supported the mastery of calculus concepts by providing an engaging learning environment and contributing to learners' proficiency in differentiation (Nacional, 2024; Nob, Roble, & Lomibao, 2024). Specifically, the study examined the academic performance levels of BSED Math 2-Block A12 students in derivatives before and after using DerivaThon. This study also aimed to determine whether the students' academic performance in derivatives significantly improved after implementing this intervention (Antonio & Tamban, 2023; Oliveira et al., 2018).

1. Methods

2.1 Research Design

This study utilized a mixed-methods approach, combining quantitative (pretest-posttest and survey ratings) and qualitative (open-ended survey responses) methods (Creswell & Creswell, 2018; Dawadi et al., 2020). The pretest-posttest design will assess students' academic performance before and after the intervention, while the survey captured students' perceptions and feedback on the DerivaThon intervention. Along with this, the qualitative part looked at open-ended survey answers, giving detailed information about students' personal experiences and views. This qualitative data was key to finding out why quantitative results changed and to spot main ideas about motivation and how well the teaching worked. By putting these different methods together, the study got strong, confirming results, making the overall findings about the intervention's success more reliable and complete.

2.2 Data Sources

The primary data sources of this study were 43 students from BSED Math 2- Block A12 of Cataingan Municipal College enrolled in Calculus 1 during the first semester of A.Y. 2024–2025. Among the participants, there were 25 females and 18 males. This block is chosen due to their struggle in differentiation techniques especially in chain rule and trigonometric differentiation. The students took both pretest and posttest assessment to measure their Calculus 1 performance before and after the implementation of DerivaThon.

Along with the primary source of data, the other sources of data were the grades of Block A12 during their final exam, which was 21% of students got 75% and below rating. Pretest and posttest results were gathered to measure the increase in performance after the intervention. Both test focused on topics such as basic differention, application of chain rule, and trigonometric differentiation. To determine if DerivaThon intervention is effective, quantitative analysis was also conducted. To assess the data normality, the Shapiro-Wilk Normality Test was used. Sangwin (2007) explored the importance of normality testing in mathematics assessment, emphasizing that verifying data distribution ensures accurate interpretation of learning gain. After assessing the data normality, Wilcoxon Signed-Ranked Test was used for valid comparison given that the data did not follow normal distribution. For qualitative insights, open-ended survey responses were subjected to thematic analysis. Kiger and Varpio (2020) highlight that thematic analysis is a well-suited method for identifying patterns and themes in textual data. Furthermore, Chambers and Chiang (2012) emphasize the value of open-ended questions in surveys for gathering rich, contextually-relevant information.

2.3 Research Procedure

The study involved 43 students from the BSED Math 2-Block A12 program at Cataingan Municipal College. Prior to the intervention, research instruments, including the pretest, posttest, and open-ended survey, underwent validation by a qualified Calculus instructor to ensure their appropriateness. Official approval to conduct the DerivaThon intervention was then secured from the college dean and the Block A12 Calculus instructor (Mertler, 2019). Throughout the research process, strict ethical considerations were observed, encompassing informed consent from participants, maintaining data confidentiality, and emphasizing voluntary participation (Creswell & Creswell, 2018).

The DerivaThon intervention, conceptualized as a gamified learning strategy, involved meticulously crafted problem sets and interactive components. These materials were validated by content experts to ensure instructional appropriateness and accuracy (Rothman & Thomas, 1994), and the research team was thoroughly oriented on study procedures for consistent delivery (Gay, Mills, & Airasian, 2012). For data collection, all assessment materials were securely handled and administered under standardized conditions. Pre-test and post-test scores, along with open-ended survey responses, were collected and subsequently anonymized to safeguard participant identities and ensure unbiased processing (Mertler, 2019).

For quantitative analysis, the Shapiro-Wilk Normality Test was initially performed to assess data distribution, crucial for accurate interpretation of learning gains (Sangwin, 2007). As the data did not follow a normal distribution, the Wilcoxon Signed-Rank Test, a non-parametric statistical tool, was employed to compare pre-test and post-test scores and evaluate intervention effectiveness (Field, 2018). For qualitative insights, open-ended survey responses underwent thematic analysis, a method highlighted by Kiger and Varpio (2020) for identifying patterns in textual data. Chambers and Chiang (2012) further emphasize the value of such open-ended questions for gathering rich, contextually-relevant information to understand student experiences.

2. Results and Discussion

3.1 Normality Testing of the Gathered Data

The results of pretest and posttest were collected from 43 respondents that participated in DerivaThon. Before concluding the Pretest and Posttest scores for the DerivaThon intervention, it is necessary to verify whether the scores follow a normal (bell-shaped) distribution. Many parametric tests, such as the paired samples t-test, assume normality. Sangwin (2007) explored the importance of normality testing in mathematics assessment, emphasizing that verifying data distribution ensures accurate interpretation of learning gains, a principle that was upheld in this study using the Shapiro-Wilk Normality Test. Shapiro-Wilk Normality Test is a commonly used method for this purpose, especially with a moderate sample size. In this test, the null hypothesis (H_0) asserts that the data are normally distributed. If the p-value is less than 0.05, H_0 is rejected, indicating that the data do not follow a normal distribution. For the study involving 43 paired observations, the test was applied separately to the Pretest and Posttest scores.

As shown in Table 1, the p-values, 0.0142 for the Pretest and 0.0013 for the Posttest, are both below the 0.05 threshold. This result leads to the rejection of the null hypothesis of normality for both sets of scores, indicating that the data do not follow a normal distribution. Considering this outcome, the use of non-parametric methods becomes necessary for further analysis of the paired observations.

Given that the data are not normally distributed, the Wilcoxon Signed-Rank Test was selected as one of the methods for comparing the paired Pretest and Posttest scores. This non-parametric test does not assume normality and examines whether the median difference between paired observations is zero. The null hypothesis (H_0) for this test states that no change exists between the Pretest and Posttest scores, while the alternative hypothesis (H_1) suggests a significant difference.

Table 1

Shapiro-Wilk Normality Test of Data

Variables	N	S-W	P-value	Interpretation
Pretest	43	0.9531	0.0142	Not Normally Distributed
Posttest	43	0.9319	0.0013	Not Normally Distributed

3.2 BSED Math 2- Block A12 Performance Level in the Less Learned Areas of Derivatives After the Implementation of DerivaThon

Table 6 show the Wilcoxon Signed-Rank test for Pretest and Posttest. The Wilcoxon Signed-Rank Test yielded a Z-score of –5.9831, and a p-value of less than 0.0001. The extremely low p-value indicates a rejection of H_0, meaning that the difference between the Pretest and Posttest scores is statistically significant. In simpler terms, this is a strong evidence that the DerivaThon intervention produced a meaningful improvement in student performance. Bautista et al. (2016) demonstrated that technology-assisted learning enhances problem-solving skills, supporting the observed improvements in students' post-test scores after the DerivaThon intervention.

The analysis of the significant difference in the performance level in less learned areas of derivatives of Block A12 after the implementation of DerivaThon showed increase and improvement. Based on the results of the Wilcoxon Signed-Rank Test, a p-value of < 0.0001 were obtained, indicating that the difference in scores was statistically significant. This finding confirmed that the performance of students after the intervention was significantly higher compared to their performance before the intervention.

As a result, the research hypothesis stating that there is a significant difference in performance levels before and after the implementation of DerivaThon was accepted, while the null hypothesis—which stated that there is no significant difference—was rejected. This outcome validated the effectiveness of the intervention program in addressing learning gaps in derivative concepts. The data suggested that the structured activities and gamified approach of DerivaThon played a crucial role in reinforcing mathematical concepts and improving students' problem-solving abilities. Dela Cruz & Ramos (2015) found that gamification fosters student engagement and motivation, which aligns with the increased enthusiasm observed among Block A12 students during the DerivaThon intervention.

The findings of this study aligned with recent local research emphasizing the positive effects of gamified and technology-enhanced instruction in mathematics education. For instance, Santos and Villanueva (2023) reported that the use of interactive learning tools significantly improved the mathematical comprehension and engagement levels of college students, particularly in abstract topics such as calculus. Their study emphasized that game-based interventions not only increased motivation but also deepened conceptual understanding through active learning. Similarly, the DerivaThon intervention provided students with opportunities to visualize and apply derivative concepts in an engaging and meaningful way. This supported the idea that localized, culturally responsive educational tools—when paired with evidence-based pedagogical approaches—could effectively bridge learning gaps and foster academic improvement in higher mathematics. The significant further implied improvement implied that targeted and well-designed instructional interventions could yield positive academic outcomes, especially for students who initially struggled with differentiation techniques. These findings highlight the importance of implementing interactive and research-driven learning strategies to enhance student proficiency in calculus.

Table 2

Results of Pretest and Posttest

Variables	N	Z-score	P-value	Interpretation
Pretest-posttest	43	-5.9831	< 0.0001	Statistically Significant

3.3 Qualitative Interpretation of Learners About DerivaThon

Exploring learners' reflections on DerivaThon provides a deeper understanding of their experiences, challenges, and engagement with calculus concepts. Yan & Matore (2023) similarly concluded that gamification enhances cognitive engagement in mathematics, reinforcing the positive impact observed in student reflections on the structured and interactive learning experience offered by DerivaThon. Through a qualitative analysis of feedback, distinct themes emerged, showcasing how students interacted with the intervention. These themes include intrinsic motivation, collaborative problem-solving, instructional clarity, practical learning strategies, and experiential learning. Examining these perspectives helps identify strengths and areas for refinement, ensuring that future implementations of DerivaThon align with student needs.

The thematic analysis in this study was conducted using MAXQDA, a qualitative research software designed for systematic coding and interpretation. The software facilitated data organization, identified recurring patterns, and visualized code frequencies to ensure structured insights from students' reflections on the DerivaThon intervention. As noted by Kuckartz and Rädiker (2019), MAXQDA supports the integrity of qualitative research by providing tools that help researchers move beyond descriptive summaries to deeper interpretative analysis, thereby grounding the findings in authentic student voices and reinforcing the trustworthiness and depth of the thematic results.

Table 3 presents the key themes emerging from student responses, offering a detailed overview of their experiences. The engagement-through-challenge theme highlights how the activity was both challenging and enjoyable, motivating students to engage actively in problem-solving. However, some respondents pointed out unclear instructions, emphasizing the need for well-defined guidelines to ensure smooth execution.

The complexity and cognitive load of differentiation were apparent, as several students struggled with understanding formulas and multi-step processes. Despite these difficulties, many participants appreciated the problem-solving aspect of DerivaThon, expressing enjoyment in answering derivative-related questions. The intervention also fostered collaborative learning, with students noting teamwork and cooperation as valuable elements in their engagement.

Additionally, responses indicated that the structured and competitive nature of DerivaThon contributed to motivation, making the learning process more enjoyable. While some students found the activity well-organized and effective, others emphasized the need for refined instructions. Critical thinking development also emerged as a key takeaway, demonstrating how gamified learning encouraged deeper analytical reasoning.

The results suggest that DerivaThon was an effective tool for improving students' understanding of differentiation while maintaining engagement through game-based learning. Future refinements should address instructional clarity to enhance its impact on mathematics education.

Table 3
Illustrative Example of the Thematic Analysis Perceived by the Respondents in the Implementation of DerivaThon

Code (Support to the Themes)	Key Quotes or Sample Responses	Themes
Challenging but enjoyable	**"I like how it challenge our knowledge and understanding." "It was challenging and I like their way of giving problems." "I like how challenging it is and how it made me motivated to engage more…" "I like the most about the DerivaThon is it is exciting and challenging."**	**Engagement through Challenge**
Unclear instructions	**"The instructions was not clearly stated…" "We encountered some conflict on what station we should go first…" "Be on time and state the instructions clearly…"**	**Need for Clear and Organized Guidelines**
Derivatives are difficult	**"It is very difficult." "Study advance difficulties… because it's not easy to understand." "There's a lot of formulas that you need to memorize."**	**Complexity and Cognitive Load**
Solving problems is enjoyable	**"I like it by solving derivatives." "Answering the math problems especially the derivative of functions." "I like the most is to how to solve basic derivatives."**	**Appreciation for Problem Solving**
Fun and motivating experience	**"It's fun and it increase my learning…" "Very interesting, I want to learn more." "It was enriching which made math more enjoyable."**	**Learning through Fun and Interest**
Group/teamwork experience	**"We are trying to solve the right derivative… and having a good teamwork…" "When we solve the problem and have cooperation."**	**Value of Collaborative Learning**
Organized and effective	**"Very well organized." "Everything is well organized and interesting."**	**Effective Activity Design**
Motivated to learn more	**"Keep on studying about DerivaThon… we can improve our skills." "It helps me to motivate and engage more in mathematics."**	**Increased Motivation and Engagement**
Developed thinking skills	**"We use our critical thinking to put so much effort…" "The way of trying to compromise on how to derive."**	**Development of Analytical Thinking**

4. Conclusion

The findings of this study clearly demonstrate that DerivaThon, a gamified learning intervention, significantly improved the academic performance of BSED Math 2-Block A12 students in the less learned areas of differentiation in Calculus 1. The statistically significant difference between pretest and posttest scores confirms that structured, interactive, and engaging learning experiences can enhance students' understanding of complex mathematical concepts such as the chain rule and trigonometric differentiation. Qualitative data further revealed that DerivaThon fostered intrinsic motivation, collaborative learning, critical thinking, and enjoyment—key elements that contributed to a deeper conceptual grasp of derivatives. While some participants noted the need for clearer instructions, the overwhelmingly positive responses highlight the value of incorporating gamified strategies into mathematics instruction. These results underscore the importance of adopting student-centered, innovative pedagogical approaches in higher education to address persistent learning challenges and better prepare future educators. Ultimately, DerivaThon proved to be an effective and scalable tool for making abstract calculus topics more accessible and engaging, aligning well with current educational priorities aimed at improving competency and enthusiasm in mathematics learning.

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