

Integrating Reader Response Theory to Enhance Pre-Calculus Conceptual Understanding

Dr. Jonathan Edwin V. Remegia

Abstract

This action research examined the effects of incorporating Reader Response Theory (RRT) into mathematics instruction to improve conceptual understanding among 84 Grade 11 STEM students at Talisay Senior High School. Addressing issues of rote memorization and superficial learning in mathematics, the intervention utilized narrative-based activities, such as problem-solving stories and mathematical journaling, to foster personal connections with the material. Quantitative data from pre- and post-tests indicated a significant enhancement in conceptual understanding. Qualitative findings from focus group discussions and analysis of student journals corroborated these results, revealing deeper engagement with the content and greater relatability of abstract concepts through the narrative approach. Students also found journaling effective for reflecting on their understanding and misconceptions. The study concludes that integrating RRT effectively promotes deeper engagement and improved conceptual understanding in Pre-Calculus education.

Keywords: Conceptual understanding, Focus Group Discussions, Mathematical Journaling, Narrative-Based Problem Solving, Reader Response Theory

Context and Rationale

Pre-Calculus teaching often falls within a positivist approach, treating mathematical concepts as objective truths that students are required to learn through memorization and repetitive practice. This emphasis results in “procedural knowledge without insight,” where learners can handle equations or plot functions but do not understand the deeper connections involved, such as how a function’s algebraic expression relates to its graphical representation (Adamon & Tan, 2018). This lack of conceptual understanding-the ability to link ideas and adapt them as needed-has been recognized as a significant barrier to success in higher-level mathematics, since students typically do not have the cognitive frameworks necessary to transition from specific procedures to more abstract reasoning (Khoule et al., 2017).

In the Philippines, mathematics education encounters significant challenges: students often find it difficult to progress beyond mere rote memorization of formulas and procedures, resulting in a limited comprehension of fundamental concepts (Capulong et al., 2020). This issue is particularly evident at the high school level, where abstract topics in algebra, geometry, and calculus necessitate a more profound conceptual understanding. Traditional instructional methods, which frequently emphasize lecture-based teaching and procedural drills, do not effectively foster the cognitive and emotional engagement essential for genuine learning. Consequently, these approaches can create a daunting educational atmosphere, where students perceive the subject matter as disconnected and inaccessible, viewing it as a series of impersonal rules (Tan, 2019).

The absence of conceptual understanding hinders students’ ability to apply mathematical knowledge to real-world situations and stifles the development of critical thinking skills (Orbillosa & Cruz, 2021). Integrating

Dr. Jonathan Edwin V. Remegia, Teacher II, Talisay Senior High School

Reader Response Theory (RRT) is an effective method for bridging this conceptual gap by using a constructivist approach that allows for personal interpretation and meaning-making of the “text.” This approach aligns with one of the fundamental tenets of the theory: meaning is derived not from the text itself but through the dynamic interaction between the reader (the student) and the text (the mathematical material) (Spirovska, 2019). By redirecting the educational emphasis from simply seeking the “correct” procedure to exploring how students personally interpret a problem, RRT promotes a deeper understanding of concepts. When students express their initial uncertainties, relate new theorems to what they already know, or contemplate graphical representations in a “math journal,” they are engaging in a process of meaning-making that is crucial for comprehending abstract concepts (Bautista et al., 2022). Additionally, RRT acknowledges students’ unique viewpoints-encompassing their prior experiences, intuitions, and initial confusions-fostering a supportive learning atmosphere. This methodology is essential for alleviating mathematics anxiety and discouraging passive learning, both of which are often linked to inadequate conceptual outcomes, by validating the challenges students face and encouraging them to reflect on and articulate their thought processes (Khoule et al., 2017; Setyaningrum et al., 2025). Ultimately, RRT offers a framework for students to meaningfully connect mathematical concepts, which is critical for building the foundational understanding necessary for success in Pre-Calculus and beyond (Siregar & Siagian, 2019).

Innovations, Interventions, and Strategy

This action research utilized innovations and strategies based on Reader Response Theory to improve conceptual understanding in mathematics.

Narrative-Based Problem Solving

- a. This strategy entails transforming conventional math word problems into relatable narratives that align with students’ experiences or interests. The aim is to shift from a mere “find the numbers and solve” methodology to one that promotes comprehension of the problem’s meaning. This approach is supported by Bressi’s (2018) assertion that narratives link abstract concepts to real-life contexts.

- b. *Example: The Solar Concentrator*

Students read a short story about an inventor trying to harness solar energy using a parabolic mirror.

Narrative Element	Mathematical Task
The Setup: The mirror is 80 cm wide and 10 cm deep. The inventor needs maximum heat.	Find the Focus: Determine the coordinates of the focus (0, p) and write the standard equation of the parabola, $x^2 = 4py$
RRT Response: Students write a quick note on what the “focus” means in the story (the goal, the highest power) versus in the equation the coordinate (0, p).	Justification: Explain why finding the focus mathematically guarantees the highest concentration of light.

Mathematical Journal

- a. This strategy allows students to express their thoughts and feelings about math, fostering metacognition beyond mere problem-solving. Supported by Diaz & Reyes (2020), it deepens emotional engagement with the material.

Example: Defining the Directrix

Students reflect on the abstract definition of the parabola.

Journal Prompt “The Line of Opposition”: The Directrix is defined as the fixed line equidistant from every point on the parabola as the Focus is. Write a journal entry titled “My Life as a Directrix.”	Required Reflection Articulate Meaning: Explain the Directrix’s purpose using a metaphor (e.g., an “anchor,” a “measuring stick,” or a “line of absolute equality”). Why is its existence necessary for the curve to form?
RRT Goal: The reflection moves beyond the equation ($y^2 = -4p$) to explore the role and relationship of the concept, enabling a deeper, personal interpretation of the mathematical “text.”	

1. **Dialogue and Collaborative Interpretation** Classroom activities fostered collaboration and varied interpretations of math concepts. Instead of adhering to a single method, students shared and justified their problem-solving strategies, enhancing their learning ownership and reflecting Rosenblatt’s (1978) transactional model of reading, which highlights the shared creation of meaning.

Example: Vertex and Standard Form

Groups analyze two mathematically equivalent ways to represent the same parabola.

Scenario Two Equations: Group A has $(x-3)^2 = 8(y-1)$ and group B has .They represent a water fountain	Discussion Task Collaborative Interpretation: Discuss which form (Standard/Vertex vs General Quadratic) is the “easiest to read” for finding vertex and the focus. Negotiate the census.
RRT Goal: The dialogue requires students to justify their preference, demonstrating that while the mathematical truth is fixed, the interpretation and usability (the “reading” experience) of the algebraic form can vary based on the task and the reader.	Consensus Report: The group writes a sentence on how the different forms serve different “reading purposes.”

Action Research Questions

This research sought to address these questions:

1. How did the integration of Reader Response Theory affect the Grade 11 STEM students’ conceptual understanding of key Pre-Calculus topics?

2. What were the students' views and experiences related to the use of narrative-driven activities and mathematical journaling in their mathematics education?
3. How did the application of Reader Response Theory affect the students' involvement and attitudes towards mathematics?

Action Research Methods

a. Participants and/ or other Sources of Data and Information

The study involved 84 Grade 11 STEM students from Talisay Senior High School. Participants were chosen from two intact classes to ensure that the intervention could be effectively implemented within a standard classroom environment.

b. Data Gathering Method

1. **Pre-Test:** All 84 participants took a pre-test to evaluate their initial understanding of the chosen pre-calculus topics.
2. **Interventions:** Over an eight-week period, RRT-based interventions, which included narrative-based problem-solving and mathematical journaling, were conducted during regular class sessions.
3. **Data Collection:** Throughout the intervention, student journals were consistently gathered and analyzed.
4. **Post-Test:** A post-test, which was identical to the pre-test, was administered to assess the students' conceptual understanding following the intervention.
5. **Focus Group Discussion (FGD):** After the post-test, two distinct FGDs were held with a purposely selected group of 10 students each to collect detailed qualitative insights about their experiences.

c. Data Analysis Plan

Quantitative Data: The pre-test and post-test scores underwent analysis using descriptive statistics (mean and standard deviation) alongside inferential statistics (paired-sample t-test) to evaluate whether a statistically significant difference in conceptual understanding existed before and after the intervention.

Qualitative Data: An analysis of the data obtained from focus group discussions and student journals was conducted through thematic analysis. The researcher discerned prevalent themes, patterns, and categories that pertain to students' perceptions, experiences, and attitudes. Direct quotations from participants were incorporated to substantiate the identified themes.

Discussion of Results

Table 1 Pre-Test and Post-Test Results		
Pre-Calculus Topic	Pre-Test (Mean)	Post-Test (Mean)
Circle	3.5	4.8
Parabola	2.8	4.5
Ellipse	3.1	4.6
Hyperbola	2.5	4.1
Series	3.0	4.7
Sigma Notation	2.9	4.4
Mathematical Induction	3.2	4.8
Binomial Theorem	3.4	4.9
AVERAGE	3.05	4.65

The quantitative analysis of the pre-test and post-test scores showed a statistically significant enhancement in the overall conceptual understanding of 84 STEM 11 students after implementing narrative-based problem solving. The research undertaken by Chen et al. (2023) identified a significant relationship between mathematics reading proficiency and value-added performance in mathematics. It was observed that students who exhibited stronger mathematics reading abilities attained greater value-added outcomes, indicating that effective reading skills are essential for sustained progress and comprehensive success in the field of mathematics.

The analysis indicates a statistically significant difference between pre-test and post-test scores after implementing the interventions, with a p-value of 0.000, which is lower than the significance threshold of 0.05. Korkheili et al. (2024) have demonstrated in their research that integrating reading strategies with working memory instruction improved fundamental math skills and enhanced students' problem-solving abilities. This improvement is linked to students' increased capacity to understand and process mathematical texts, including problems and notations.

Table 2 Test of Significant Difference between Pre-Test and Post-Test Results									
Paired Samples Test									
		Paired Differences					t	df	Sig. (2-tailed)
		Mean	Std. Deviation	Std. Error Mean	95% Confidence Inter- val of the Difference				
					Lower	Upper			
Pair 1	PRE-TEST and POST-TEST	-1.550	0.131	0.046	-1.659	-1.441	-33.484	7	0.000

This research supports the connection between reading-centered teaching approaches and success in mathematics. Although not explicitly rooted in Reader Response Theory (RRT), the incorporation of reading strategies into math instruction reflects RRT's focus on the active role of the reader in making meaning from texts, which is essential for deeper understanding in problem-solving situations.

Moreover, a study by Baful & Derequito (2022) in a literary context found that the Reader Response Strategy contributed to advancements in three of four key competencies: defining, classifying, and drawing conclusions. RRT also successfully engaged both cognitive and emotional aspects of learners, resulting in heightened interest.

A solid grasp of mathematical concepts fundamentally depends on the ability to define concepts, classify examples, and make reasoned conclusions. Since this study indicates that RRT boosts these vital skills, it provides compelling evidence that utilizing RRT's methodology-such as active interpretation, personal connection, and evidence-based responses-in mathematics will similarly enhance the cognitive processes necessary for a profound understanding of concepts.

The ability to read mathematics-encompassing the interpretation of problems, diagrams, and mathematical symbols-is an active process similar to the transactional reading described by RRT. This study confirms that a high level of engagement with mathematical texts, as promoted by RRT, has a positive effect on achievement, which is an important result of a thorough conceptual understanding.

Qualitative Findings

The qualitative data from the focus group discussions and student journals corroborated the quantitative findings.

1. **Theme1: Personal Connection and Relatability:** Students indicated that the narrative-based approach rendered mathematics more tangible. One student noted in their journal, "The budget story helped me understand how linear equations apply in real life, rather than as merely 'x' and 'y'." Another participant stated, "Previously, math seemed like just numbers; now, it resembles a comprehensible story."
2. **Theme2: Deeper Understanding and Reflection:** The mathematical journaling process promoted enhanced cognitive engagement. Students expressed their confusion, paraphrased concepts, and incorporated diagrams in their journals to reinforce understanding. A frequent observation was that "writing it out clarified my errors." This reflective practice enabled deeper comprehension beyond surface-level knowledge.

3. Theme3: Reduced Anxiety and Increased Engagement:

Participants reported diminished anxiety regarding mathematics. The RRT approach, which fostered personal interpretation and collaborative discussion, contributed to a more supportive learning atmosphere. One student remarked, "I used to hesitate to ask questions, but sharing our 'stories' made it safe to be incorrect." This shift in mindset resulted in higher levels of participation and engagement in class.

Discussion

The notable quantitative enhancement in conceptual understanding substantiates the effectiveness of integrating RRT strategies as a pedagogical approach in Pre-Calculus instruction. The results corroborate the idea that positioning students as active “readers” who engage with the mathematical “text” enables instruction to transcend the confines of the conventional procedural-based model (Andamon & Tan, 2018). The qualitative data offered essential insights into the nature of this learning process. The requirement for students to articulate and justify their interpretations in journals and discussions compelled them to partake in higher-order thinking and the pursuit of meaning, which are foundational to achieving true conceptual mastery (Bautista et al., 2022). In particular, the observed decrease in anxiety and the rise in student engagement, consistent with prior research (Khoule et al., 2017), indicate that RRT effectively mitigated the emotional obstacles typically associated with the complexities of Pre-Calculus content. This transactionally oriented instructional model has demonstrated itself to be a practical and influential method for fostering critical thinking and establishing a solid conceptual foundation for advanced studies in STEM fields.

Conclusion

The findings indicate that employing Reader Response Theory significantly enhances conceptual understanding of mathematics among Grade 11 STEM students. This study demonstrates that perceiving mathematics as a narrative to be actively interpreted, rather than a collection of rigid rules, leads to notable improvements in both test scores and learning experiences. The approach fosters personal connections with the content, promotes deeper reflection, and positively influences students’ attitudes toward mathematics. This research presents a valuable alternative to conventional procedural instruction and underscores the importance of emotional and cognitive engagement in STEM education.

Recommendations

Based on the findings of this action research, the following recommendations are proposed:

The findings of this action research suggest that the school administration should officially adopt the RRT-integrated method for all foundational mathematics courses, such as Pre-Calculus and Basic Calculus, in the Senior High School STEM Track. It is recommended that training sessions and workshops be organized for all mathematics teachers to focus on the practical application of RRT strategies, which should include guidance on how to effectively assess and provide constructive feedback on Transactional Math Journals. Additionally, instructional materials should be updated to feature RRT-aligned tasks, incorporating specific sections for “Conceptual Interpretation” or “Meaning-Making Reflection” within existing modules. Future action research could investigate the long-term effects of RRT on students’ performance in subsequent courses like Basic Calculus, as well as its effectiveness across various learning styles.

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