Transforming Confusion into Clarity: Employing the Feynman Technique to Overcome Mathematics Anxiety

Eric Machisi[1], Abdullah Kurudirek[2]

[1]Department of Mathematics, Fujairah Boys High School, Fujairah, United Arab Emirates
[2] College of Education, Al-Naji University, Baghdad, Iraq

e.machisi@yahoo.com*, abdullah.kurudirek@alnaji-uni.edu.iq

Abstract: This study examines the effectiveness of the Feynman Learning Technique (FLT) in improving mathematics performance and reducing math anxiety among tenth-grade students learning about parabolas. A quasi-experimental design was employed, involving 67 students from Erbil, Iraq, who were divided into an experimental and a control group. The experimental group received instruction through FLT, which focuses on learning by teaching, while the control group followed conventional teaching methods. Data were collected using a pretest, post-test, and a modified version of the Abbreviated Math Anxiety Scale. Analysis conducted with Quade's nonparametric ANCOVA revealed that students taught using FLT significantly outperformed their peers in the control group. Additionally, a Wilcoxon signed-rank test indicated a statistically significant reduction in mathematics anxiety within the experimental group, while anxiety levels increased in the control group. These findings suggest that FLT not only enhances conceptual understanding but also effectively reduces math-related stress. This study recommends that teachers adopt the FLT in mathematics classrooms to promote self-directed learning and enhance students' conceptual understanding and retention of knowledge. Future research should expand on this work by investigating the effectiveness of FLT across various mathematical topics and educational levels.

Keywords: Feynman Learning Technique, mathematics anxiety, mathematics education

INTRODUCTION

Education is one of the most important elements shaping societies' future (Iksal et al., 2024). Education is not merely about transmitting knowledge; it also instills high ideals in students. Furthermore, it is essential to recognize that education is a process of character development, and schools play a pivotal role in this journey (Kurudirek & Berdieva, 2024). Educators are uniquely positioned to transform society. To improve the educational system's performance, it is essential to identify existing shortcomings and make the necessary adjustments, especially in mathematics instruction (Lotfi et al., 2012).

Many students around the world experience mathematics anxiety. Approximately 17% of the

United States population is reported to suffer from mathematics anxiety (Ashcraft & Moore, 2009). Across the 34 countries that participated in the 2012 Programme for International Student Assessment (PISA), 59% of the students reported experiencing mathematics anxiety (Luttenberger et al., 2018). Several other cases have been reported in Sub-Saharan Africa (Luneta & Sunzuma, 2022), Belgium (Demedts et al., 2022), Finland, and Korea (Fan et al., 2019). Lee (2024) identifies mathematics anxiety as a global issue.

Mathematics anxiety involves stress and decreased performance during mathematics tasks, particularly affecting high school students. Research shows a correlation between higher anxiety levels and lower mathematics achievement (Baral et al., 2024; Zanabazar et al., 2023; Zhang et al., 2019). Addressing anxiety is vital in mathematics education, as its origins often stem from personal experiences, lack of confidence, fear of failure, and ineffective teaching methods (Ambion et al., 2021). Conventional pedagogical approaches and rote learning further increase anxiety. Therefore, employing methodologies that enhance learning and foster student autonomy can help reduce mathematics anxiety.

This study evaluates the impact of the Feynman Learning Technique (FLT) on students' performance and mathematics anxiety. This technique, developed by physicist Richard Feynman in the twentieth century and popularized in the early 2000s, emphasizes the concept of "learning by teaching." Feynman believed that explaining concepts to others enhances understanding and helps identify knowledge gaps, creating a positive feedback loop that ensures accuracy and thoroughness (Feynman et al., 2006). Figure 1 visually represents the FLT.

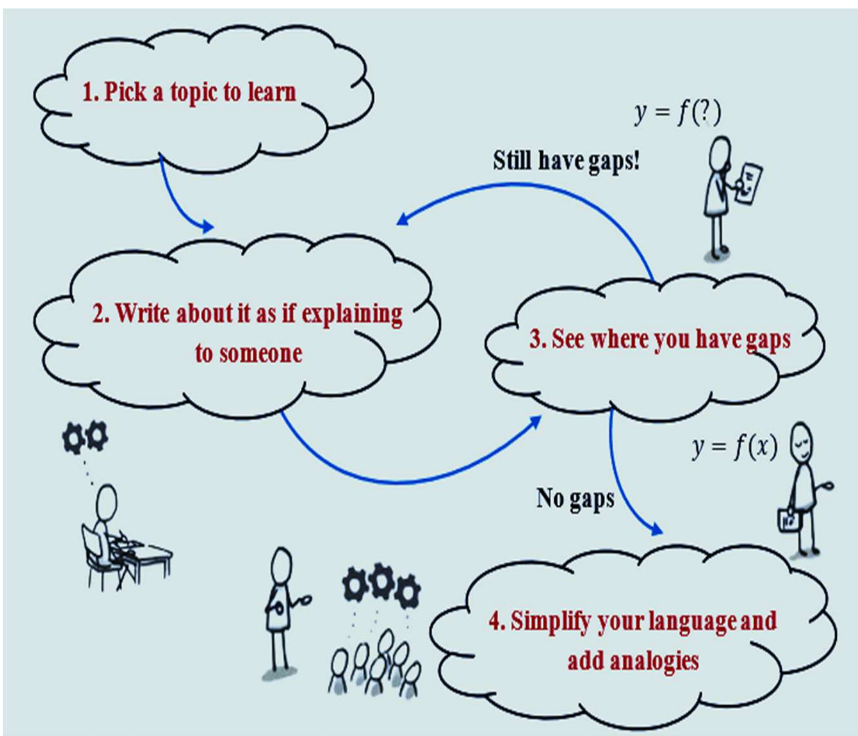


Figure 1: The Feynman Learning Technique (Adapted from Substack, 2023)

The Feynman Technique has four phases, which encompass the subsequent steps (see Feynman et al., 2006):

- Phase 1: Pick a topic to learn.

  Select a concept that you would like to explore and study independently.

- Phase 2: Write about it as if explaining it to yourself or someone else.

  Teach the concept to yourself or someone else, as if you were explaining it to a child.

- Phase 3: See where you have gaps.

  If you find yourself confused, revisit the original material, whether a book, lesson notes, or videos, and clarify any misunderstandings.

- Phase 4: Simplify your language and add analogies.

  Simplify your notes and explanations until the ideas become clear (Feynman et al., 2006)

The Feynman Learning Technique has improved student performance in subjects like English (Bsharat et al., 2024; Reyes et al., 2021) and Physics (Wea et al., 2023). However, its impact on mathematics education is largely unexplored. Our literature review found no studies on its application in this field, prompting us to investigate its potential to enhance students' performance in mathematics and decrease mathematics anxiety. Our research objectives and questions are detailed in the following subsections.

Research Objectives

This study seeks to:

(1) Assess whether the Feynman Learning Technique leads to a statistically significant improvement in tenth-grade students' performance on concepts related to parabolas.

(2) Investigate the impact of the Feynman Learning Technique on the mathematics anxiety levels of tenth-grade students.

Research Questions

The following research questions guide the study:

(1) Does the Feynman Technique lead to a statistically significant improvement in tenth-grade students' performance on parabolas in the coordinate plane?

(2) Do tenth-grade students employing the Feynman Technique exhibit a reduction in mathematics anxiety over time?

Hypotheses

The study seeks to test the following hypotheses:

Hypothesis 1: Mathematics Achievement

H_0: There is no significant difference in students' performance between those taught with the Feynman approach and those taught with conventional methods on the topic of parabolas in the coordinate plane.

H_a: Students using the Feynman approach achieve significantly better results than those taught with conventional methods on parabolas in the coordinate plane.

Hypothesis 2: Anxiety Levels

H_0: There is no statistically significant difference in students' mathematics anxiety levels before and after employing the Feynman Learning Technique.

H_a: Students experienced a significant reduction in their mathematics anxiety levels after using the Feynman Learning Technique.

The Significance of the Study

This study aims to enhance students' understanding of mathematics and reduce anxiety, particularly regarding parabolas, among tenth-grade students. By employing the Feynman Learning Technique, the study aims to enhance retention and make abstract ideas more comprehensible. Employing clarity-based strategies can help students appreciate mathematics as an art (Gordon, 2019), especially when traditional teaching methods fall short.

This study aims to provide empirical evidence on the effectiveness of the Feynman Technique as a teaching and learning strategy to reduce mathematics anxiety among tenth-grade students. It addresses the emotional and psychological barriers that hinder engagement in mathematics (Luttenberger et al., 2018). By identifying factors that contribute to mathematics anxiety, the research aims to support students more effectively. If a positive correlation is found between the Feynman Technique and reduced anxiety, it could enhance the teaching and learning environment, boosting students' confidence and motivation.

The implications of this study extend beyond the classroom, offering valuable insights for educators, curriculum developers, and policymakers seeking to enhance mathematics education. If the Feynman Technique effectively enhances mathematics performance and reduces anxiety, it could be incorporated into teacher training programs and educational resources, equipping educators with a practical tool to support student learning. Additionally, the study's findings could inform the development of targeted interventions for students who experience high levels of mathematics anxiety, providing personalized support tailored to their specific needs.

THEORETICAL FRAMEWORK AND LITERATURE REVIEW

This study is grounded in constructivism and self-directed learning, which emphasize that students should actively create their own understanding of the subject matter rather than depend solely on teachers (Karagiorgi & Symeou, 2005; Magas, 2025). It challenges the passive acceptance of ideas typical of traditional teaching methods. In contemporary mathematics education, traditional "chalk-and-talk" methods are considered inadequate, as they cover excessive content while promoting insufficient critical thinking (Tshering, 2024; Wittmann, 2019). Instead, educators are encouraged to use instructional scaffolding, providing support that is gradually removed as students develop independent learning skills.

Scaffolding is the targeted support that helps students achieve their educational goals. According to Van de Pol et al. (2010), this involves techniques that assist learners in bridging cognitive gaps, enabling them to progress in their studies. Scaffolding encompasses various teaching strategies that guide students toward a deeper understanding and increased independence in their learning journey. When using the Feynman Learning Technique, teachers must first explain the strategy to students, providing essential scaffolding.

Vygotsky's social learning theory posits that learning primarily occurs through social interactions (Vygotsky & Cole, 2018). Individuals develop knowledge and cognitive skills through collaborative experiences within their cultural contexts. This theory emphasizes the importance of dialogue in the learning process. The Feynman Learning Technique exemplifies this by encouraging peer teaching, where students explain concepts to each other. This interaction deepens their understanding and enhances critical thinking and communication skills, highlighting the value of collaboration in effective learning.

Bandura's self-efficacy theory emphasizes the significance of students' self-belief in their abilities for academic success (Tessényi et al., 2024). High self-efficacy leads students to embrace challenges, persist through difficulties, and achieve better results (Syahbana & Nopriyanti, 2024). The Feynman Learning Technique is an effective method for boosting self-efficacy, as it encourages students to break down complex concepts and clearly explain them, thereby reinforcing their understanding and confidence, ultimately enhancing their academic performance. The following section reviews empirical studies on the Feynman Learning Technique in educational contexts.

Empirical Studies on the Feynman Learning Technique

The Feynman Learning Technique has gained significant attention as a potentially effective learning strategy in various educational contexts (Reyes et al., 2021). Although there is anecdotal evidence and theoretical support for the Feynman Technique, a thorough review of recent empirical studies is essential to evaluate its impact on student learning outcomes in specific subjects.

The study by Wea et al. (2023) explores the Feynman Learning Technique in an Indonesian physics classroom. It was discovered that this method enhances student engagement and promotes independent learning. Students actively participated by explaining concepts in their own words and identifying gaps in their understanding. However, challenges arose as some students memorized facts without grasping concepts, and many viewed physics as complex, which affected their use of the technique. The study recommends that teachers foster positive attitudes towards physics and provide support to help students overcome anxieties.

Bsharat et al. (2024) conducted a quasi-experimental study using a mixed-methods approach to examine the effects of the Feynman Learning Technique on students' English language proficiency at Al-Quds Open University in Jenin, Palestine. The study involved 44 students and 10 educators from the university's English language program. Quantitative data were collected through standardized English proficiency tests administered before and after a 12-week intervention. Additionally, qualitative data were obtained through interviews, self-report questionnaires, and observational notes to assess participants' confidence, engagement, and comfort levels. The results indicated a significant improvement in students' English language proficiency, confidence, and engagement after using the Feynman Learning Technique. The study concluded that this technique can potentially transform language education by fostering greater student autonomy and global competence.

Reyes et al. (2021) conducted an experimental study in the Philippines that involved randomly assigning participants to treatment and control groups. The research aimed to evaluate the effectiveness of the Feynman Technique as a heutagogical strategy for online learning among students in grades 4, 7, and 11. Students in the experimental group were taught using the Feynman Technique, while students in the control group received traditional instruction. Although the specific sample sizes for each grade were not provided, statistical analyses using paired t-tests showed that the experimental group had significantly higher post-test scores. The findings of the study support a causal relationship regarding the effectiveness of the Feynman Technique and demonstrate its applicability across various educational levels.

Adeoye (2023) conducted a systematic literature review that compiled findings from various sources to identify key patterns regarding the impact of the Feynman Technique on academic achievement and learner confidence among slow learners. The study emphasizes the positive effects associated with the Feynman Technique, including improved academic performance and increased self-confidence among slow learners.

In a study conducted in the Philippines, Ambion et al. (2020) investigated the impact of the Feynman Technique and team teaching on students' understanding of evolution in a Grade 10 adult night high school biology class. Data analyzed using a t-test indicated insufficient evidence to support a significant difference in the outcomes between the experimental and control groups. These findings suggest that the effectiveness of the Feynman Learning Technique may vary depending on the subject matter and environmental context. Therefore, it is necessary to further explore the effectiveness of the Feynman Learning Technique across different subject areas and educational settings (Ambion et al., 2020; Wea et al., 2023).

The Research Gap

A review of the existing literature reveals a growing body of research investigating the application of the Feynman Learning Technique in subjects such as English, Biology, and Physics. However, research specifically addressing the use of the Feynman Learning Technique in mathematics education remains limited. Besides, no study has investigated the impact of the Feynman Learning Technique on students' mathematics anxiety levels. This study is intended to address these research gaps.

METHODS

Research Design

This study employed a quasi-experimental design with non-equivalent intact groups to assess the impact of the Feynman Learning Technique on students' achievement and levels of mathematics anxiety. Practically, random assignment of students to experimental and control groups was practically impossible.

Research Sample

This study involved a convenience sample of 67 tenth-grade students from two secondary schools in Erbil, Iraq. The students were enrolled in a mathematics course based on the Iraqi national curriculum. At the time of the study, they were learning about *parabolas in the coordinate plane*, which is a required part of the Grade 10 syllabus.

In their regular classes, the students typically experienced conventional, teacher-centered instruction that emphasized explanations, note-taking, and practice exercises. In this study, two intact classes comprising a total of 43 students were randomly assigned to the experimental group, while one intact class with 24 students served as the control group. This random assignment ensured an unbiased distribution between the experimental and control groups, despite the use of intact classes as units of selection. Participation in the study was voluntary and based on the students' willingness to take part.

Although the overall sample was defined by convenience, the assignment of intact classes to the experimental and control groups was determined through random selection to avoid systematic bias. This approach ensured that any observed differences could be attributed to the instructional method with greater confidence, rather than to pre-existing characteristics of the groups.

Instruments

Data were collected using a pretest, a posttest, and a modified Abbreviated Mathematical Anxiety Scale (AMAS) developed by the researchers. The pretest consisted of ten multiple-choice questions that assessed students' basic knowledge of parabolas (see Appendix A). The prior knowledge examined included identifying parabolas from given shapes, recognizing the axis of symmetry and vertices, and explaining how the sign of the leading coefficient affects the shape of the parabola. The internal consistency of the pretest was assessed using Kuder-Richardson Formula 20 (KR-20).

$$KR20=\frac{n}{n\text{-}1}\times\left[1\text{-}\frac{\sum pq}{Var}\right] \qquad (1)$$

In this formula, KR20 is the score that estimates the instrument's internal reliability. n is the number of items that make up the test; p is the proportion of students who passed each item, and q is the proportion of students who failed each item; Var is the variance across all items. The pretest's reliability based on the KR20 formula was 0.91, above 0.7, the minimum requirement for acceptance (Setyaedhi, 2024).

The post-test included four open-ended questions that assessed students' understanding of concepts related to parabolas, such as vertex, focus, directrix, symmetry, finding equations, and determining the direction in which the parabola opens, as outlined in the grade 10 mathematics curriculum (see Appendix B). The questions spanned various levels of Bloom's taxonomy, from basic recall to application.

Expert judgment was used to evaluate the test instrument to ensure content validity. Eight grade 10 mathematics teachers in Iraq, each with at least 10 years of teaching experience, were asked to rate the relevance and clarity of the test items. The item-level content validity index (I-CVI) was calculated by dividing the number of raters who scored each item as 3 or 4 by the total number of raters on the panel. The item CVIs were adjusted using the modified kappa statistic to account for chance agreement. The overall scale-level content validity index was found to be 0.99, which exceeds the acceptable threshold of 0.78 for content validity assessments involving at least nine experts (Yusoff, 2019). The reliability of the post-test instrument was evaluated through a test-retest method with a sample of 30 students who were not part of the targeted group. A Pearson's r value of 0.92 was obtained, indicating a strong correlation between the scores from the first test and the subsequent retest. Therefore, the test instrument was deemed reliable.

A nine-item modified Anxiety Management Assessment Scale (AMAS), adapted from Hopko et al. (2003), was utilized to gauge participants' anxiety levels both before and after the intervention (see Appendix C). The AMAS employed a five-point rating scale, with scores ranging from 1 to 5: 1 indicating low anxiety, 2 representing some anxiety, 3 denoting moderate anxiety, 4 signifying a significant amount of anxiety, and 5 reflecting a high anxiety level. The Cronbach's alpha reliability coefficient for the modified AMAS is 0.76, exceeding the acceptable minimum of 0.7 (Arof et al., 2018).

Ethical Considerations

The study was approved by the Tishk International University Human Research Ethics Committee (Date: 13 April 2025, Protocol number: 17). All prospective participants received information about the research, including its purpose, duration, and activities involved, prior to data collection. Students were informed that participation was voluntary and based on informed consent. They were made aware of their right to decline participation in the study without penalty. No names or identifiable information were gathered from the participants. Participants in the experimental group were assigned random codes starting with the letter "E" (e.g., E11092), while those in the control group were assigned random codes starting with the letter "C" (e.g., C11251). Additionally, the study did not disrupt normal school operations.

Data Collection Procedures

Data were collected in the period April-May 2025. Data collection procedures were implemented in three phases: pre-intervention, intervention, and post-intervention.

Pre-Intervention Stage

In the pre-intervention stage, participants were required to sign informed consent forms, indicating that they voluntarily agreed to participate in the study without being coerced by the researchers. The researchers administered the pretest and AMAS to both the experimental and control groups. The pretest lasted for 20 minutes. To reduce concerns about researcher bias, the pre-test scripts were graded by a teacher who was not involved in the research. The pretest scores and students' pre-intervention mathematics anxiety levels were recorded.

Intervention Stage: Enactment of the Feynman Learning Technique

Over the course of two weeks, students received eight 40-minute lessons on parabolas. In the experimental classes, one researcher implemented the FLT, while in the control class, another teacher covered the same content using conventional instruction. All worksheets, class tasks, and homework were identical across groups, and experimental-group students received a one-page FLT handout.

Experimental lessons followed the FLT's four phases:

1. *Pick a topic.* Students (individually or in pairs) selected a micro-concept from the unit (e.g., orientation by the sign of a; vertex; axis of symmetry; focus/directrix; standard versus vertex form).
2. *Teach it.* Students prepared a concise, plain-language explanation intended for their peers, optionally incorporating everyday analogies.
3. *Find gaps.* While presenting, their peers and the teacher asked clarifying questions; any uncertainty was logged on a "knowledge gap slip."
4. *Refine and analogize.* Students consulted the textbook/notes (sources cited by the teacher) and returned with a more concise explanation in the next session, minimizing jargon and incorporating helpful analogies.

The teacher's facilitation emphasized scaffolding without overt instruction, prompting students to specific textbook pages or examples, and summarizing key takeaways at the end of each presentation cycle. Each lesson concluded with a brief practice session to reinforce the ideas. To support implementation quality, the same lesson outline was used throughout the intervention period (present → question → gap log → resource consult → re-teach → summarize → practice). The materials used in the experimental group matched those of the control group, and a facilitator checklist was used to ensure that all aspects of the FLT were incorporated in the implementation process. Here is an example of how the FLT was applied in the sixth session.

Step 1: Topic Selection

A volunteer chose the quadratic function $f(x)=ax^2+bx+c$ and its graph (a parabola) as the focus.

Step 2: Initial Explanation (student-led)

On the whiteboard, the student stated the general form $y=ax^2+bx+c$ and explained orientation: if $a>0$, the parabola opens upward, and if $a<0$, it opens downward. To aid intuition, the student used the "smile/frown" metaphor and a soccer-ball trajectory analogy.

Step 3: Gap Identification (peer/teacher prompts)

Peer: "What's the special name for the highest point on the soccer-ball path?"

Presenter: "The vertex."

Peer: "How do we find it?"

The presenter was uncertain and recorded this as a gap to refine. The presenter promised to bring a definite response in the next session. The facilitator referred the student to a textbook page where information about how to find the coordinates of the vertex could be found.

Step 4: Refined Re-teach (next session)

The student returned with a definite explanation: the vertex is the function's maximum (if $a<0$) or minimum (if $a<0$). The student presented the following worked example:

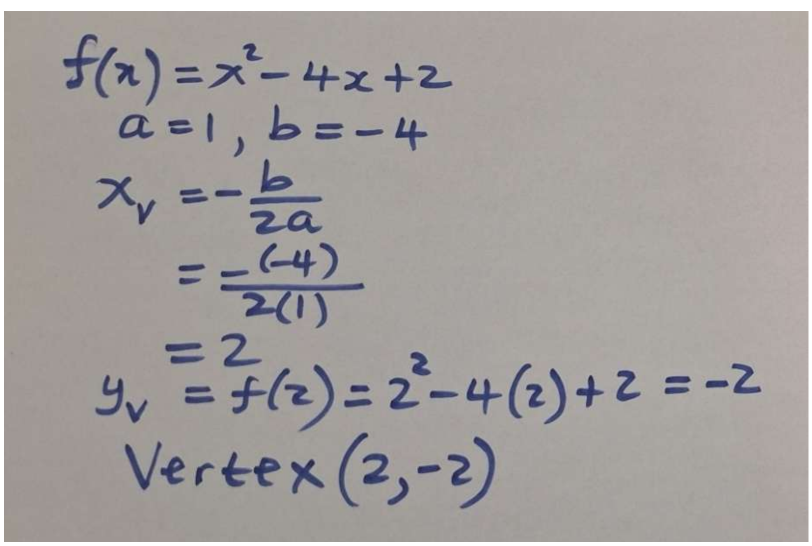


Figure 2: Student presentation sample

The student then posed guiding checks to peers: "First, what is the sign of a? Is the parabola a 'smile' or a 'frown'? Does the vertex give a max or a min?" The peers were able to answer these questions correctly.

Synthesis and Consolidation

The session concluded with the facilitator synthesizing the three key points from the presentation:

- If a>0, the parabola opens upward.
- If a<0, the parabola opens downward.
- The vertex can be determined using x_v=-$\frac{b}{2a}$, then y_v=$f(x_v)$.

To enhance learning, students were assigned a short exercise in which they needed to state the orientation and calculate the vertices of the functions y=2x^2+4x+5 and y=-x^2+6x-5 homework.

Post-intervention Stage

In the post-intervention stage, both the post-test and the AMAS were administered to the experimental and control groups. The post-test duration was 45 minutes. The post-test scripts were graded by the same teacher who evaluated the pre-test scripts. Additionally, a second marker, an experienced Grade 10 mathematics teacher from Stirling Schools in Iraq, moderated the grading of the post-test scripts. The results of the post-test, along with the AMAS survey results collected after the intervention, were recorded for analysis. The following section explains how the data were analyzed.

Data Analysis

Students' pretest scores were analyzed using descriptive statistics and the Kruskal-Wallis test to assess differences between the experimental and control groups prior to intervention. The Kruskal-Wallis test was used because the pretest scores violated the assumption of normality, as determined by the Shapiro-Wilk test. Post-test scores were analyzed using descriptive statistics, effect size comparisons, and Quade's nonparametric ANCOVA, following violations of the normality assumption. Quade's nonparametric ANCOVA was selected to incorporate pretest scores as covariates in the analysis, as significant differences were observed between the control and experimental groups prior to the intervention. Effect sizes on mathematics anxiety levels were computed by dividing the mean gain by the pooled standard deviation across all pre- and post-survey responses. The Wilcoxon signed-rank test was employed to evaluate whether the intervention had a statistically significant effect on students' mathematics anxiety levels.

RESULTS

A comparison of the descriptive statistics for the pretest scores revealed similar variations between the two groups in terms of minimum, maximum, range, and interquartile range. However, there were significant differences in the measures of central tendency between the groups. The experimental group exhibited higher mean and median values than the control group (Table 1).

	Group	Mean	Med.	Std. Dev.	Min.	Max.	Range	IQR
Pretest	Control	56.25	55.00	21.226	20	100	80	30
	Experimental	73.72	70.00	19.883	20	100	80	30

Notes. Std. Dev: Standard Deviation, Min.: Minimum, Max.: Maximum, IQR: Interquartile Range

Table 1: Pretest descriptive statistics

To assess whether there was a statistically significant difference in performance between students taught using the Feynman approach and those taught through conventional methods on parabolas in the coordinate plane, we first evaluated the students' prior knowledge of the topic with a multiple-choice pretest. The results indicated that the pretest scores of the experimental group did not meet the normality assumption, as determined by the Shapiro-Wilk test ($p < 0.05$) (Table 2). Consequently, parametric statistical measures were abandoned in favor of non-parametric methods.

		Kolmogorov-Smirnov[b]			Shapiro-Wilk		
	Group	Statistic	df	Sig.	Statistic	df	Sig.
Pretest	Control	0.153	24	0.151	0.946	24	0.223
	Experimental	0.170	43	0.003	0.929	43	0.011

b. Lilliefors Significance Correction

Table 2: Test of normality on pretest scores

The Kruskal-Wallis test revealed significant differences in pretest scores between the experimental and control groups ($\chi^2(1,67)=10.225, p=0.001$). This result indicates that pretest scores should be considered covariates when analyzing post-test scores.

Analysis of the posttest scores reveals substantial differences between the experimental and control groups. The mean and median values of the experimental group were higher than those of the control group. The standard deviation of the experimental group's post-test scores indicates a greater variation in student performance than in the control group. These results do not assert that students in the experimental group performed significantly better than those in the control group, as the two groups had differences before the intervention. Additional statistical analyses are needed to determine if the differences in performance between the two groups resulted from the interventions they received.

	Group	Mean	Median	Std. Dev	Min.	Max.	Range	IQR
Post-test	Control	0.83	0.00	2.036	0	8	8	0
	Experimental	46.05	44.00	26.994	0	92	92	48

Table 3: Post-test descriptive statistics

The posttest mean scores for both groups were significantly lower than their pretest mean scores due to differences in test formats. The pretest consisted of multiple-choice questions, while the posttest included free-response questions.

The Shapiro-Wilk test on posttest scores indicated a violation of the normality assumption in the control group ($p<0.001$). Using parametric statistics to compare the scores of the experimental and control groups was inappropriate, so nonparametric statistical measures were utilized instead.

	Group	Kolmogorov-Smirnov[b]			Shapiro-Wilk		
		Statistic	df	Sig.	Statistic	df	Sig.
Posttest	Control	0.492	24	<0.001	0.472	24	<0.001
	Experimental	0.093	43	0.200*	0.955	43	0.090

b. Lilliefors Significance Correction

Table 4: Normality tests on post-test scores

The post-test scores were analyzed using Quade's nonparametric analysis of covariance (ANCOVA) in SPSS, with pretest scores as covariates (Table 5). The between-subjects effects of Quade's ANCOVA analysis revealed a statistically significant difference in students' post-test scores, after adjusting means (averages) for pre-intervention differences ($F(1,67)=69.066$, $p<0.001$). The differences in performance between the experimental and control groups could be attributed to the impact of the different learning techniques employed in the two groups – Feynman Learning Technique versus Conventional approaches.

Tests of Between-Subjects Effects					
Dependent Variable: Unstandardized Residual					
Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Corrected Model	11619.985[a]	2	5809.993	34.533	<0.001
Intercept	514.889	1	514.889	3.060	0.085
RPretest	1800.276	1	1800.276	10.700	0.002
Group	11619.985	1	11619.985	69.066	<0.001

Error	10767.663	64	168.245
Total	22387.648	67	
Corrected Total	22387.648	66	
a. R Squared = 0.519 (Adjusted R Squared = 0.504)			

Table 5: Quade's nonparametric ANCOVA

The null hypothesis, which stated that there is no significant difference in the performance of students taught parabolas using the Feynman learning approach compared to those taught with conventional methods, was rejected. Consequently, we accepted the alternative hypothesis: students who learn about parabolas with the Feynman approach achieve significantly better results than those taught using traditional methods.

Most students in the control group did not attempt the majority of the questions on the posttest. For the few control group students who attempted the posttest questions, their solutions demonstrated a complete lack of understanding of the concepts related to parabolas. Figure 3 illustrates the contrast between the responses from a control group student (C11251) and an experimental group student (E13129) when solving question 2 of the posttest. The samples of student work presented in Figure 3 highlight a significant difference in the approaches taken by students in tackling the posttest items. Student C11251 seems to be answering by randomly selecting values from the given function. The student's responses do not follow the expected format. For example, the vertex and the focus should be provided in coordinate form.

To address the study's second objective, we compared the pre- and post-intervention survey responses of each group, focusing on changes in means, medians, and effect sizes. The results in Table 6 indicate negative effect sizes for all survey items, suggesting a decrease in anxiety levels among students in the experimental group regarding parabolas. However, these findings alone are insufficient to conclude that the intervention led to a statistically significant reduction in students' anxiety levels. Additional statistical tests are needed to obtain conclusive results.

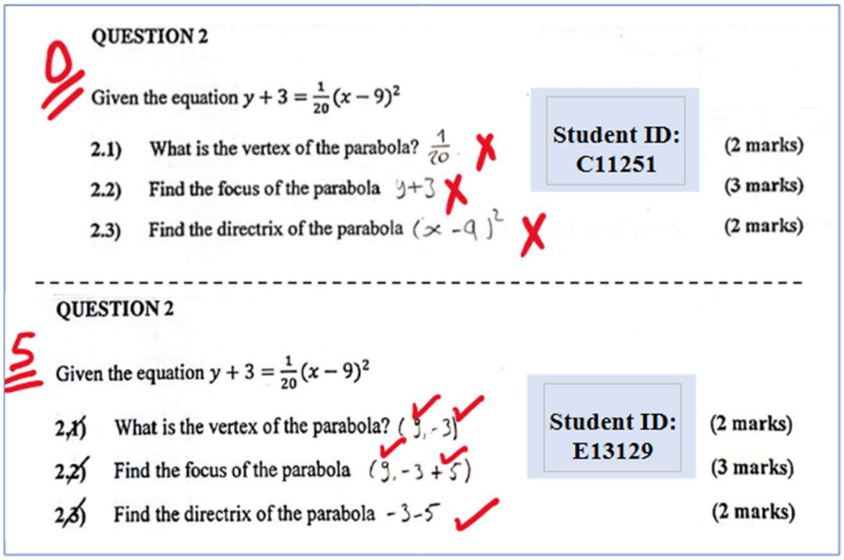


Figure 3: Samples of Students' Solutions

Item	Pre-intervention		Post-intervention		Comparison		Effect Sizes
	M	Med.	M	Med.	M Diff.	Med. Diff.	
1	2.42	2	1.74	1	-0.68	-1	-0.5
2	3.72	4	2.72	2	-1.00	-2	-0.7
3	2.72	3	2.02	1	-0.70	-2	-0.5
4	2.95	3	2.60	2	-0.35	-1	-0.3
5	2.56	2	2.23	2	-0.33	0	-0.2
6	2.44	2	2.33	2	-0.11	0	-0.1
7	2.00	2	1.98	2	-0.02	0	-0.01
8	2.02	1	1.84	2	-0.18	1	-0.1
9	3.30	3	2.74	3	-0.56	0	-0.4

Notes: M = Mean; Med. = Median; Diff. = Difference

Table 6: Experimental group comparison of pre- and post-intervention survey responses

In contrast, comparisons of pre- and post-learning survey responses in the control group, focusing on means, medians, and effect sizes, reveal increases in students' anxiety levels across seven out of nine survey items (see Table 7). Interestingly, the control group survey data showed two negative effect sizes (items 6 and 7), indicating a decrease in students' anxiety levels for these two items.

Item	Pre-intervention		Post-interven-tion		Comparison		Effect Sizes
	M	Med.	M	Med.	M Diff.	Med. Diff.	

1	2.38	2	2.79	3	+0.41	+1	+0.3
2	2.63	2	3.29	3	+0.66	+1	+0.5
3	2.13	1.5	2.88	3	+0.75	+1.5	+0.6
4	2.75	3	3.17	3	+0.42	0	+0.3
5	2.46	2	3.25	3	+0.79	+1	+0.6
6	2.83	3	2.54	2.5	-0.29	-0.5	-0.21
7	2.63	3	2.5	2.5	-0.13	-0.5	-0.1
8	2.29	2	2.88	3	+0.59	+1	+0.4
9	3.25	3	3.63	4	+0.38	+1	+0.3

Notes: M = Mean; Med. = Median; Diff. = Difference

Table 7: Control group comparison of pre- and post-learning survey responses

To assess whether the decrease in anxiety levels among the students in the experimental group was statistically significant, 11 outlier cases from the experimental group survey data were removed. The remaining data was tested to see if it met the normality assumption. Despite removing the outliers, the experimental group's pre- and post-intervention survey data still violated the normality assumption ($p < .05$), which meant using parametric statistics to analyze the differences between the two datasets was inappropriate. The Wilcoxon signed-rank test in SPSS was performed on the remaining 32 valid cases from the experimental group survey data, yielding a statistically significant result ($Z = -3.378$, $p < 0.001$) (Table 8). The conclusion was that implementing the Feynman Learning Technique significantly reduced anxiety levels among students in the experimental group.

		N	Mean Rank	Sum of Ranks
Post Mean – Pre-Mean	Negative Ranks	26[a]	17.10	444.50
	Positive Ranks	6[b]	13.92	83.50
	Ties	0[c]		
	Total	32		
a. Post Mean < Pre-Mean				
b. Post Mean > Pre-Mean				
c. Post Mean = Pre-Mean				

Test Statistics[a]	
	Post Mean – Pre-Mean
Z	-3.378[b]
Asymp. Sig. (2-tailed)	<0.001
a. Wilcoxon Signed Ranks Test	
b. Based on positive ranks.	

Table 8: Wilcoxon signed-rank test results

A Wilcoxon signed-rank test was conducted on the survey data from the control group to assess whether the changes in students' anxiety levels were statistically significant. The results indicated that the differences in anxiety levels before and after learning about parabolas in this group were statistically significant ($Z = 2.050$, $p < 0.05$). These findings, along with the positive effect sizes presented in Table 7, suggest that conventional teaching methods may increase students' anxiety levels in certain mathematics.

DISCUSSION

Improved Academic Performance

The study found that students taught using the Feynman Learning Technique performed significantly better on post-tests about parabolas than those taught using conventional methods. Quade's nonparametric ANCOVA test confirmed a significant difference in performance between the experimental and control groups. This supports earlier findings from studies in other disciplines, such as those by Reyes et al. (2021), Bsharat et al. (2024), and Wea et al. (2023), which demonstrated the effectiveness of FLT in enhancing academic outcomes. The findings of this study contribute to existing literature by demonstrating that the FLT, which has proven effective in subjects such as English and Physics, is also effective in the context of mathematics education.

Reduction in Mathematics Anxiety

A Wilcoxon signed-rank test revealed a statistically significant reduction in mathematics anxiety among students in the experimental group. In contrast, the control group experienced increased anxiety levels. Research has shown that increased mathematics anxiety affects students' attitudes toward various mathematics topics (Ferrer et al., 2025). The findings of this study fill a gap in the literature by empirically linking FLT to reduced mathematics anxiety. This is a notable contribution given the global prevalence of this issue (Ashcraft & Moore, 2009; Luttenberger et al., 2018). The increase in mathematics anxiety levels among students in the control group underscores the urgent need for mathematics educators to move away from traditional teaching methods. Instead, they should adopt innovative, student-centered approaches that foster conceptual understanding rather than merely memorizing mathematics concepts.

Implications for Mathematics Teaching in the Classroom

Based on the findings of this study, teachers should incorporate the FLT into mathematics lessons to promote student autonomy and active engagement with mathematical concepts. This approach aligns with heutagogical principles (Reyes et al., 2021) and self-directed learning theories (Magas, 2025), which emphasize the importance of learners taking initiative in their own educational process. Mathematics teachers can support this by allowing time for individual exploration and encouraging peer teaching. Students should be motivated to explain concepts to their peers, write simplified explanations, and identify areas where they have knowledge gaps. This approach is consistent with constructivist learning theory, which advocates for students constructing their own understanding (Karagiorgi & Symeou, 2005).

Encouraging students to simplify and explain mathematical concepts through the FLT enhances their conceptual understanding. This approach shifts the focus from rote memorization to meaningful learning, addressing one of the primary sources of math anxiety (Ambion et al., 2021). Research shows that the FLT significantly reduces anxiety among learners, while traditional methods can increase it. This highlights the need to move from teacher-centered approaches to student-centered ones. Bandura's theory of self-efficacy supports this shift; as students succeed with the FLT, their confidence in their abilities grows, which in turn helps to reduce anxiety (Tessényi et al., 2024).

The FLT promotes formative assessment by encouraging peer explanation and reflection. Teachers can create assessments that evaluate students' abilities to teach and articulate mathematical reasoning, in addition to traditional summative assessments. Peer teaching among students is a highly regarded strategy in mathematics education (Kimbrough et al., 2022; Moliner & Alegre, 2020). While the study focused on parabolas, the principles of FLT can also be applied to other topics and grade levels. Future classroom practices should test FLT across various mathematical topics to investigate its broader applicability.

It is essential to recognize that implementing the FLT does not occur automatically. It requires initial scaffolding where teachers model the technique and support students as they practice. This aligns with Vygotsky's Zone of Proximal Development and the concept of instructional scaffolding (Van de Pol et al., 2010). As students gain confidence over time, this support can be gradually reduced.

Given its positive outcomes, education stakeholders should consider integrating FLT into teacher training programs and curriculum guides. This would provide a systematic approach to addressing mathematics under-performance and anxiety. FLT, based on strong educational theories, offers a practical and effective framework for enhancing both mathematical understanding and emotional well-being. Teachers, curriculum developers, and policymakers are encouraged to adopt and promote this approach to improve mathematics education.

CONCLUSION

The Feynman Learning Technique has proven to be a transformative approach in enhancing mathematics performance while simultaneously alleviating anxiety associated with the subject. By breaking down complex concepts into simple, understandable language, this method effectively addresses both the cognitive challenges students face and the emotional barriers that often hinder their learning in mathematics education. Although there are some limitations to the technique, its strong potential makes it an invaluable resource for educators who are committed to improving learning outcomes and fostering a more positive educational experience for their students.

Limitations

This study focused on parabolas and involved students in the 10th grade. It included a small sample of students from a single geographical location, which limited the generalizability of the findings. Therefore, readers are cautioned against applying the results to contexts beyond the scope of this study. Additionally, the research utilized self-report surveys with Likert scales, which may introduce bias. The non-random selection of participants also presents the possibility of pre-existing differences between groups. Lastly, the study was conducted over a short-term period. A long-term follow-up on students' performance or levels of mathematics anxiety may be necessary to further validate the findings.

Recommendations

Considering these limitations, future researchers can expand this study to cover additional mathematics topics and different age groups. Future studies could explore the application of the Feynman technique in specific high school mathematics topics such as quadratic equations, circle theorems, trigonometric identities, conditional probability, and introductory calculus, where students often struggle with abstraction and conceptual understanding. Longitudinal studies could also be beneficial in exploring the long-term impacts of the Feynman Learning Technique on retention and anxiety levels. Additionally, teacher training is essential to provide educators with the skills to implement the Feynman Learning Technique effectively. Moreover, future studies should incorporate qualitative research methods to gain a deeper understanding of the research topic.

ACKNOWLEDGEMENTS

We want to express our heartfelt gratitude to the students and teachers at Stirling Schools who participated in this study. This research would not have been possible without your participation. We also extend our thanks to the school principals of the participating schools for allowing their institutions to serve as research sites for this study.

REFERENCES

[1] Adeoye, M. A. (2023). From Struggle to Success: The Feynman Techniques' Revolutionary Impact on Slow Learners. *Thinking Skills and Creativity Journal, 6(2)*, 125-133. https://doi.org/10.23887/tscj.v6i2.69681

[2] Ambion, R. I., De Leon, R. S., Mendoza, A. P., & Navarro, R. M. (2020). The Utilization of the Feynman Technique in Paired Team Teaching Towards Enhancing Grade 10 ANHS Students' Academic Achievement in Science. 2020 IEEE Integrated STEM Education Conference (ISEC) (pp. 1-3). Princeton, NJ, USA: IEEE. https://doi.org/10.1109/ISEC49744.2020.9397848

[3] Arof, K. Z., Ismail, S., & Saleh, A. L. (2018). Contractor's performance appraisal system in the Malaysian construction industry: Current practice, perception and understanding.

International Journal of Engineering & Technology, 7(3.9), 46-51. https://doi.org/10.14419/ijet.v7i3.9.15272

[4] Ashcraft, M. H., & Moore, A. M. (2009). Mathematics anxiety and the affective drop in performance. Journal of Psychoeducational Assessment, 27(3), 197–205. https://doi.org/10.1177/0734282908330580

[5] Baral, D., Dasgupta, N., McLeman, L., Bista, R., Jones, J., & Biswakarma, M. (2024). Exploring the predictive relationship between students' math anxiety and their mathematical performance. American Journal of STEM Education, 3, 1–15. https://doi.org/10.32674/c9zg4c28

[6] Bsharat, T. R., Febrianingrum, L., & Habibullah, M. (2024). Empowering Language Learners: Unleashing the Potential of The Feynman Technique in English Language Acquisition. PANYONARA: Journal of English Education, 6(2), 67-78. https://doi.org/10.19105/panyonara.v6i2.14936

[7] Demedts, F., Reynvoet, B., Sasanguie, D., & Depaepe, F. (2022). Unraveling the role of math anxiety in students' math performance. Frontiers Psychology, 13, 979113. https://doi.org/10.3389/fpsyg.2022.979113

[8] Fan, X., Hambleton, R., & Zhang, M. (2019). Profiles of Mathematics Anxiety Among 15-Year-Old Students: A Cross-Cultural Study Using Multi-Group Latent Profile Analysis. Frontiers in Psychology, 10, 1217. https://doi.org/10.3389/fpsyg.2019.01217

[9] Ferrer, C. J., Janeo, J. C., & Iglesias, J. C. (2025). Learning Experiences of Students on the Least Preferred Topics in Mathematics. Mathematics Teaching Research Journal, 17(1), 264-279. https://eric.ed.gov/?id=EJ1470641

[10] Feynman, R. P., Leighton, R. B., & Sands, M. (2006). The Feynman lectures on physics: The definitive edition (Vols. 1–3). San Francisco, CA: Addison-Wesley Longman. https://www.feynmanlectures.caltech.edu

[11] Kimbrough, E. O., McGee, A. D., & Shigeoka, H. (2022). How do peers impact learning? An experimental investigation of peer-to-peer teaching and ability tracking. Journal of Human Resources, 57(1), 304-339. https://doi.org/10.3368/jhr.57.1.0918-9770R2

[12] Gordon, M. (2019). Mathematics Students as Artists: Broadening the Mathematics Curriculum. Journal of Humanistic Mathematics, 9(2), 192-210. https://doi.org/10.5642/jhummath.201902.13

[13] Hopko, D. R., Mahadevan, R., Bare, R. L., & Hunt, M. K. (2003). The abbreviated math anxiety scale (AMAS) construction, validity, and reliability. Assessment, 10(2), 178-182. https://doi.org/10.1177/1073191103010002008

[14] Iksal, I., Hayani, R. A., & Aslan, A. (2024). Strengthening character education as a response to the challenges of the times. Indonesian Journal of Education (INJOE), 4(3), 761-774. https://injoe.org/index.php/INJOE/article/view/116

[15] Karagiorgi, Y., & Symeou, L. (2005). Translating Constructivism into Instructional Design: Potential and Limitations. Educational Technology & Society, 8(1), 17-27. http://www.jstor.org/stable/jeductechsoci.8.1.17

[16] Kurudirek, A., & Berdieva, O. (2024). The more empowered schools, the more fruitful students. Educenter : Jurnal Ilmiah Pendidikan, 3(1), 1-9. https://doi.org/10.55904/educenter.v3i1.921

[17] Lee, C. (2024). Mathematics anxiety as a global problem. In S. Johnston-Wilder & C. Lee (Eds.), The Mathematical Resilience Book (pp. 193–219). London: Routledge. https://doi.org/10.4324/9781003334354

[18] Lotfi, F., Dehkordi, S., & Vaez-Ghasemi, M. (2012). Teaching Method Survey Based on Constructivist Approach in Permanent Learning Geometry. Applied Mathematical Sciences, 6(6), 259-267. https://m-hikari.com/ams/ams-2012/ams-5-8-2012/lotfiAMS5-8-2012-5.pd

[19] Luneta, K., & Sunzuma, G. (2022). Instructional Interventions to Address Mathematics Anxiety in Sub-Saharan Africa: A Systematic Review (1980-2020). Africa Education Review, 19(1), 103-119. https://hdl.handle.net/10520/ejc-educare-v19-n1-a6

[20] Luttenberger, S., Wimmer, S., & Paechter, M. (2018). Spotlight on math anxiety. Psychology research and behavior management, 11, 311–322. https://doi.org/10.2147/PRBM.S141421

[21] Magas, J. C. (2025). Construction and Evaluation of Self-Directed Learning Material and Its Effect on STEM Students' Academic Performance in Mathematics. Mathematics Teaching Research Journal, 17(1), 232–263. https://eric.ed.gov/?id=EJ1470615

[22] Moliner, L., & Alegre, F. (2020). Effects of Peer Tutoring on Middle School Students' Mathematics Self-Concepts. Plos one, 15(4), e0231410. https://doi.org/10.3389/fpsyg.2020.01610

[23] Reyes, E. P., Blanco, R. M., Doroon, D. R., Limana, J. L., & Torcende, A. M. (2021). Feynman technique as a heutagogical learning strategy for independent and remote learning. Recoletos Multidisciplinary Research Journal, 9(2), 1-13. https://doi.org/10.32871/rmrj2109.02.06

[24] Setyaedhi, H. S. (2024). Comparative Test of Cronbach's Alpha Reliability Coefficient, Kr-20, Kr-21, And Split-Half Method. Journal of Education Research and Evaluation, 8(1), 47–57. https://doi.org/10.23887/jere.v8i1.68164

[25] Substack. (2023, May 28). The Feynman Learning Technique. https://sketchplanations.com/feynman-learning-technique

[26] Syahbana, A., & Nopriyanti, T. D. (2024). Development of Student Self-Efficacy for Mathematics Learning in Indonesia. Mathematics Teaching Research Journal, 16(3), 265-291. https://eric.ed.gov/?id=EJ1442292

[27] Tessényi, J., Katona, N., & Kun, Z. (2024). Exploring entrepreneurial inclination: Schwartz's values theory and Bandura's self-efficacy scale applied to Hungarian university students. International Journal of Entrepreneurship and Innovation Management, 28, 224-239. https://doi.org/10.1504/IJEIM.2024.144397

[28] Tshering, G. (2024). Teaching Algebra to a Grade 7 Student: Action Research Intervention. Mathematics Teaching Research Journal, 16(4), 132–153. https://eric.ed.gov/?id=EJ1442417

[29] Van de Pol, J., Volman, M., & Beishuizen, J. (2010). Scaffolding in Teacher–Student Interaction: A Decade of Research. Educational Psychology Review, 22(3), 271-296. https://doi.org/10.1007/s10648-010-9127-6

[30] Vygotsky, L., & Cole, M. (2018). Lev Vygotsky: Learning and social constructivism. In S. MacBlain, Learning Theories for Early Years Practice (pp. 68–73). London: SAGE.

[31] Wea, K. N., Dua, Y. S., & Elizabeth, A. (2023). An exploratory study to investigate the implementation of Feynman learning method in a physics classroom setting. Journal of Innovative Science Education, 12(3), 331–339. https://doi.org/10.15294/jise.v12i3.78672

[32] Wittmann, E. (2019). Understanding and Organizing Mathematics Education as a Design Science–Origins and New Developments. Hiroshima Journal of Mathematics Education, 12, 13–32. https://doi.org/10.24529/hjme.1202

[33] Yusoff, M. S. (2019). ABC of Content Validation and Content Validity Index Calculation. Education in Medicine Journal, 11(2), 49–54. https://doi.org/10.21315/eimj2019.11.2.6

[34] Zanabazar, A., Deleg, A., Ravdan, M., & Tsogt-erdene, E. (2023). The Relationship between Mathematics Anxiety and Mathematical Performance among Undergraduate Students. Jurnal Ilmiah Peuradeun, 11(1), 309-322. https://doi.org/10.26811/peuradeun.v11i1.780

[35] Zhang, J., Zhao, N., & Kong, Q. P. (2019). The relationship between math anxiety and math performance: A meta-analytic investigation. Frontiers in Psychology, 10, 1613. https://doi.org/10.3389/fpsyg.2019.01613

APPENDIX A: PRE-TEST INSTRUMENT

PARTS AND FEATURES OF A PARABOLA

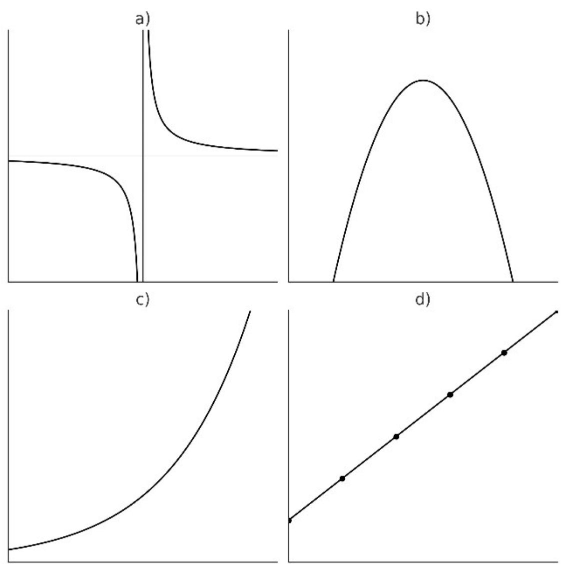
(PRE-TEST)

TOTAL MARKS: 10 **TIME ALLOWED: 20 MINUTES**

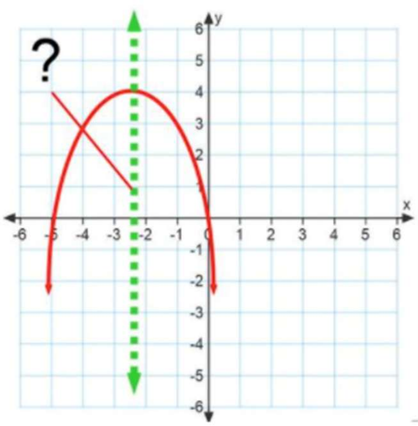
INSTRUCTIONS TO THE CANDIDATE:

1. This question paper consists of **10 multiple-choice questions**.
2. Please answer all questions by encircling the letter of the correct answer.

1. Which graph is a parabola?



2.



What is the green dashed line referred to as?

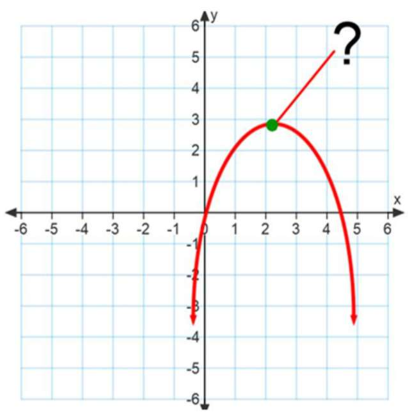
a) parabola

b) line of dashes

c) x-intercepts

d) axis of symmetry

3.



What is the green dot on this parabola called?

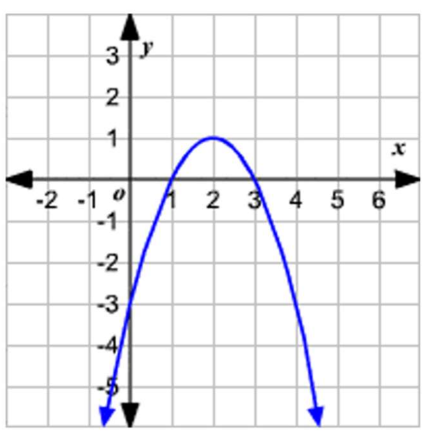
a) solution

b) root

c) zero

d) vertex

4.



What is the symmetry axis for this graph?

a) $y = -3$

b) $x = 2$

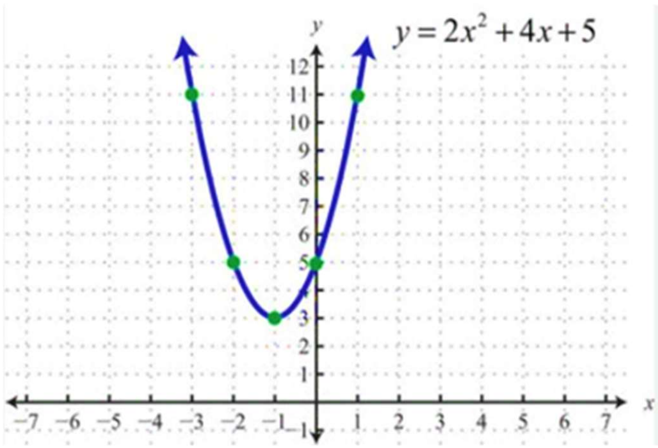
c) $y = 2$

d) $x = 3$

5. Which of the following best describes the vertex of a parabola?

a) Any point on the parabola b) A point on the x-axis

c) A point on the y-axis d) The highest or lowest point of a parabola

6. 

What is the vertex of this parabola?

a) (-2,5)

b) (0,5)

c) (-1,3)

d) (-1,-3)

7. In which direction does the parabola $\boldsymbol{y=x^2-2x+4}$ open?

a) up

b) down

c) right

d) left

8. The parabola $y=x^2-2x+4$ will have …

a) a maximum vertex.

b) a minimum vertex.

c) no vertex

d) many vertices

9. In which direction does the parabola $y=-2x^2-4x+1$ open?

a) down

b) up

c) left

d) right

10. How can you determine if a parabola $y=ax^2+bx+c$ opens upward or downward by simply looking at the equation?

a) All parabolas open upwards.

b) All parabolas open downwards.

c) The value of "a" tells you the direction of the opening.

d) It is impossible to determine simply by looking at the equation.

APPENDIX B: POST-TEST INSTRUMENT

PARABOLAS IN THE COORDINATE PLANE

TOTAL MARKS: 25 **TIME ALLOWED: 45 MINUTES**

INSTRUCTIONS TO THE CANDIDATE:

1. This question paper consists of 4 questions.
2. Answer ALL questions.
3. Write neatly and clearly.
4. The use of a nonprogrammable scientific calculator is allowed

QUESTION 1:

The set of points equidistant from (3,5) and the line $y=9$ is a parabola.

1.1) What is the vertex of the parabola? **(2 marks)**

1.2) Describe the graph of the parabola in terms of the **direction of opening** and the **line of symmetry.** **(2 marks)**

QUESTION 2:

Given the equation $y+3=\frac{1}{20}(x-9)^2$

2.1) What is the vertex of the parabola? **(2 marks)**

2.2) Find the focus of the parabola **(3 marks)**

2.3) Find the directrix of the parabola **(2 marks)**

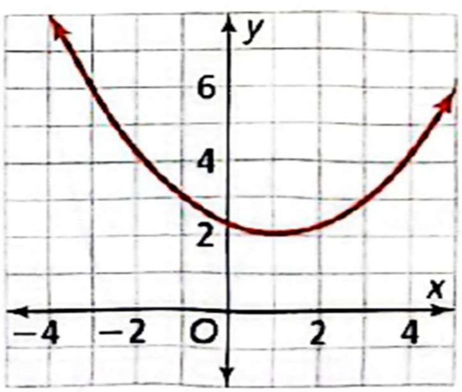
QUESTION 3:

3.1) What equation represents the parabola with focus (-1,4) and directrix y=-2? **(6 marks)**

3.2) What equation represents the parabola with focus (3,5) and vertex (3,-1)? **(5 marks)**

QUESTION 4:

Study the diagram and answer the question that follows:



Using the vertex, any other point on the parabola, and the equation

$y\text{-}k=\frac{1}{4p}(x\text{-}h)^2$, what is the value of p? **(3 marks)**

APPENDIX C: MODIFIED AMAS

*** Please rate each item below in terms of how you would feel in each situation. Please indicate your choice by circling the corresponding number.

ITEM NO.	STATEMENTS	Low anxiety	Some anxiety	Moderate anxiety	A significant amount of anxiety	High anxiety
1	Your math teacher tells you that your next topic in math is parabolas in the coordinate plane.	1	2	3	4	5
2	You find out that you are going to write a surprise math test on parabolas when you start your math lesson.	1	2	3	4	5
3	Your math teacher tells you that you will write a text on parabolas the next day.	1	2	3	4	5
4	Your math teacher asks you to complete a worksheet on parabolas independently.	1	2	3	4	5
5	You are given some homework with challenging questions on parabolas that you must complete and submit the next day.	1	2	3	4	5
6	Your math teacher talks about parabolas in the coordinate plane for a long time.	1	2	3	4	5
7	You are listening to a student in your class explaining a solution to a problem on parabolas in the coordinate plane.	1	2	3	4	5
8	You are watching your math teacher solving a problem on parabolas on the board.	1	2	3	4	5
9	You are currently taking a math test focused on parabolas in the coordinate plane.	1	2	3	4	5
Adapted from Hopko et al. (2003) *AMAS: Abbreviated Math Anxiety Scale*						