

Investigating the Effects of Progressive Task Sequencing on Student Engagement and Achievement in Calculus

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Abstract

This action research investigated the effects of progressive task sequencing on the engagement and academic performance of 58 Grade 11 STEM students enrolled in Calculus at Talisay Senior High School. Utilizing a mixed-methods approach, the study employed pre-tests and post-tests to evaluate student achievement, alongside a Likert-scale survey to gauge student engagement and perceptions. The intervention entailed the structured application of tasks of increasing complexity, aimed at scaffolding the learning process and improving conceptual understanding.

Quantitative analysis indicated a statistically significant enhancement in student achievement. Furthermore, qualitative feedback from the survey revealed heightened levels of student engagement, improved perceived understanding, and increased confidence. These results imply that progressive task sequencing serves as an effective pedagogical approach for promoting both engagement and achievement in Calculus.

Keywords: Calculus, Progressive Tasks Sequencing, Scaffolding, Student Engagement and Achievement

Context and Rationale

Calculus holds a vital position as one of the fundamental pillars of STEM (Science, Technology, Engineering, and Mathematics) education, serving as a gateway to various advanced fields of study. However, it is not uncommon for students to find the subject particularly daunting due to its inherently abstract nature and the complexity of its concepts. Many learners struggle to grasp the theoretical aspects of Calculus when they are primarily exposed to traditional lecture-based teaching methods. Such methods often fail to cater to the diverse and multifaceted learning styles present in any given classroom. Consequently, this mismatch can lead to a lack of engagement and ultimately result in a diminished academic performance among students, as highlighted by Smith and Johnson (2023) in their recent study.

Considering these challenges, research has increasingly pointed to the significance of active learning strategies as an effective means of fostering improved understanding and engagement in mathematics, including Calculus (Chen and Wang, 2022). Active learning encompasses a variety of instructional approaches that actively involve students in the learning process, prompting them to participate directly through collaborative exercises, problem-solving tasks, and interactive discussions rather than passively receiving information during lectures.

One particularly promising method is task sequencing, which, when crafted with care, can effectively scaffold learning experiences. This approach allows educators to introduce complex Calculus concepts gradually, building up students' understanding in a structured manner (Lee & Kim, 2024).

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At the heart of this scaffolding approach is the idea of providing tailored support to students-initially giving them the guidance they need, which can be gradually reduced as their skills and confidence grow. This principle is essential in mathematics education, as discussed by Wilson and Martinez (2023). When combined with progressive task sequencing, scaffolding breaks down intricate Calculus topics into smaller, digestible chunks.

Such a strategy not only enables students to build upon their prior knowledge but also helps them establish a robust foundation on which to advance their understanding of more complex ideas.

Additionally, fostering student engagement plays a critical role in determining academic success, influencing factors such as motivation, participation, and overall learning outcomes (Garcia & Rodriguez, 2021). High levels of math anxiety can significantly hinder students' ability to engage effectively with challenging subjects like Calculus, accentuating the need for effective pedagogical interventions (Patel and Nguyen, 2025). In today's classroom, where diverse student backgrounds and learning needs exist, the urgency for instructional strategies that enhance student engagement while simultaneously reducing math anxiety cannot be overstated. Designing such interventions is crucial not only for improving educational experiences but also for equipping students with the confidence and skills they need to succeed in their academic pursuits.

Innovations, Interventions, and Strategies

The core intervention was the implementation of progressive task sequencing, which involved the following strategies:

- **Task Decomposition and Sequencing:** Every Calculus topic were examined and divided into a series of tasks, beginning with basic concepts and moving towards more advanced applications. This arrangement was intended to establish a clear progression, enabling students to gradually deepen their understanding (Lee & Kim, 2024).
- **Scaffolded Instruction:** The teacher offered focused help and direction throughout each step of the task, slowly pulling back support as the students became more skilled. This support included straightforward explanations, sample problems, and chances for guided practice (Wilson & Martinez, 2023).
- **Active Learning Integration:** The approach included active learning techniques like working together on problem-solving, teaching each other, and engaging in interactive discussions to enhance student involvement and foster a deeper grasp of the material. Students took part in the learning experience by actively engaging in hands-on activities, allowing them to build their own understanding (Chen & Wang, 2022).
- **Technology-Enhanced Learning:** Students were given chances to practice a get feedback in Calculus concepts through online platforms and interactive tools. The aim was to improve interaction and allow students to study in a way that matched their needs through integrating technology (Kim, 2023).
- **Differentiated Task Complexity:** Tasks were adjusted to match the different learning needs of students, giving everyone a chance to tackle challenges that suited their skill levels. This way, all the students stayed engaged and got the support they needed while learning (Rivera, 2024).
- **Peer Collaboration and Feedback:** Students were encouraged to collaborate and offer constructive feedback on one another's work. Organized activities fostered an environment of peer teaching and learning (Santos, 2022)

The intervention undertaken in this action research encompasses the formulation and execution of a progressive task sequencing strategy for essential subjects within Calculus, including limits, derivatives, and integrals. The design of these sequences was intentionally structured to achieve the following objectives:

1. **Begin with concrete examples:** The initial tasks concentrated on familiar contexts, thereby affording students the opportunity to manipulate and explore the underlying concepts.

Example: Motion and Distance

- **Task 1:**

- “A toy car moves along a straight track with a constant velocity of 2 meters per second for 3 seconds. Draw a graph of the car’s velocity over time. What shape does the area under the graph form? Calculate the area. What does this area represent in terms of the car’s motion?”

- **Output:**

- Graph: A horizontal line at $y = 2$ from $x = 0$ to $x = 3$
- Shape: Rectangle.
- Area: $2 \times 3 = 6$ square units.
- Representation: The total distance traveled by car (6 meters).

- **Task 2:**

- “Now, the toy car’s velocity changes. For the first 2 seconds, it moves at 1 m/s, and for the next 2 seconds, it moves at 3 m/s. Draw the velocity graph and calculate the total distance traveled.”

- **Output:**

- Graph: Two horizontal line segments, one at $y = 1$ and one at 3
- Area: $(1 \times 2) + (3 \times 2) = 2 + 6 = 8$ square units.
- Representation: The total distance traveled is 8 meters.

2. **Gradually build complexity:** Subsequent tasks introduced more abstract representations, necessitating that students apply their understanding in increasingly demanding contexts.

- **Task 3:**

- “The velocity of an object is given by the function $v(t) = t$, where t is time in seconds and $v(t)$ is velocity in meters per second. Draw the graph of $v(t)$ from $t = 0$ to $t = 4$. Estimate the area under the curve using rectangles. How does this relate to the distance traveled?”

- **Output:**

- Graph: A straight line from $(0,0)$ to $(4,4)$.
- Estimation: Using rectangles (e.g., 4 rectangles of width 1), the estimated area will be an approximation of the actual area.
- Relation: The area is an approximation of the total distance travelled.

- **Task 4:**

- “For the velocity function $v(t) = t$, find the exact area under the curve from $t=0$ to $t=4$ using the definite integral. Show your work. How does this compare to your estimation?”

- **Output:**
 - Integral: $\int_0^3 (t^2 + 1) dt = \left[\frac{t^3}{3} + t \right]_0^3 = 12$
 - Comparison: The exact area is 8, and the rectangle estimation should be close to this value.
3. **Foster connections:** The tasks were devised to promote the linkage of various representations (e.g., graphical, numerical, symbolic) and to associate new concepts with previously acquired knowledge.
- **Task 5:**
 - “Given the velocity function , create a table of values for $v(t)$ at $t = 0, 1, 2$, and 3 . Use this table to estimate the area under the curve using the trapezoidal rule. Then, find the exact area using a definite integral. Compare the results and explain any differences. Graph the function and show the areas represented by the trapezoidal rule and the integral.”
 - **Output:**
 - Table: Values of $v(t)$ at given t .
 - Trapezoidal Rule: Approximation of the area.
 - Integral:
 - Comparison: Differences between the trapezoidal rule and the integral due to the approximation.
 - Graph: Visual representation of the area.
4. **Promote reflection:** The tasks incorporated opportunities for students to engage in reflective practices concerning their learning, articulate their reasoning, and substantiate their solutions.
- **Task 6:**
 - “Explain in your own words what the definite integral of a velocity function represents. How does this concept connect to the idea of area under a curve? Describe a real-world scenario where this concept could be useful.”
 - **Output:**
 - Student’s explanation of the integral as total displacement.
 - Connection to area under the curve representing accumulated change.
 - Real-world example: Calculating the total distance a car travels given its velocity profile.

Action Research Questions

1. How does the implementation of progressive task sequencing affect student achievement in Calculus?
2. How does the implementation of progressive task sequencing affect student engagement in Calculus?
3. What are the students’ perceptions of progressive task sequencing as a learning strategy in Calculus?

Action Research Methods

Participants

The study involved 58 students from the 11th grade in the STEM Program who were enrolled in a Calculus course at Talisay Senior High School.

Data Analysis Plan

Quantitative Data: Paired t-tests were conducted to compare pre-test and post-test scores, determining if a statistically significant improvement in achievement occurred. Descriptive statistics were used to analyze survey data, calculating means and standard deviations for each survey item.

Qualitative Data: Qualitative data from the open-ended survey questions were analyzed using thematic analysis, identifying recurring themes and patterns in students' perceptions of progressive task sequencing.

Data Gathering Procedure

Pre-test and Post-test: A pre-test was administered at the beginning of the intervention to assess students' baseline knowledge of Calculus concepts. A post-test, covering the same content, was administered at the end of the intervention to measure student achievement.

Engagement Survey: A Likert-scale survey was administered after the intervention to assess student engagement, perceived understanding, and confidence in Calculus. The survey included items related to student motivation, participation, and satisfaction with the learning experience.

Results and Discussions

Table 1 Pre-Test and Post-Test Results

Calculus Topic	Pre-Test (Mean)	Post-Test (Mean)
Limits	12.00	15.00
Derivatives	19.77	23.26
Integrals	21.25	27.04
Application of Calculus	20.50	23.23
Average	18.38	22.26

The quantitative analysis of the pre-and post-assessment scores indicated as statistically significant improvement in the overall performance of the 58 STEM 11 students following the implementation of progressive tasks. Wright et al. (2022) in their study, highlights the potential of progressive pedagogies to foster a more equitable learning environment by focusing on sense-making rather than rote learning.

Table 2 Test of Significant Difference between Pre-Test and Post-Test Results

Paired Samples Test								
				95% Confidence Interval of the Difference				
	Mean	Std. Deviation	Std. Error Mean	Lower	Upper	t	df	Sig. (2-tailed)
Pair 1 Pre-Test and Post-Test	-3.75250	1.3428	0.69714	-5.97112	-1.53238	-5.383	3	0.013

The analysis reveals a statistically significant difference between pre-test and post-test scores following the implementation of a progressive task sequencing intervention, with a probability value below the 0.05 significance level indicating performance improvement. This suggests that the changes are not merely due to chance, thus affirming the intervention's effectiveness.

Both theoretical and empirical evidence supports these findings. The intervention aligns with Cognitive Load Theory (CLT) by systematically managing cognitive load, breaking down complex tasks into smaller, manageable steps, which minimizes extraneous cognitive burden and optimizes cognitive resource allocation for schema construction and automation. The significant improvement in post-test scores aligns with CLT predictions, indicating that the intervention facilitated efficient cognitive processing and learning.

Furthermore, Vygotsky's sociocultural theory, particularly the concepts of scaffolding and the zone of proximal development (ZPD), underpins the intervention's success. The gradual increase in task complexity reflects the removal of scaffolding, enabling learners to transition from assisted performance to independent mastery, thereby reinforcing the efficacy of this scaffolded learning approach.

Extensive research in skill acquisition supports the effectiveness of progressive practice techniques. Studies in various domains, including motor and cognitive skill development, show that deconstructing complex skills into sequential steps enhances performance and retention. The current study's intervention aligns with this principle, providing a rationale for the observed improvement.

Additionally, the incremental nature of the intervention embodies the principles of mastery learning, emphasizing proficiency in foundational concepts before advancing to more complex material. The significant improvement observed indicates the intervention's effectiveness in facilitating mastery learning, thereby establishing a solid foundation for subsequent learning.

Table 3 Student Perception of Progressive Tasks

Survey Statement	Mean Response	Standard Deviation
I felt more engaged in Calculus class when we work on progressive tasks.	4.3	0.7
The progressive tasks help me understand Calculus concepts better.	4.0	0.8
I enjoyed working on the progressive tasks.	4.2	0.6
The progressive tasks helped me improve my problem-solving skills in Calculus.	3.9	0.7
I would like to see more progressive tasks used in Calculus class.	4.1	0.8

The findings from the student survey revealed an affirmative view of the progressive task as a pedagogical strategy. The statement receives the highest mean score of 4.3 was, "I felt more engaged in Calculus class when we worked on progressive tasks." Clark & Roche (2018) highlight in their research the importance of tasks that are relevant to the context and systematically escalate in complexity to improve student engagement.

Qualitative Findings

- **Theme 1: Scaffolding and Gradual Learning:** Students valued the way the tasks were structured, enabling them to develop their understanding step by step. “The assignments began with simpler ideas and then slowly became more complex,” one student mentioned. “This approach really helped me understand the basics before facing tougher challenges.”
- **Theme 2: Deeper Understanding:** Many students believed that the step-by-step tasks helped them gain a better grasp of the concepts. One student remarked, “I didn’t just memorize the formulas; I really understood how they work.” Another added, “These tasks encouraged me to think critically about the fundamental ideas.”
- **Theme 3: Increased Confidence:** As the students worked through the assignments, they became more self-assured in their calculus problem-solving skills. One student admitted, “I was really intimidated by Calculus at first, but the tasks gradually helped me gain confidence bit by bit.”
- **Theme 4: Time Commitment and Effort:** Several students indicated that the progressive assignments demanded considerable time and effort. One student remarked, “It required a lot of time to complete the tasks, but ultimately, it was worthwhile.”
- **Theme 5: Value of Feedback:** Students highlighted the significance of obtaining prompt and constructive feedback on their assignments. One student remarked, “The teacher’s feedback was beneficial. It allowed me to recognize my errors and learn from them.”

Triangulation and Integration

The quantitative and qualitative data combined to create a compelling illustration of the beneficial effects of progressive tasks.

Convergence: The marked enhancement in conceptual understanding and problem-solving abilities identified in the quantitative analysis was reinforced by qualitative findings, which indicated that students perceived the tasks as instrumental in promoting a deeper comprehension and bolstering their confidence. The qualitative insights elucidated the reasons behind the improvements observed in the quantitative scores.

Complementarity: The qualitative data offered valuable perspectives on the student experience, including the significance of scaffolding, the required time commitment, and the importance of feedback. These elements were not adequately captured by the quantitative assessments.

Discrepancy/Challenge: Although the overall findings were favorable, a possible discrepancy emerged regarding the time commitment involved. Students recognized the necessity of time investment but generally considered it to be worthwhile. This nuanced understanding of the time commitment was not fully represented by the quantitative data, which primarily concentrated on pre- and post-test scores. This discrepancy encouraged a deeper examination of how to balance the advantages of progressive tasks with the potential demands on students’ time and workload. Future iterations may benefit from exploring strategies to optimize task design to enhance learning outcomes while effectively managing time constraints.

Discussion

This research emphasizes the benefits of using progressive tasks in Calculus. The quantitative results present compelling evidence of enhanced conceptual comprehension and problem-solving abilities, while the qualitative findings shed light on the students' experiences. The convergence of these findings enhances the credibility of the conclusions drawn. The outcomes indicate that progressive tasks can serve as an effective teaching method for fostering deeper learning and increasing student engagement in Calculus.

Conclusion

This research integrates both quantitative and qualitative data, offering an in-depth analysis of the influence of progressive tasks within the context of Calculus. The results indicate that this methodology may significantly enhance student learning outcomes. Subsequent studies could examine the enduring effects of progressive tasks and assess their relevance across various mathematical disciplines. Additionally, exploring strategies for optimizing the design and execution of these tasks could be beneficial in maximizing their advantages while managing potential challenges, notably the demands on time that such tasks may entail.

Recommendations

According to the results of this action research, it is proposed that the application of progressive tasks as a pedagogical strategy in Calculus courses should be maintained and further developed. The notable enhancement in student assessment scores, along with the favorable trends identified in student engagement, conceptual comprehension, and student perceptions, provide substantial evidence for the efficacy of this approach.

To ensure the ongoing and successful execution of progressive tasks, it would be helpful to provide mathematics teachers with professional development opportunities focused on creating, facilitating, and evaluating these tasks. This could involve training on strategies for scaffolding, offering constructive feedback, and managing group work effectively.

Future studies might examine the enduring impacts of incorporating progressive task in Calculus on students' educational paths in later mathematics and STEM disciplines. Additionally, analyzing the efficacy of distinct types of progressive tasks for tackling specific learning difficulties in Calculus could yield significant insights beneficial for curriculum design and teaching methodologies.

Future action research efforts might benefit from a more direct integration of student perspectives during the design and evaluation stages, thereby further empowering participants and improving the significance and efficacy of the interventions.

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