Proficiency Level of Grade 9 Students on Quadratic Functions Through Process-Oriented Guided Inquiry Learning (POGIL)

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Abstract: This study investigated the impact of Process-Oriented Guided Inquiry Learning (POGIL) approach in the proficiency level of Grade 9 students along quadratic functions. It employed a quasi-experimental design with a qualitative approach. Two groups with 40 students each from Saint John Berchmans High School Incorporated were considered as the subjects of the study. Results revealed that the students' proficiency level on quadratic functions before and after exposure to POGIL approach improved. Whereas, the other group of students who were exposed under direct instruction remained at a low proficiency level in the same lesson. Students in both groups significantly improved their proficiency level in quadratic functions before and after the use of the both instructional approaches. However, results show that between two approaches used in this study, the POGIL approach of teaching quadratic functions to students is more effective than direct instruction. For the continual improvement of teaching quadratic functions to students using the POGIL approach, observers' feedback was gathered and these involved students' engagement, incorporation of higher-order thinking-skills and multimedia presentations, and time engagement in the given activities. These suggestions were carried out in the enhancement of the POGIL activities ready for utilization of Grade 9 mathematics teachers.

Keywords: direct instruction, higher-order thinking skills, inquiry-based learning, students' engagement

INTRODUCTION

Mathematics is a fundamental tool in our lives and in every scientific field since it fosters personal growth and development on a large scale (Sharma, 2021). Mathematics is also an effective means of establishing mental discipline and an essential subject since it equips students with a uniquely powerful set of tools to understand and change the world (Andamon & Tan, 2018; Sharma, 2021). These tools include logical reasoning, problem-solving skills, and the ability to think in abstract ways (Andamon & Tan, 2018). Mathematics Proficiency is not only essential for academic success but also for potential employment opportunities in various fields such as science, technology, engineering, and finance (Bone et al., 2021). However, students' mathematics performance has raised concerns in various countries, including the Philippines. Most students find mathematics difficult to deal with (Baring & Alegre, 2019). The results in the TIMSS 2019 and PISA 2018 showed that Filipino students performed poorly in Mathematics where the Philippines scored below the average of participating countries (Mullis et al., 2019;Department of Education, 2019). The poor performance of Filipino students in Mathematics is also evident in the National Achievement Test 2018 where the students from Cagayan Valley Region (Region II) gained a Mean Percentage Score in Mathematics which is far from the 75% passing rate. Moreover, problem solving and critical thinking are the 21st century skills with the lowest percentage (Department of Education, 2019).

One of the critical mathematical concepts that needs to be understood by the students is Quadratic Function since it plays a vital role in the development of mathematical concepts since they cross a range of mathematical content domains, including algebra and geometry. As such, Parent (2015) said that learning quadratic function is vital because the concepts will become foundational for advanced mathematics, particularly when working with higher polynomial functions. Moreover, according to Leinhardt et al. (1990), this topic holds significance due to two key reasons: (a) the growing acknowledgment of the function concept as a powerful organizing principle spanning from middle school mathematics to more advanced high school and college-level topics, and (b) the symbolic links it offers, which enhance students' ability to connect and understand the graphical and algebraic representations of mathematical ideas. Further, Hoon et al. (2018) added that students who understand quadratic functions, their properties, and applications will be able to construct and develop a good understanding of more complicated and various kinds of functions and concepts. In addition, acquiring knowledge in quadratic functions fosters the application of mathematical cognition and logical reasoning, which includes decision-making (Hoon et al., 2018). Similarly, Díaz et al. (2020) stated that quadratic functions have practical relevance in real-world mathematical thinking and reasoning. However, this lesson is regarded as one of the most conceptually challenging topics in the curriculum (Nielsen, 2015). Susandi (2021) stated that students' low critical thinking skills are associated with misconceptions, procedural errors, and calculation errors. Such errors are caused by a method of mathematics learning that prioritizes memorization over comprehension. There are several errors made by the students regarding this concept, these include: learners' inability to interpret graphs of functions, inability to represent functions graphically, and converting flexibly between different representations of functions (Dillingerová & Vankúš, 2020). Additionally, Arnal-Palacian et al. (2022) highlighted the challenges students face when working with quadratic functions. One common difficulty involves understanding the relationship between the coefficient of the linear term and the position of the parabola's axis of symmetry. Many students struggle to derive the coefficient of the quadratic term based solely on visual representations. The authors also noted that most student errors stem from a lack of conceptual understanding and procedural skills, particularly in situations that demand more than the straightforward application of formulas. Su et al. (2016) suggest that teachers need to replace the current math classes with meaningful mathematical experiences that teach students "how to think through math" rather than memorizing formulas. This encourages students to think critically and discover new relationships between mathematical concepts, which leads to innovation and the creation of ideas.

Nowadays, one of the innovative approaches in teaching mathematics that could enhance the students' proficiency in mathematics is Process Oriented Guided Inquiry Learning (POGIL). It is a method combining guided inquiry and cooperative learning in mathematics education (Muhammad & Purwanto, 2020). The three phases of learning in POGIL model are exploration, concept discovery, and application of concepts. Kartono & Shora (2020) stated that POGIL has seven stages of learning; elicit, engage, explore, explain, elaborate, evaluate, and extend. In the context of constructivist theory by Jean Piaget and discovery learning theory by Jerome Bruner, students will continuously build their knowledge when they are actively involved in the learning process (Pasion, 2019). Moreover, through inquiry-based approach to teaching, learning is more meaningful to learners when they have the chance to independently uncover the connections between various ideas (Dumigsi & Cabrella, 2019).

The implementation of POGIL demonstrates positive outcomes on students' conceptual understanding, analytical reasoning and problem-solving abilities which supports the twin goals of mathematics curriculum.

With this context, the researcher aimed to determine the effect of Process Oriented Guided Inquiry Learning (POGIL) on the Proficiency Level of Grade 9 students in Quadratic Function.

Specifically, this study sought to answer the following questions:

1. To determine the proficiency level of the Grade 9 students along quadratic function before and after being taught through:
    a. Process Oriented Guided Inquiry Learning (POGIL); and
    b. Direct Instruction.
2. To find the effect of the interventions in the proficiency level of Grade 9 students along quadratic function through:
    a. determining if significant difference exists between the pretest and posttest; and
    b. determining if significant difference exists in the level of proficiency of Grade 9 students along quadratic function when taught using the direct instruction and POGIL.
3. To enhance the student activities to integrate in the Process Oriented Guided Inquiry Learning (POGIL) approach.

Figure 1 presents a research paradigm formulated based on the variables discussed and served as a guide in the conduct of the study.

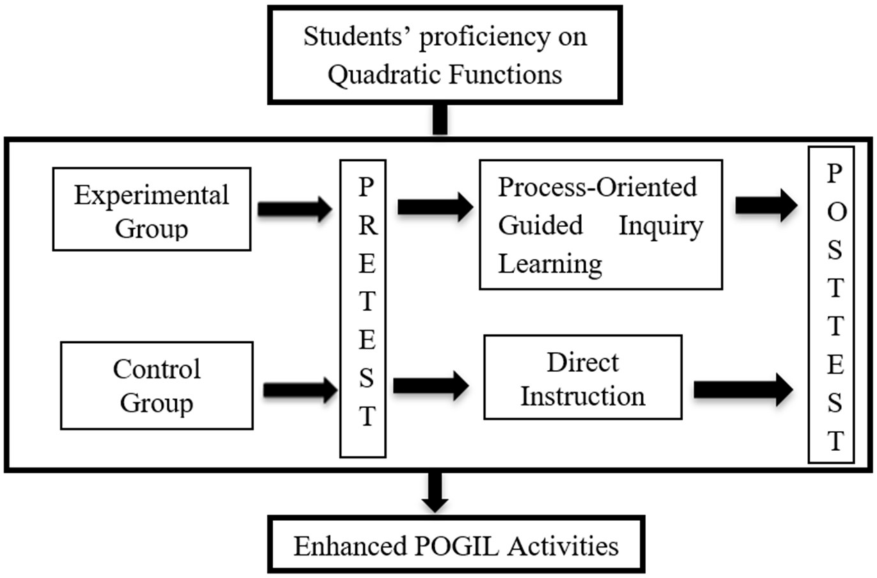

Figure 1. Research Paradigm

LITERATURE REVIEW

The POGIL teaching approach highlights the collaborative elements of constructivism used in the three phases of learning: exploration, concept discovery, and application of concepts (Kartono & Shora, 2020). In the exploration stage, students engage in activities such as observing, experiment designing, collecting, checking, analyzing data, investigating, and testing the hypothesis. In concept formation, students are asked to think critically and analyze the concept formation. In the application phase, students are involved in applying new knowledge in exercising, problem-solving, or even research situations. During this task, students collaborate in teams to deepen their learning and integrate it with the new concept they have (Muhammad & Purwanto, 2020). On the other hand, Kartono and Shora (2020) stated that POGIL has seven stages of learning: elicit, engage, explore, explain, elaborate, evaluate, and extend. Moreover, the members in POGIL approach have their specific roles, including leader, speaker, secretary, and strategy analyst/reflector. As for the teacher's role, Datu-dacula and Anda (2021) stated teachers assist students in their knowledge creation. Engaging students actively in the learning process will encourage them to generate information and develop critical thinking skills, which will fill gaps in their mental representations.

Numerous studies have explored the effectiveness of POGIL as a teaching strategy. POGIL is a successful teaching strategy that can help students build their mathematical HOTS, as demonstrated by Brion et al. (2022). Furthermore, Diniyyah et al. (2022) said that in the context of online learning, combining the POGIL model with a digital mind map might improve students' capacity for critical thought and problem-solving. According to research by Samosir (2022) and Aiman et al. (2020), students' critical thinking abilities are positively impacted by the POGIL methodology. Similar results were obtained by Kisworo and Gusman (2019), who found that the POGIL technique significantly improved students' critical thinking abilities and cognitive development. Furthermore, it has been demonstrated by Muhammad and Purwanto (2020) and Sanggara et al. (2018) that students taught utilizing the POGIL paradigm had a higher level of success in solving mathematical problems than students taught directly. This is in line with research by Andriani et al. (2019), which found that POGIL students outperform traditional learning methodologies in terms of logical reasoning and mathematical proficiency. Irwanto et al. (2018) also found that POGIL is a useful technique for raising students' performance, particularly in terms of their ability to solve problems and think critically. Additionally, POGIL enhances students' academic performance and cultivates a positive attitude toward learning, as demonstrated by Bug-os and Caro (2019). This bolsters the findings of Artuz and Roble (2021) that guided inquiry learning promotes students' active engagement in tasks, which improves learning outcomes. Additionally, this study showed that POGIL improved students' analytical, problem-solving, communication, and critical thinking abilities. Meanwhile, Kartono and Shora (2020) showed that POGIL can also develop the mathematical reasoning ability of the students. Additionally, Pradiyanasari et al. (2020) claimed that guided inquiry learning or POGIL can also develop students' understanding and mastery of concepts because it emphasizes a learning process that directs students to find answers to questions or problems on their own, allowing them to gain a deeper understanding. Sen et al., (2015) findings claimed that POGIL has a positive impact on students' mastery approach, self-efficacy for learning and performance, critical thinking, peer learning, metacognitive self-regulation, and effort regulation.

Method

Design

The study utilized both descriptive quantitative and qualitative approaches of researches and employed a quasi-experimental design. In this study, Process-Oriented Guided Inquiry Learning (POGIL) was used as an intervention for the experimental group while direct instruction was used for the control group. A descriptive comparative research design was also utilized to compare the proficiency level of the students in quadratic function in the Process-Oriented Guided Inquiry Learning (POGIL) and direct instruction. Moreover, qualitative method was used to identify the points of improvement on the students' activities in the 7 stages of POGIL approach.

Research Instrument

There were two main instruments that were used in this study, the pre-/post-tests and the observation note form. The pre-/post-tests were researcher-made tests with 50-item multiple choice type of test containing all the learning competencies in quadratic functions. These were parallel tests with equal difficulties of items covering the same competencies. The pre-/post-tests were validated by subject matter experts and tried out by the Grade 10 students of SJBHSI during S.Y. 2022-2023 to ensure reliability of the instrument. The reliability value of the test items was $\alpha=0.7831$ which was reliable. The pretest was administered to identify the initial proficiency level of the students and a posttest to determine whether there was an effect in the students' proficiency level along quadratic functions after the execution of POGIL approach and direct instruction. Additionally, feedback from observers through observation note form was used as an instrument to identify the points of improvement in the students' activities in the 7 stages of learning in POGIL approach. The other materials that were used in the implementation of the interventions were the students' worksheets and the lesson plan.

Locale

The study was conducted within the Junior High School Department of Saint John Berchman's High School Incorporated (SJBHSI). It is a private institution located at Magsaysay, Cordon, Isabela. This 2023, selected Grade 7 and Grade 10 students participated in the Performance Appraisal in Math (PATH) Mathematics Challenge District Level held in the municipality and secured first place. However, in 2020, the Performance Assessment of Standards and Skills (PASS)results revealed that the students' proficiency in Mathematics is at the "Developing level".

Samples and Sampling Procedures

There were two main participants in this study namely: the subjects of the study and the observers. The subjects of the study were the Grade 9 students of SJBHSI enrolled in SY 2023-2024. Grade 9 students were chosen as the subjects of the study because they met the criteria of having a lesson on quadratic functions for the first quarter. Two comparable classes with the same level of performance in Mathematics 9, specifically the two low-performing classes were selected and became the experimental and control groups.

	Section Name	Male	Female	Total
Grade 9	St. Thomas of Aquinas	13	31	44
	St. Therese of Avila	23	21	44
	St. Jerome	23	22	45
	St. Augustine	27	18	45
	Sub total	86	92	178

Table 1. Population of Grade 9 students in SJBHSI for SY 2023-2024

From these four sections, St. Jerome class was selected as the experimental group and St. Augustine served as the control group. In Table 2, the proficiency level of the students for both classes was compared before their exposure to the interventions.

Group	Intervention	Mean	SD	T	df	Sig. (2-tailed)
Control Experimental	*Direct Instruction* *POGIL*	12.90 13.10	2.55 3.05	-0.32	78	0.751

**p< 0.05*

Table 2. Comparison in the Initial Proficiency of the Two Groups in Quadratic Functions

It can be gleaned from the table that the students' proficiency level in quadratic functions of the control and experimental groups had no significant difference $t(78)$=-0.32, p=0.751. This implies that initially, the two groups had a similar level of proficiency in quadratic functions. The two classes that were selected have 45 students each; however, due to some limitations such as learners' unwillingness to join the study, lack of consent from their parents and absenteeism, only 40 students from each class were able to complete the interventions. The other students who were not able to take part in the interventions joined the other class of their mathematics teacher.

Meanwhile, three teachers were purposely selected and served as the observers during the execution of the POGIL teaching approach. Each teacher has more than 10 years of teaching experience and has the mandate to conduct instructional supervision. They used the observation note form during the POGIL implementation to identify the points of improvement in the students' activities on the 7 stages of learning in POGIL approach.

The constructed pre-/post-test on Quadratic functions used by the two groups was validated by subject matter experts and tried out by the Grade 10 students of SJBHSI during S.Y. 2022-2023 to ensure reliability of the instrument. The reliability value of the test items was α=0.7831 which was found to be reliable.

Data Treatment

To determine the students' proficiency on quadratic functions, Mean Percent Scores were used. To interpret the mean percent scores of the students, the five levels of proficiency adapted from the new standard of Department of Education (DepEd Order No.024, s.2022) was employed. To determine the effects of POGIL and direct instruction on students' proficiency in quadratic functions, t-tests for paired samples were utilized. Meanwhile, a one-way Analysis of Covariance (ANCOVA) was conducted to compare the effects of the interventions in the proficiency level of Grade 9 students in quadratic functions after controlling the pretest scores. Moreover, thematic analysis was used to analyze the feedback of the observers about the enhancements in the students' activities on the 7 stages of POGIL approach and was integrated into the proposed activities of Process-Oriented Guided Inquiry Learning.

Ethical Considerations

This study was submitted to Saint Mary's University Research Ethics Board (SMUREB) for ethics review. The researcher affirms that there was no conflict of interest in the study that influenced the validity of the findings. The researcher made sure that all the gathered data that personally identified the subjects of the study were treated with utmost confidentiality. No one was able to recognize them as the study subjects aside from the researcher. The data provided by the participants were transferred to excel in number coded format. After the study is completed and finally bound in a book, all the data collected were deleted for good. Since the participants are under 18 years old, parents' consent was secured by the researcher. A consent form was also given to research participants. Participants fully understood the given form as well as the research's purpose. The students were free to decide whether to participate or not and asked questions for any word or concept in the form that they did not understand. If they feel uncomfortable during the data gathering process, they were allowed to withdraw from the study at any moment without explanation. Any information they had provided was used in the study. They were allowed to join to the other sections of grade 9 if they did not want to participate on the intervention programs that were implemented by the researcher. Their non-participation or withdrawal did not affect their standing as a student. The study was funded by the Department of Science and Technology under the Capacity Building Program in Science and Mathematics Education.

Results and Discussion

A. Proficiency Level of Students along Quadratic Functions

Proficiency Level	**Before**		**After**	
	f	%	f	%
Highly proficient	0	0	0	0
Proficient	0	0	0	0
Nearly Proficient	0	0	30	75
Low Proficient	22	55	10	25
Not Proficient	18	45	0	0
Overall	**MPS= 26.2% Level: Low Proficient**		**MPS=54.4% Level: Nearly Proficient**	

Legend: MPS (Mean Percent Score); 0-24% (Not Proficient); 25-49% (Low Proficient); 50-74% (Nearly Proficient); 75-89% (Proficient); 90-100% (Highly Proficient)

Table 3. Frequency Count and Percent of Students' Level of Proficiency in Quadratic Functions in POGIL Approach

It can be gleaned from the table that students of the POGIL group have low proficiency level in quadratic functions (MPS=26.2%) before they were taught in the POGIL approach of teaching. Majority (55% or 22) of the students have low proficiency level while 45% or 18 students are not proficient in quadratic functions.

After exposure to the POGIL approach in learning quadratic functions, the students' proficiency level increased (MPS=54.4%). Majority (75% or 30) of the students are nearly proficient while few (25% or 10) of the students are still in low proficiency level. This signifies that students' proficiency in quadratic functions improved after they were taught using the POGIL approach.

Related studies conducted by Irwanto et al. (2018), Artuz and Roble (2021), Brion et al. (2022), Samosir (2022), Aiman et al (2020), and Kisworo and Gusman (2029) found out that POGIL is an effective method in improving student performance. According to these authors, POGIL enhanced students' engagement, communication, critical thinking, and problem-solving skills.

To further see the proficiency of the students in the POGIL class, Table 4 shows the mean percent scores and proficiency level of the students for each competency of quadratic functions.

Learning Competencies	**Mean Percent Score**		**Proficiency Level**	
	Pretest	**Posttest**	**Pretest**	**Posttest**
1. Models real-life situations using quadratic functions.	45.0	89.4	Low Proficient	Proficient
2. Represents a quadratic function using: (a) table of values; (b) graph; and (c) equation.	29.8	56.9	Low Proficient	Nearly Proficient
3. Transforms the quadratic function defined by $y = ax^2 + bx + c$ into the form $y = a(x – h)^2 + k$.	23.8	40.6	Not Proficient	Low Proficient
4. Graphs a quadratic function: (a) domain; (b) range; (c) intercepts; (d) axis of symmetry; (e) vertex; (f) direction of the opening of the parabola.	23.1	55.2	Not Proficient	Nearly Proficient
5. Analyzes the effects of changing the values of a, h and k in the equation $y = a(x – h)^2 + k$ of a quadratic function on its graph.	20.0	57.5	Not Proficient	Nearly Proficient
6. Determines the equation of a quadratic function: (a) a	24.3	50.7	Not Proficient	Nearly Proficient

table of values; (b) graph; (c) zeros.				
7. Solves problems involving quadratic functions.	21.4	38.6	Not Proficient	Low Proficient
Overall	**26.2**	**54.4**	**Low Proficient**	**Nearly Proficient**

Legend: 0-24% (Not Proficient); 25-49% (Low Proficient); 50-74% (Nearly Proficient); 75-89% (Proficient); 90-100% (Highly Proficient)

Table 4. Mean Percent Scores and Proficiency Level of Students in Each Learning Competency of Quadratic Functions in POGIL Approach

As shown in the table, the students' proficiency level before exposure to POGIL approach ranged from not proficient to low proficient. The mean percent scores of the students on five out of seven competencies is not proficient. These competencies are: transforming the quadratic function defined by $y = ax^2 + bx + c$ into the form $y = a(x - h)^2 + k$; graphing a quadratic function: (a) domain; (b) range; (c) intercepts; (d) axis of symmetry; (e) vertex; (f) direction of the opening of the parabola; analyzing the effects of changing the values of a, h and k in the equation $y = a(x - h)^2 + k$ of a quadratic function on its graph; determining the equation of a quadratic function: (a) a table of values; (b) graph; (c) zeros; and solving problems involving quadratic functions. This implies that prerequisite knowledge and skills have not been acquired or developed in the competencies of quadratic functions. Meanwhile, students were low proficient in modeling real-life situations using quadratic functions and representing a quadratic function using: (a) table of values; (b) graph; and (c) equation. This means that students possess the minimum knowledge, skills and core understandings, but need help throughout the performance of authentic tasks.

It can be gleaned from the table that the students' proficiency level for each competency improved when they were taught using the POGIL approach. Most of the students' mean percent scores were nearly proficient in the competencies of quadratic function. Students became proficient in modeling real-life situations using quadratic functions where they developed their fundamental knowledge and skills, and can transfer them independently through authentic performance tasks. Moreover, the mean percent scores of the students on four competencies increased to nearly proficient which implies that the students have developed fundamental knowledge, skills, and core understanding in representing and graphing quadratic functions, analyzing the effects of changing the values of the variables in graph of quadratic functions and determining the equation of quadratic function, but students still need little guidance from the teacher. The mean percent scores of the students also increased from not proficient to low proficient in the competencies; transforming the quadratic function defined by $y = ax^2 + bx + c$ into the form $y = a(x - h)^2 + k$ and solving problems involving quadratic functions. This suggests that students only acquired minimum knowledge and skills, and still need help to develop their proficiency in these competencies. Thus, in implementing the POGIL approach in teaching quadratic functions, the teacher should provide enough time for the students to better grasp the lesson and further develop their proficiency level in the aforementioned competencies of quadratic functions.

Proficiency Level	**Before**		**After**	
	F	%	F	%
Highly proficient	0	0	0	0
Proficient	0	0	0	0
Nearly Proficient	0	0	3	7.5
Low Proficient	22	55	34	85
Not Proficient	18	45	3	7.5
Overall	**MPS= 25.8%** **Level: Low Proficient**		**MPS=36.5%** **Level: Low Proficient**	

Legend: MPS (Mean Percent Score); 0-24% (Not Proficient); 25-49% (Low Proficient); 50-74% (Nearly Proficient); 75-89% (Proficient); 90-100% (Highly Proficient)

Table 5. Frequency Count and Percent of Students' Level of Proficiency in Quadratic Functions in Direct Instruction

It can be seen from the table that students of the non-POGIL group before they were taught using direct instruction have low proficiency in quadratic functions (MPS=25.8%). Majority (55% or 22) of the students were low proficient while 45% or 18 students were not proficient in quadratic function. It can be noticed that the number of students in not proficient and low proficient before exposure to direct instruction were the same with the number of students before exposure to POGIL.

After their exposure to direct instruction, the proficiency level of the students remained at a low proficiency level (MPS=36.5%). Majority (85% or 34) of the students were low proficiency while only few (7.5% or 3) of the students improved their proficiency in quadratic functions. This suggests that direct instruction did not enhance the students' proficiency in quadratic functions.

The result is similar with the study of Artuz and Roble (2021) which revealed that despite an increase in the mean scores of the students in non-POGIL , their scores remained below the expectation level, indicating they did not meet the set standards.

Moreover, Table 6 displays the mean percent scores and proficiency level of the students for each learning competency of quadratic functions in direct instruction.

Learning Competencies	**Mean Percent Score**		**Proficiency Level**	
	Pretest	Posttest	Pretest	Posttest
1. Models real-life situations using quadratic functions.	40.6	60.0	Low Proficient	Nearly Proficient
2. Represents a quadratic function using: (a) table of values; (b) graph; and (c)	29.0	39.8	Low Proficient	Low Proficient

equation.				
3. Transforms the quadratic function defined by y = ax^2 + bx + c into the form y = a(x – h)^2 + k.	22.5	24.4	Not Proficient	Not Proficient
4. Graphs a quadratic function: (a) domain; (b) range; (c) intercepts; (d) axis of symmetry; (e) vertex; (f) direction of the opening of the parabola.	22.9	39.4	Not Proficient	Low Proficient
5. Analyzes the effects of changing the values of a, h and k in the equation y = a(x – h)^2 + k of a quadratic function on its graph.	24.4	25.6	Not Proficient	Low Proficient
6. Determines the equation of a quadratic function: (a) a table of values; (b) graph; (c) zeros.	21.8	36.1	Not Proficient	Low Proficient
7. Solves problems involving quadratic functions.	23.6	26.1	Not Proficient	Low Proficient
Overall	**25.8**	**36.5**	**Low Proficient**	**Low Proficient**

Legend: 0-24% (Not Proficient); 25-49% (Low Proficient); 50-74% (Nearly Proficient); 75-89% (Proficient); 90-100% (Highly Proficient)

Table 6. Mean Percent Scores and Proficiency Level of Students in Each Learning Competency of Quadratic Functions in Direct Instruction

Table 6 presents the results of the pretest and posttest given to Grade 9 students who were exposed to direct instruction. It can be noticed that the students' proficiency level for each competency before exposure to direct instruction was the same with the proficiency level of the students in POGIL class in their pretest. Wherein, students were not proficient in transforming the quadratic function; graphing a quadratic function; analyzing the effects of changing the values of a, h and k in the equation $y = a(x - h)^2 + k$ of a quadratic function on its graph; determining the equation of a quadratic function; and solving problems involving quadratic functions. Additionally, the students were low proficient in modeling real-life situations using quadratic functions and representing a quadratic function using table of values, graph, and equation.

The students' mean percent scores in their posttest slightly increased for each competency; however, most of them were at low proficiency level. After exposure to direct instruction, the students were still low proficient in representing quadratic functions, graphing quadratic functions, analyzing the effects of changing the values of a, h and k in the equation $y = a(x - h)^2 + k$ of a quadratic function on its graph; determining the equation of a quadratic function; and solving problems involving quadratic functions. Some of the students remained not proficient in transforming the quadratic function defined by $y = ax^2 + bx + c$ into the form $y = a(x - h)^2 + k$. Furthermore, only one of the competencies reached the expected standard where students became nearly proficient in modeling real-life situations using quadratic functions. This implies that generally, the students have not yet developed their knowledge and essential skills in solving quadratic functions when they were taught using direct instruction.

B. The Effects of POGIL and Direct Instruction in the Proficiency Level of Students along Quadratic Functions

1. Significant Difference Between Pretest and Posttest of the Interventions

Intervention	Test	N	Mean	SD	t	df	Sig. (2-tailed)
POGIL	*Pretest*	40	13.10	3.05	-24.92	39	0.000
	Posttest	40	27.20	4.56			
Direct Instruction	*Pretest*	40	12.90	2.55	-11.98	39	0.000
	Posttest	40	18.25	4.57			

$*p< 0.05$

Table 7. Significant Difference between Mean Pretest and Posttest in POGIL Approach and Direct Instruction

As presented in the table, the proficiency level of the students after the POGIL intervention ($\overline{x}$=27.20, SD=4.56) was higher than their proficiency before($\overline{x}$=13.10, SD=3.05) they were taught using the POGIL approach in discussing the lesson on quadratic functions. Moreover, the result reveals that the post-test mean score of the students is significantly different from their pre-test mean score, t(39)=-24.92, p<0.0. This indicates that the POGIL approach used in teaching Quadratic Functions significantly elevated the students' proficiency level. Thus, the Process-Oriented Guided Inquiry Learning (POGIL) approach is effective in improving students' proficiency in Quadratic Functions. This result is supported by the findings of Artuz & Roble (2021) and Kisworo & Gusman (2019), which showed that POGIL teaching approach significantly improved the mathematics proficiency of the students, especially their critical thinking skills.

On the other hand, students mean scores in pre-test ($\overline{x}$=12.90, SD=2.55) slightly increased in their post-test ($\overline{x}$=18.25, SD=4.57) when they were exposed in Direct instruction. Additionally, there is a significant difference (t(39)=-11.98, p<0.0) between the pre-test and post-test scores of the students. However, the mean difference was low, which made their proficiency level remain in low proficiency but the gain is significant. Similarly, In the study of Bug-os & Caro (2019), it was found out that students mean scores in Non-POGIL class increased. The authors added that, regardless of strategy whether it is conventional way of instruction or POGIL approach, it will always provide some learning to the students.

2. *Comparison in the Level of Proficiency of Grade 9 Students along Quadratic Functions Between Direct Instruction and POGIL*

Source	Type III Sum of Squares	Df	Mean Square	F	Sig.	Partial Eta Squared
Corrected Model	2435.452[a]	2	1217.726	118.018	.000	.754
Intercept	202.729	1	202.729	19.648	.000	.203
PreTest	833.402	1	833.402	80.770	.000	.512
Treatment (Intervention)	1517.962	1	1517.962	147.116	.000*	.656
Error	794.498	77	10.318			
Total	44544.000	80				

a. R Squared = .754 (Adjusted R Squared = .748), *significant at 5% level

Table 8. Analysis of Covariance for Proficiency Level as a Function of the Intervention Using Pretest Scores as a Covariate

Results indicate that after controlling the pretest scores, there is a significant difference between the proficiency level of students in the two groups, one using the POGIL approach and the other direct instruction, $F(1, 77) = 147.12$, $p < 0.05$. The partial Eta Squared value of 0.66 indicates moderate effect size which means that the variance in the proficiency level of Grade 9 students along quadratic functions is explained by 66% of the interventions used, POGIL and direct instruction.

The post hoc test was carried out to determine significant difference in the proficiency level of Grade 9 students along quadratic functions in both interventions.

Interventions	Mean (Unadjusted)	Mean (Adjusted)	Std. Error	Mean Difference	Std. Error	Sig.[b]
Direct Instruction	18.25	18.366[a]	.508	8.718*	.719	.000
POGIL	27.20	27.084[a]	.508			

a. Covariates appearing in the model are evaluated at the following values: PreTest Scores = 13.0000.

b. Adjustment for multiple comparisons: Least Significant Difference (equivalent to no adjustments).

*. The mean difference is significant at the .05 level.

Table 9. Pairwise Comparisons of the Adjusted and Unadjusted Means for Proficiency Level Using Pretest Scores as a Covariate

The estimated adjusted means after controlling the pretest scores in the proficiency level of Grade 9 students along quadratic functions surfaced almost the same with the unadjusted means. This simply tells that there is a significant difference in the proficiency levels of Grade 9 students in quadratic functions taught under POGIL and direct instruction as shown by the mean difference of

8.718 with $p < 0.05$. For this adjusted means, after removing the effect of the pretest scores, Grade 9 students taught under POGIL approach ($M_{Adj} = 27.08$) have statistically higher proficiency level than the Grade 9 students taught under direct instruction ($M_{Adj} = 18.37$). This further implies that POGIL approach is a more effective in teaching quadratic functions to Grade 9 students than the direct instruction.

This result is consistent with the study of Bug-os and Caro (2019) which found a significant difference in the academic performance of students exposed in POGIL and non-POGIL class. Moreover, Sanggara et al. (2018) and Muhammad and Purwanto (2020) showed that the performance and mathematical problem- solving ability of students who are taught using the POGIL model is better than students who are taught using direct Learning. Also, Datu-Dacula and Anda (2021) found that POGIL approach is more beneficial than direct instruction in raising students' achievement. This further supports the findings of Dinniyah et al. (2022), Samosir (2022), Aiman (2022), and Andriani et al. (2019) that POGIL is an effective teaching method for enhancing students learning.

C. The Enhancement to be Integrated to the Students' Activities in POGIL

The observers gave their comments and suggestions in the given activities during the Process-Oriented Guided Inquiry Learning implementation through observation notes. Their feedback was further elaborated through dialogue with the researcher. Based on their feedback, four themes emerged: (1) Students' Engagement; (2) Students' Higher Order Thinking Skills; (3) Multimedia Presentations; and (4) Time Management.

1. *Students' Engagement*

By actively engaging in the learning process, students develop a deeper understanding of the subject matter and are more likely to retain the knowledge and skills they acquire. Based on the teacher-observers feedback, they indicated that students were actively engaged in the different activities during the POGIL instruction of the quadratic function.

Teacher	Comments/Suggestions
Teacher Gary	*"The review is well-participated by the students. This signifies that the previous lesson is well explained and understood by the students. The previous knowledge is properly used in presenting the new concept/lesson."* *"The students work collaboratively to attain the desired result."*
Teacher Zasha	*"The learners participated well in the recall."* *"Students were very active during recitation and the whole period. Students were able to identify the values of the variable correctly."* *"The results in the group activity can be presented on the board by the students and can become a point of discussion."*

Teacher Regine	*"Collaboration of the members of each group is evident."* *"It must have been better if during the presentation of answers, the graphs of quadratic functions were shown on the board so that students could easily identify and compare their answers from the rest."*

Table 10. Observers' Comments and Suggestions on the Students' Engagement

During the lesson about graphs of quadratic functions, the teacher only asked the group reporters to read their answers or observations about the effects of changing the values of h, and k in the equation $y = a(x - h)^2 + k$ of a quadratic function on its graph. In this activity, the teacher should let the students explain their answers on the board so that students will be more engaged in the lesson. This promotes a dynamic and interactive learning environment, where everyone can contribute their thoughts and perspectives, leading to a deeper understanding of the topic. In the study of Li (2014), it was revealed that student group presentations increased students' retention and success rate about the lesson. The author further added that students were actively engaged in learning the materials instead of listening to the lectures. Moreover, Murillo and Tan (2019) showed that students in inquiry-based learning were more positively engaged than the students who were exposed in the traditional way of teaching.

2. *Students' Higher-Order Thinking Skills (HOTS)*

During the POGIL instruction, students were encouraged to think critically by asking them HOTS questions. Exploration activities were also in HOTS-based questions to develop students' critical thinking and problem-solving skills. The observers noted that incorporating HOTS questions helped the students understand better the lesson.

Teacher	Comments/Suggestions
Teacher Gary	*"The students are asked HOTS questions that enable them to think critically. The teacher processes students' understanding."*
Teacher Zasha	*"The lesson/activity is quite congested but delivered smoothly because the teacher guided the students through asking HOTS questions."*
Teacher Regine	*"Through HOTS questions, the students are able to identify the effect of changing the value of 'a' in the graph of the quadratic function."*

Table 11. Observers' Comments and Suggestions on the Students' Higher-Order Thinking Skills

It can be inferred from the observers' comments that HOTS-based questions foster critical thinking skills, helping students approach mathematical concepts with a deeper level of analysis, leading them to a better understanding of the subject matter. In the study of Brion et al. (2022), it was revealed that POGIL is an effective teaching strategy that successfully improved mathematical

HOTS of the students. However, the findings of Zana et al. (2022)showed that students had difficulty in solving and answering HOTS-based questions due to low reading interest and diverse student abilities.

3. *Multimedia Presentations*

One of the instructional materials that could help students in grasping the lesson is through the use of multimedia presentations. According to the observers, the visual/video presentations were very useful in teaching the quadratic functions. They helped the students understand the concepts and answer correctly the questions that were asked.

Teacher	Comments/Suggestions
Teacher Gary	*"It must have been better if the students were able to identify the next lesson based on the video presented."*
Teacher Zasha	*"The use of visual presentation of the graph of quadratic function was very useful. It helped the student identify the concepts presented in the previous lesson. The students were able to answer the questions asked by the teacher correctly."* *"It must have been better if the descriptions of the concepts used were also given by the students together with the expected values of each concept."* *"Moreover, while asking for the values of the different properties of quadratic function, concepts must be reviewed and presented on the slide."* *"Students were engaged in doing their task however, some groups were not done in answering some of the questions. The problem and graph can be presented through video so that students can visualize the situation better."*
Teacher Regine	*"The video presentation enhances students' curiosity about the lesson" and that "the presentation of the lesson and its objectives was done smoothly."*

Table 12. Observers' Comments and Suggestions on the Students' Higher-Order Thinking Skills

In the lesson on quadratic function graphs, the identification and video-analysis stages were carried out smoothly through a visual presentation and a GeoGebra-based recorded video. However, in the exploration activity, some of the groups struggled to finish their tasks since they could not visualize properly the problem/situation. After the group activity, the teacher explained the problem with the use of video presentation, the students analyzed better how changing the values of h, and k affect the graph of quadratic functions.

Murillo and Tan (2019) stated that visual presentation helps learners understand and retain information better by associating ideas, words and concepts with images. The authors' findings also revealed that visual learning tools increased the students' HOT skills. Additionally, the study of Debrenti (2015) showed that the use visual representations in teaching mathematics help students understand the problem and improve their mathematical reasoning. Furthermore, Lalian (2018) revealed that use of videos as a learning media in mathematics plays a role in improving students' motivation in learning, enhancing students' knowledge and understanding of the lesson and improving the students' achievements.

4. *Time Management*

One of the challenges that occurred in the implementation of POGIL is the insufficient time frame. The observers indicated that there were too many objectives and questions in the worksheet that led to unfinished activities of the students. This scenario happened many times in the 16-day instruction of the teacher using the POGIL approach. These activities that were not done served as their assignments and continued the next day.

Teacher	Comments/Suggestions
Teacher Gary	*"Some of the students' activities were not finished due to limited time."*
Teacher Zasha	*"The objectives are too many for a 1-hour class, one objective is enough to cater all the activities."*
Teacher Regine	*"Variations of assessment were provided. However, due to time constraints, some activities were not completely done."*

Table 13. Observers' Comments and Suggestions on the Students' Higher-Order Thinking Skills

Apparently, the number of items in the group activity and evaluation was one of reasons why students did not finish all the tasks within the limited time frame. Peer feedback was not also daily executed due to the numerous activities. Thus, it is better to eliminate the peer-feedback in the daily activities in POGIL and just do it before their summative exam. According to Leong and Chick (2011), time pressure is a real day-to-day classroom experience. Teachers have multiple goals to fulfil in their instructional work which include syllabus coverage, helping students learn the deeper meanings of the content, teaching mathematical reasoning, and encouraging students to participate in discourse about mathematics within limited time.

In using POGIL approach, the teacher should prioritize key concepts and consider the number of learning objectives that can be achieved within a 1-hour instruction. Additionally, the teacher should create activities with realistic time limits to maximize learning. Thus, the teacher should manage the time efficiently when using the POGIL approach, including setting goals and priorities and using time management methods.

From the qualitative responses of the observers, it can be deduced that the POGIL approach increased students' engagement and developed students' critical thinking and problem-solving skills through HOTS-based questions. Moreover, the use of multimedia presentations helped the students understand the mathematical concepts and problems properly. However, insufficient time frame became the challenge in the implementation of POGIL wherein some of the activities were not executed within the available time. Thus, POGIL activities used in the study were further improved by prioritizing key objectives, eliminating some of the items, making the given equations easier, allocating time for each activity, and incorporating multimedia presentations in the exploration activity. The table 10 shows the description of activities for 7 learning stages.

Learning Stages	Description of Activities
1. Elicit	This is a short activity that piques students' curiosity, eliciting their prior knowledge related to quadratic functions. This can be done by the students individually or by pair within 2 mins.
2. Engage	This activity is a problem or scenario that is associated to the lesson and can be accomplished within 3 mins. It can also be done individually or by-pair.
3. Explore	In this activity, students delve into the core content. They work on guided inquiry questions that prompt them to explore concepts, apply their knowledge, and formulate their own solutions. Aside from the worksheet to be given, the problem/scenario could also be presented through visual and video presentations. It can be done by groups with four members and can be accomplished within 15 mins.
4. Explain	Following exploration, students articulate their understanding of the concepts. This involves sharing of findings or output to the class. The teacher facilitates the discussion to clarify misconceptions and reinforce ideas. This can be done within 15 mins.
5. Elaborate	The teacher will have a short discussion about the topic and encourage students to participate on the discussion. This can be done within 15 mins.
6. Evaluate	This is an individual activity, following the procedures that were discussed by the teacher. This can be accomplished within 5 mins.
7. Extend	This is a problem-based activity that will let the students apply their learned concepts to a more complex scenario. This will serve as their assignment.

Table 14. Description of the Enhanced POGIL Activities for Each Leaning Stage

CONCLUSIONS

Based on the findings, the following conclusions are drawn:

1. Before instruction, both the POGIL and non-POGIL groups exhibited low proficiency in quadratic functions, with similar mean percentage scores—26.2% for the POGIL group and 25.8% for the non-POGIL group. In both groups, 55% of students were classified as low

proficient, while 45% were not proficient. After being taught using the POGIL, the POGIL group showed significant improvement in proficiency, with the mean score increasing to 54.4%. A majority of students (75%) reached nearly proficient levels, while only 25% remained in the low proficiency category. Students showed noticeable gains across key competencies such as modeling real-life situations, graphing, analyzing parameter changes, and determining quadratic function equations. These results suggest that POGIL helped students build fundamental knowledge and apply it independently in authentic tasks, though some still needed minimal guidance. In contrast, the non-POGIL group taught through direct instruction showed only a modest increase in mean score (36.5%), and the majority (85%) remained low proficient, with only 7.5% showing improvement. Students continued to struggle with representing and transforming quadratic functions and did not meet the expected proficiency standards. These findings are supported by previous research from Irwanto et al. (2018), Artuz and Roble (2021), Brion et al. (2022), Samosir (2022), Aiman et al. (2020), and Kisworo and Gusman (2029), which consistently highlight POGIL's effectiveness in enhancing student performance. According to these studies, POGIL promotes deeper engagement, better communication, and improved critical thinking and problem-solving skills—leading to more meaningful learning outcomes compared to traditional teaching methods.

2. Students taught using the POGIL approach significantly improved their proficiency in quadratic functions. Their mean score increased from 13.10 (SD = 3.05) in the pretest to 27.20 (SD = 4.56) in the posttest, with a statistically significant difference, $t(39) = -24.92$, $p < 0.05$. This demonstrates that the POGIL method effectively enhanced students' understanding and performance. These findings are supported by Artuz & Roble (2021) and Kisworo & Gusman (2019), who also reported improved mathematics proficiency and critical thinking among students using POGIL. On the other hand, students who received direct instruction showed only a slight increase in scores—from a pretest mean of 12.90 (SD = 2.55) to a posttest mean of 18.25 (SD = 4.57)—although the gain was statistically significant, $t(39) = -11.98$, $p < 0.05$. However, their proficiency level remained low. This aligns with Bug-os & Caro (2019), who noted that while learning occurs under any teaching strategy, the depth of learning may vary. The adjusted mean score for the POGIL group (MAdj = 27.08) was significantly higher than that of the direct instruction group (MAdj = 18.37), confirming POGIL's greater effectiveness.These results are consistent with findings by Bug-os & Caro (2019), Sanggara et al. (2018), Muhammad & Purwanto (2020), Datu-Dacula & Anda (2021), Dinniyah et al. (2022), Samosir (2022), Aiman (2022), and Andriani et al. (2019), all of whom concluded that POGIL enhances students' academic performance, problem-solving skills, and overall learning outcomes more effectively than traditional methods.

3. The observer's feedback for the improvement of POGIL activities in teaching quadratic functions involved students' engagement, development of students' higher-order thinking skills, use of multimedia presentations, and time management in the given activities. Students were actively engaged during POGIL activities, leading to deeper understanding and better knowledge retention. This aligns with findings by Li (2014) and Murillo & Tan

(2019), who emphasized the benefits of active and inquiry-based learning over traditional lectures. POGIL also encouraged critical thinking through HOTS-based questions, which helped improve students' problem-solving skills. This is supported by Brion et al. (2022), though Zana et al. (2022) noted challenges among students with low reading interest and varied abilities in tackling HOTS tasks. Multimedia tools, especially visual and video presentations, were effective in enhancing student understanding, motivation, and achievement. Studies by Murillo & Tan (2019), Debrenti (2015), and Lalian (2018) support the positive impact of visual learning on comprehension and reasoning in mathematics.However, time management was a notable challenge. Observers pointed out that extensive worksheets and objectives often led to unfinished tasks. This issue reflects broader classroom realities noted by Leong & Chick (2011), where teachers must balance deep learning goals with time constraints.

RECOMMENDATIONS

As manifested in the findings and conclusions of the study, the following are hereby proposed:

1. Mathematics teachers should employ the POGIL approach in teaching mathematics lessons that involve problem-based activities. On the other hand, direct instruction can be used on other topics such as the least-mastered competencies in mathematics.
2. POGIL approach may be used in teaching quadratic functions to improve students' proficiency.
3. The enhanced POGIL activities made by the researcher can be utilized by the mathematics teachers in teaching quadratic functions to Grade 9 students. This may be further developed to fully achieve its objective of assisting students in increasing their proficiency in quadratic functions.
4. Future researchers may also consider the impact of POGIL in other areas of mathematics and science such as trigonometry, geometry, calculus, biology, chemistry, and physics because these subjects offer valuable opportunities for cultivating the students' higher-order thinking skills.

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References

[1] Aiman, U., Hasyda, S., & Uslan. (2020). The influence of process oriented guided inquiry learning (POGIL) model assisted by realia media to improve scientific literacy and critical thinking skill of primary school students. European Journal of Educational Research, 9(4), 1635–1647. https://doi.org/10.12973/EU-JER.9.4.1635

[2] Andamon, J. C., & Tan, D. A. (2018). Conceptual understanding, attitude and performance in mathematics of Grade 7 Students. *International Journal of Scientific and Technology Research*, *7*(8), 96–105.

[3] Andriani, S., Nurlaelah, E., & Yulianti, K. (2019). The effect of process oriented guided inquiry learning (POGIL) model toward students' logical thinking ability in mathematics. *Journal of Physics: Conference Series*, *1157*(4), 1–5. https://doi.org/10.1088/1742-6596/1157/4/042108

[4] Arnal-Palacian, M., Baeza, M. A., & Claros-Mellado, J. (2022). Quadratic Functions Representation: Pencil and Paper vs GeoGebra. International Journal for Technology in Mathematics Education, 29(3), 165-178.

[5] Artuz, J. kevin A., & Roble, D. (2021). Developing Students' Critical Thinking Skills in Mathematics Using Online-Process Oriented Guided Inquiry Learning (O-POGIL). *American Journal of Educational Research*, *9*(7), 404–409. https://doi.org/10.12691/education-9-7-2

[6] Baring, C. C., & Alegre, E. M. (2019). Difficulties Encountered in Solving Quadratic Equation of the Grade 9 Students: Basis for Constructing Instructional Materials. *International Journal of Scientific and Research Publications (IJSRP)*, *9*(5), 271–276. https://doi.org/10.29322/ijsrp.9.05.2019.p8931

[7] Bone, E., Bouck, E., & Witmer, S. (2021). Evidence-Based Systematic Review of Literature on Algebra Instruction and Interventions for Students With Learning Disabilities. *A Contemporary Journal*, *19*(1), 1–22. https://files.eric.ed.gov/fulltext/EJ1295341.pdf

[8] Brion, C. L., Pagkaliwangan, M. E., & Ching, D. A. (2022). Process Oriented Guided Inquiry Learning and Mathematical Higher Order Thinking Skills of Grade 10 Students. *The Research Probe*, *2*(2), 53–68.

[9] Bug-os, M. A. A. C., & Caro, V. B. (2019). Academic performance and attitudes towards general physics of grade 12 students in a process-oriented guided inquiry learning (POGIL). *Science International*, *13*(1), 31–34. https://www.researchgate.net/publication/352018771

[10] Datu-Dacula, N., & Anda, A. (2021). Process Oriented Guided Inquiry Learning on Students' Achievement in Biology. *Turkish Online Journal of Qualitative Inquiry*, *12*(6).

[11] Department of Education. (2019). *2018 National Achievement Test (NAT) 6, 10, & 12*

Results and analysis.
[12] Department of Education. (2019). *PISA 2018: National report of the Philippines*. 1–44. https://www.deped.gov.ph/wp-content/uploads/2019/12/PISA-2018-Philippine-National-Report.pdf
[13] Díaz, V., Aravena, M., & Fores, G. (2020). Solving problem types contextualized to the quadratic function and error analysis: A case study. *Eurasia Journal of Mathematics, Science and Technology Education*, *16*(11). https://doi.org/10.29333/EJMSTE/8547
[14] Dillingerová, M., & Vankúš, P. (2020). How to avoid some misconceptions in the tasks dealing with the functions at the university level. *19th Conference on Applied Mathematics, APLIMAT 2020 Proceedings*, 360–367.
[15] Diniyyah, M., Susilo, H., Balqis, B., & Kamal, A. (2022). Improving critical thinking and problem- solving skills through POGIL combined with digital mind map. *JPBI (Jurnal Pendidikan Biologi Indonesia)*, *8*(3), 275–286. https://doi.org/10.22219/jpbi.v8i3.18992
[16] Dumigsi, M. P., & Cabrella, J. B. B. (2019). Effectiveness of Strategic Intervention Material in Mathematics as Remediation for Grade 9 Students in Solving Problems Involving Quadratic Functions. *Asian Journal of Education and Social Studies*, *5*(1), 1–10. https://doi.org/10.9734/ajess/2019/v5i130137
[17] Hoon, T. S., Singh, P., & Halim, U. Ka. A. (2018). Understanding Of Function And Quadratic Functios Among Secondary School Students In Selangor. *Asian Journal of Education, Faculty of Education, UiTM*, *14*(1), 77–88.
[18] Irwanto, Saputro, A. D., Rohaeti, E., & Prodjosantoso, A. K. (2018). Promoting critical thinking and Problem Solving Skills of Preservice Elementary Teachers through Process-Oriented Guided-Inquiry Learning (POGIL). *International Journal of Instruction*, *11*(4), 777–794. https://doi.org/10.12973/iji.2018.11449a
[19] Kartono, & Shora, R. Y. (2020). Effectiveness of process oriented guided inquiry learning with peer feedback on achieving students' mathematical reasoning capabilities. *International Journal of Instruction*, *13*(3), 555–570. https://doi.org/10.29333/iji.2020.13338a
[20] Kisworo, B., & Gusman, T. A. (2019). Process oriented guided inquiry learning to increase student's critical thinking ability on chemistry learning at Islamic High School in Cirebon. *AIP Conference Proceedings*, *46*(08), 46–4453. https://doi.org/10.5860/choice.46-4453
[21] Leinhardt, G., Zaslavsky, O., & Stein, M. K. (1990). Functions, graphs, and graphing: Tasks, learning, and teaching. Review of educational research, 60(1), 1-64.
[22] Muhammad, M., & Purwanto, J. (2020). The effect of Process Oriented Guided Inquiry Learning (POGIL) on mathematical problem solving abilities. *Journal of Physics: Conference Series*, *1469*(1). https://doi.org/10.1088/1742-6596/1469/1/012171
[23] Mullis, I. V. S., Martin, M. O., Foy, P., Kelly, D. L., & Fishbein, B. (2019). Timss 2019 International Results in Mathematics and Science Timss & Pirl. In *International Association for the Evaluation of Educational Achievement*. https://www.iea.nl/sites/default/files/2021-01/TIMSS 2019-International-Results-in-Mathematics-and-Science.pdf
[24] Nielsen, L. E. J. (2015). Understanding quadratic functions and solving quadratic equations: An analysis of student thinking and reasoning. *Dissertation Abstracts International Section A: Humanities and Social Sciences*, *77*(2-A(E)), No-Specified.

http://ovidsp.ovid.com/ovidweb.cgi?T=JS&PAGE=reference&D=psyc13&NEWS=N&AN=2016-31152-106

[25] Parent, J. S. S. (2015). Students' understanding of quadratic functions: Learning from students' voices. *Dissertation Abstracts International Section A: Humanities and Social Sciences*, *76*(4-A(E)), No-Specified. http://ovidsp.ovid.com/ovidweb.cgi?T=JS&PAGE=reference&D=psyc12&NEWS=N&AN=2015-99190-195

[26] Pasion, R. (2019). The Efficacy of Strategic Intervention Materials (SIMS) in Teaching Social Studies Among Third Year High School Students. *SMCC Higher Education Research Journal*, *6*(1). https://doi.org/10.18868/sherj6j.06.010119.11

[27] Pradiyanasari, N. W. E., Verawati, N. N. S. P., & Doyan, A. (2020). The Effect of Process Oriented Guided Inquiry Learning (POGIL) Model on Students' Concepts Mastery. *Jurnal Kependidikan Fisika*, *8*(1), 25–30.

[28] Samosir, B. (2022). Implementation of Process Oriented Guided Inquiry Learning Model Learning (Pogil) on Understanding of Science Concepts, Skills Science Process and Student's Critical Thinking Ability. *International Journal of Multidisciplinary: Applied Business and Education Research*, *3*(9), 1673–1682. https://doi.org/10.11594/ijmaber.03.09.08

[29] Sanggara, P. W., Doyan, A., & Verawati, N. N. S. P. (2018). The Effect of Process Oriented Guided Inquiry Learning Model Based on Virtual Laboraory Toward Problem Solving Abilities of Physics Student. *Jurnal Penelitian Pendidikan IPA*, *5*(1), 1–5. https://doi.org/10.29303/jppipa.v5i1.154

[30] Şen, Ş., Yılmaz, A., & Geban, Ö. (2015). the Effects of Process Oriented Guided Inquiry Learning Environment on Students' Self-Regulated Learning Skills. *Problems of Education in the 21st Century*, *66*(1), 54–66. https://doi.org/10.33225/pec/15.66.54

[31] Sharma, P. (2021). Importance and Application of Mathematics in Everyday Life. *International Journal for Research in Applied Science and Engineering Technology*, *9*(11), 868–879. https://doi.org/10.22214/ijraset.2021.38869

[32] Su, H. F. H., Ricci, F. A., & Mnatsakanian, M. (2016). Mathematical teaching strategies: Pathways to critical thinking and metacognition. *International Journal of Research in Education and Science*, *2*(1), 190–200. https://doi.org/10.21890/ijres.57796

[33] Susandi, A. D. (2021). Critical Thinking Skills of Students in Solving Mathematical Problem. *Numerical: Jurnal Matematika Dan Pendidikan Matematika*, *5*(2), 115–128. https://doi.org/10.25217/numerical.v5i2.1865

APPENDIX I

PRE-TEST

Name (Optional):____Section:___________

MULTIPLE CHOICE. *Directions:* Read each item carefully and choose the correct answer from the options given and then write the letter of your answer on the line provided before the number.

_______1. The height of the object from the ground at time t is h, which is given by, $h(t) = -25t^2 + 15t + 28$. What function best describe the situation?

a. Linear function c. Radical function
b. Quadratic function d. Rational function

_______2. Throwing a ball, shooting a cannon, diving from a platform and hitting a golf ball are all examples of situations that can be modeled by ___________________.

a. Linear function c. Radical function
b. Quadratic function d. Rational function

_______3. Which of the following situation does NOT represent a quadratic function?

a. The rock is thrown off a 75 meter high cliff into some water. The height of the rock relative to the cliff after t seconds is given by $h(t) = -5t^2 + 20t$.
b. The area A of a room with width 5m more than the length.
c. The width of a frame in creating a border using all of the 10sq. feet of fabric for a quilt that is 4 feet by 5 feet.
d. The total number of credit hours C that remain for a student to earn a degree after semesters have been completed successfully is given by C = 130 -9s.

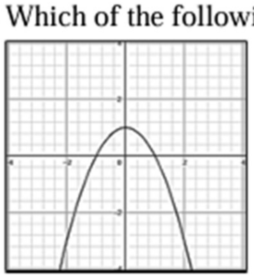
_______4. Which of the following situations represents a quadratic function?

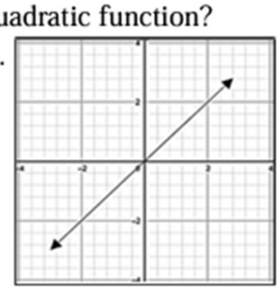
a. The train travels 45 miles every hour after departing the station.
b. The equation $h(t) = -4.9t^2 + 8t + 5$ represents Jeremiah's height (h) in meters above the water t seconds after he leaves the diving board.
c. The amount of money in a bank account increases by 1 percent each year.
d. The cost C of sending m text messages C = ₱1m.

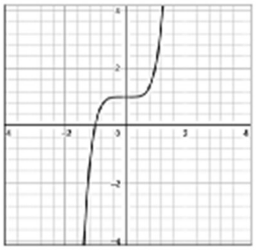
_______5. Which of the following equations is a quadratic function?

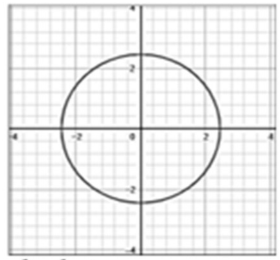
a. $y = 3 + 2x^2$ b. $3 + 2y^2 = x$ c. $y = 3x - 2^2$ d. $y = 2^x - 3$

_______6. Which of the following graphs represents quadratic function?

a.


c.


b. 

d. 

_______7. The graph of a quadratic function is a parabola that opens ___________only.

a. upward and downward b. to the left c. to the right d. both b and c

_______8. In the quadratic function of the form $y = ax^2 + bx + c$, which of the following must NOT be equal to 0?

a. a b. b c. c d. x-term

_______9. What are the values of a, b, and c in the equation $y + 5 = 2x - 3x^2$, if written in the form $y = ax^2 + bx + c$?

a. $a = 5$, $b = -3$, $c = 2$
c. $a = -3$, $b = 2$, $c = -5$
b. $a = -3$, $b = -5$, $c = 2$
d. $a = -3$, $b = 2$, $c = 5$

_______10. If $y = (x + 2)^2 + 1$ is written in the form $f(x) = ax^2 + bx + c$, find $a + b + c$.

a. 10 b. 12 c. 15 d. 26

_______11. What is true about the equation $y + 2x^2 = 2x(x + 1) - 3$?

a. The equation represents quadratic function because the highest degree of the variable is 2.

b. If you will simplify and rearrange the function, it will be in the form of $y = mx + b$. Therefore, it is not quadratic function, but a linear function.

c. The highest degree of the variable is 3. Thus, it is not quadratic function.

d. If the function is expanded it will be $y = 2x^2 + 2x + 1$. Thus, the equation represents quadratic function.

_______12. Identify the table that represents the graph of quadratic function.

a.

x	-3	-2	-1	0	1
y	0	4	6	4	0

b.

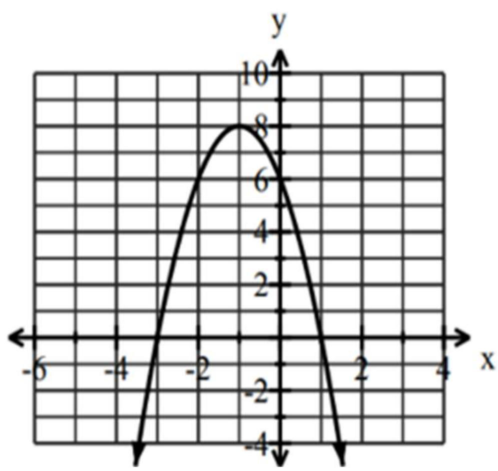
x	-3	-2	-1	0	1
y	0	6	8	6	0

c.

x	-4	-2	0	2	4
y	0	4	6	4	0

d.

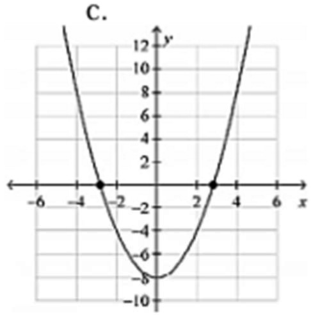
x	-4	-2	0	2	4
y	0	6	8	6	0

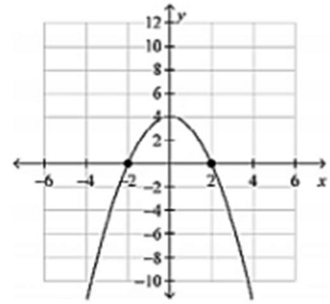


________13. Identify the graph that best represent the equation $y = x^2 - 4$.

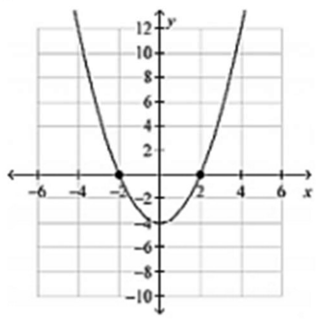
a.

c.





b.



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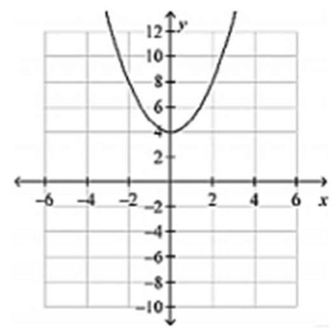


________14. Which of the following is true about this given table of values?

x	1	2	3	4	5
y	5	12	19	26	33

a. The y values are all positive. Hence, the table represents a quadratic function.

b. The y values are all positive. Hence, the table does not represent a quadratic function.

c. The first and second differences of the y values are equal. Hence, the table represents a quadratic function.

d. The first differences of the y values are already equal. Hence, the table does not represent a quadratic function.

________15. Which of the following table of values does NOT represent a quadratic function?

a.

x	-2	-1	0	1	2
y	6	3	2	3	6

b.

x	-2	-1	0	1	2
y	5	2	1	2	5

c.

x	-2	-1	0	1	2
y	4	1	0	1	4

d.

x	-2	-1	0	1	2
y	8	1	0	-1	-8

________16. Given the equation $y = -2x^2 + 4x + 7$, what value of m and n make the table complete:

x	-3	-2	-1	0	1	2	3	4
y	m	-9	1	7	9	n	1	-9

a. -23 and 7
b. -13 and 7
c. -23 and 1
d. 1 and 7

________17. What must be the value of c if $y = 3(x-1)^2 - 6$ is transformed into general form?

a. -3 b. 3 c. -9 d. 9

________18. Express $f(x) = 5x^2 - 10x + 7$, in the form $f(x) = a(x-h)^2 + k$.

a. $f(x) = 5(x-1)^2 + 2$
b. $f(x) = 5(x-1)^2 - 2$
c. $f(x) = 5(x-2)^2 + 1$
d. $f(x) = 5(x-2)^2 - 1$

________19. The quadratic function $y = x^2 + 2x - 5$, is expressed in vertex form as:

a. $y = (x+1)^2 - 6$
b. $y = (x+1)^2 - 4$
c. $y = (x+1)^2 + 4$
d. $y = (x+1)^2 + 6$

________20. The quadratic function d $y = (x+3)^2 - 1$, is expressed in general form as:

a. $y = x^2 + x - 6$
b. $y = x^2 + 6x + 8$
c. $y = x^2 + 6x - 8$
d. $y = x^2 + 8x + 14$

________21. It is the turning point of the parabola, which indicates the highest/lowest point of the graph?

a. Axis of symmetry b. Range c. Vertex d. Zeros

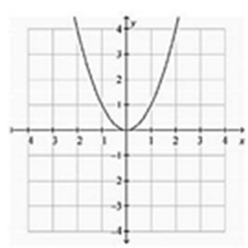
________22. In the quadratic form $y = a(x-h)^2 + k$, what is the vertex?

a. (a, x) b. (h, k) c. (y, k) d. (y, a)

________23. What is the value of (h, k) in the quadratic function $y = 2(x-3)^2 + 4$?

a. $(-3, -4)$ b. $(-3, 4)$ c. $(3, -4)$ d. $(3, 4)$

________24. Identify the vertex of the graph. Tell whether it is a minimum or maximum.



a. (0,0); minimum
b. (1,0); maximum
c. (0,1); minimum
d. (2,0); maximum

________25. Which quadratic function opens upward and has a vertex of $(0,3)$?

a. $y = -(x-3)^2$ c. $y = (x-3)^2$

b. $y = x^2 + 3$ d. $y = -x^2 + 3$

________26. Find the equation of the axis of symmetry and the coordinate of the vertex of the graph of $y = x^2 - 8x + 7$?

a. $x = 4; vertex(4, -9)$ c. $x = -4; vertex(-4, -9)$

b. $x = -9; vertex\ (-9,4)$ d. $x = 4; vertex(-4, -9)$

________27. What is the y-intercept of the parabola defined by the equation $y = (x+2)^2$?

a. $(0, -4)$ b. $(0, -2)$ c. $(0,2)$ d. $(0,4)$

________28. What is the x-intercepts of the quadratic function $y = 2x^2 - 4x - 6$?

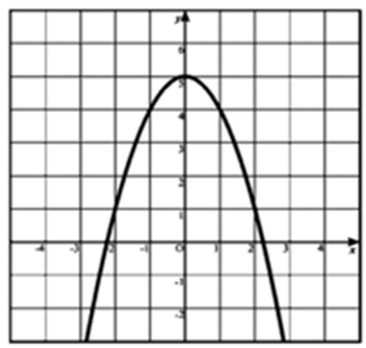
a. $(-1,0), (3,0)$ b. $(1,0), (-3,0)$ c. $(-1,0), (-3,0)$ d. $(-1,0), (3,0)$

________29. Which quadratic function opens downward and has a vertex of $(0,7)$?

a. $y = -(x-7)^2$ c. $y = (x-7)^2$

b. $y = x^2 + 7$ d. $y = -x^2 + 7$

For items 30-31, refer to the graph at the right.



________30. What is the range of the parabola?

a. $(-\infty, -5]$ c. $(-\infty, +\infty)$

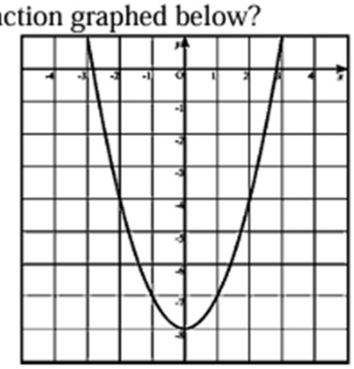
b. $(-\infty, 5]$ d. $[5, +\infty)$

________31. What is the domain of the parabola?

a. $(-\infty, -5]$ c. $(-\infty, +\infty)$

b. $(-\infty, 5]$ d. $[5, +\infty)$

________32. Which statement is correct for the quadratic function graphed below?



a. The graph of the function is $y = x^2 + 8$ with a maximum value of -8.

b. The graph of the function is $y = -x^2 + 8$ with a maximum value of -8.

c. The graph of the function is $y = x^2 - 8$ with a minimum value of -8.

d. The graph of the function is $y = -x^2 - 8$ with a minimum value of -8

________33. In the quadratic function $y = a(x-h)^2 + k$, if $h > 0$ then the parabola moves:

a. h units downward   c. h units to the right

b. h units upward   d. h units to the left

________34. In the quadratic function $y = a(x-h)^2 + k$, if $k < 0$ then the parabola moves:

a. k units downward c. k units to the right

b. k units upward d. k units to the left

________35. The graph of $y = x^2 - 3$ is obtained by sliding the graph of $y = x^2$:

a. 3 units downward c. 3 units to the right

b. 3 units upward d. 3 units to the left

________36. Which of the following equations of parabola has a wider opening?

a. $y = \frac{1}{4}x^2$ b. $y = \frac{1}{2}x^2$ c. $y = 3x^2$ d. $y = 5x^2$

________37. What are the zeros of the quadratic function $y = x^2 - 2x - 63$?

a. -9 and -7 b. -9 and 7 c. -7 and 9 d. 7 and 9

________38. Which quadratic function has no zeros?

a. $y = x^2 - 4$ c. $y = -x^2 + 4$

b. $y = -x^2 - 4$ d. $y = x^2 + 4x$

________39. Determine the quadratic function if the zeros are 5 and -3?

a. $y = x^2 - 2x - 15$ c. $y = -x^2 + 2x + 8$

b. $y = x^2 - 8x + 15$ d. $y = x^2 + 2x + 15$

________40. Identify the zeros of the quadratic function $y = x^2 + 5x - 24$?

a. 8 and -3 b. -8 and 3 c. -3 and -8 d. 3 and 8

________41. Which quadratic function contain the point (1,7)?

a. $y = -x^2 - 2x - 4$ c. $y = -x^2 - 2x + 4$

b. $y = -x^2 + 2x - 4$ d. $y = x^2 + 2x + 4$

________42. What is the second difference of y-values of

x	-2	-1	0	1	2
y	-3	0	1	0	-3

a. -2 b. -1 c. 1 d. 2

________43. Use the coordinates from the table to determine which equation models the table below:

X	-2	-1	0	1	2
Y	6	0	-4	-6	-6

a. $f(x) = x^2 - 3x - 4$ c. $f(x) = x^2 + 3x - 4$

b. $f(x) = 3x^2 - 12x - 16$ d. $f(x) = 3x^2 - 6x - 8$

________44. A farmer has 120 m of fencing. He wants to put a fence around three sides of a rectangular plot of land, with the side of a barn forming the fourth side. What dimensions give this area?

a. 30 m by 60 m c. 20 m by 40 m

b. 20 m by 30 m d. 40 m by 60 m

For question numbers 45-46: From a 96-foot building, an object is thrown straight up into the air then follows a trajectory. The height S(t) of the ball above the building after t seconds is given by the function $S(t) = 80t - 16t^2$.

________45. What maximum height will the object reach?

a. 50 ft b. 80 ft c. 100 ft d. 200 ft

________46. How long will it take the object to reach the maximum height?

a. 1.5 secs b. 2.5 secs c. 3 secs d. 2 secs

For numbers 47-48: A projectile is launched from a point above the ground. The height at ground level is given by the equation $h = -3t^2 + 24t$, where h is the height in meters and t is the time in seconds.

________47. What maximum height it can be reach?

a. 40 m b. 35 m c. 24 m d. 48 m

________48. How long will it take to reach the maximum height?

a. 2 secs b. 4 secs c. 3 secs d. 5 secs

For numbers 49-50: A ball is launched upward at 14 m/s from a platform 30 m high. The height of the ball is given by the function $h(t) = -4.9t^2 + 14t + 30$.

________49. Find the maximum height the ball reaches?

a. 50 m b. 20 m c. 80 m d. 40 m

________50. How long will it take the ball to reach the maximum height?

a. 2.2 secs b. 1.81 secs c. 2 secs d. 1.43 secs

APPENDIX II
POST-TEST

Name(Optional): ______________________________________Section: ______________

MULTIPLE CHOICE. *Directions:* Read each item carefully and choose the correct answer from the options given and then write the letter of your answer on the line provided before the number.

_______1. There are many real-world situations that can be modeled by this function, such as throwing a ball, shooting a cannon, diving from a platform, and hitting a golf ball.

a. Linear function c. Radical function
b. Quadratic function d. Rational function

_______2. The height of the ball from the ground at time t is h, which is given by, $h = -16t^2 + 64t + 80$. What function best describe the situation?

a. Linear function c. Radical function
b. Quadratic function d. Rational function

_______3. Which of the following situation does NOT represents a quadratic function?

a. The employee is paid P570 for each day worked.
b. The maximum area of a rectangular cardboard that can be framed using 140 inches of boarder materials.
c. The rock is thrown off a 75 meter high cliff into some water. The height of the rock relative to the cliff after t seconds is given by $h(t) = -5t^2 + 20t$.
d. The area A of a room with width 5m more than the length.

_______4. Which of the following situations represents a quadratic function?

a. The train travels 50 miles every hour after departing the station.
b. The equation $h(t) = -6t^2 + 10t + 7$ represents John's height (h) in meters above the water t seconds after he leaves the diving board.
c. The amount of money in a bank account increases by 1.5 percent each year.
d. The cost C of sending m text messages C = ₱2m.

_______5. Which of the following equations is NOT a quadratic function?

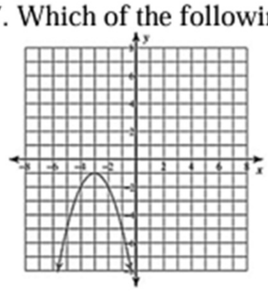
a. $y = 3 + 2x^2$ b. $1 + 5x^2 = y$ c. $y = 3x + 7$ d. $y = x^2 - 1$

_______6. The graph of a quadratic function is a parabola that opens ______________ only.

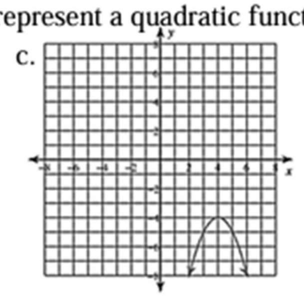
a. upward and downward b. to the left c. to the right d. both b and c

_______7. Which of the following graph does NOT represent a quadratic function?

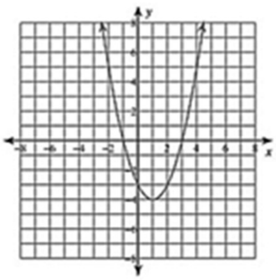
a.



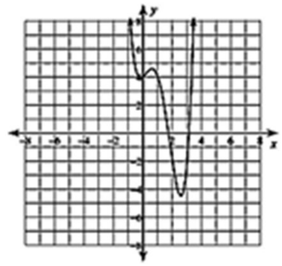
c.



b.



d.



________8. Quadratic function is any function of the form: $y = ax^2 + bx + c$, where a, b and c are real numbers and ______________________.

a. $a \neq 0$ b. $a < 0$ c. $a = 0$ d. $a \geq 0$

________9. If $y - 6 = 1 + x^2 + 3x$ is written in the form $y = ax^2 + bx + c$, find a, b, and c.

a. $a = 1$, $b = 3$, $c = 7$
c. $a = 1$, $b = 1$, $c = 3$
b. $a = 1$, $b = 3$, $c = -5$
d. $a = 3$, $b = 1$, $c = 7$

________10. If $y = (x + 1)^2 + 2$ is written in the form $y = ax^2 + bx + c$, find $a + b + c$.

a. -3 b. 5 c. 6 d. 10

________11. What is true about the equation $y + x - 1 = 3x(x + 2)$?

a. The equation represents linear function because the highest degree of the variable is 1.
b. If you will simplify and rearrange the function, it will be in the form of $y = mx + b$. Therefore, it is not quadratic function, but a linear function.
c. The highest degree of the variable is 3. Thus, it is not quadratic function.
d. If the function is expanded it will be $y = 3x^2 + 5x + 1$. Thus, the equation represents quadratic function.

________12. Which of the following is true about this given table of values?

x	-1	0	1	2	3
y	2	1	2	5	10

a. The y values are all positive. Hence, the table represents a quadratic function.
b. The y values are all positive. Hence, the table does not represent a quadratic function.
c. The first difference of y values are not equal but the second differences are equal. Thus, the table represents a quadratic function.
d. The first differences of the y values are already equal. Hence, the table does not represent a quadratic function.

________13. Which of the following table of values represent a quadratic function?

a.

x	-2	-1	0	1	2
y	2	1	0	1	2

b.

x	-2	-1	0	1	2
y	2	1	0	-1	-2

c.

x	-2	-1	0	1	2
y	4	1	0	1	4

d.

x	-2	-1	0	1	2
y	8	1	0	-1	-8

________14. Identify the table that represents the graph of quadratic function.

a.

x	-2	-1	0	1	2
y	0	-3	-4	-3	0

b.

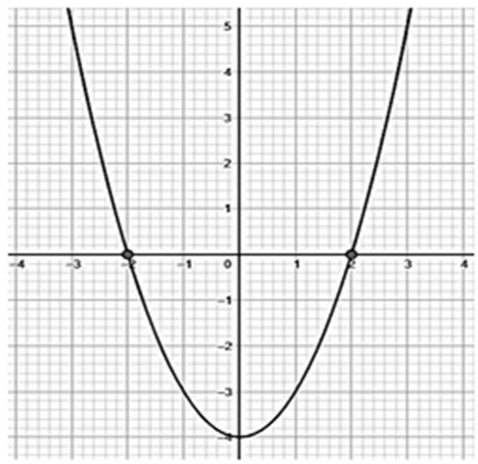
x	-2	-1	0	1	2
y	-3	0	-4	0	-3

c.

x	-2	-1	0	1	2
y	0	4	-3	4	0

d.

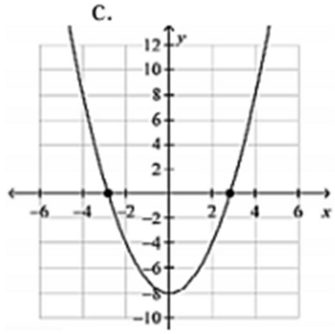
x	-2	-1	0	1	2
y	0	-3	4	3	0

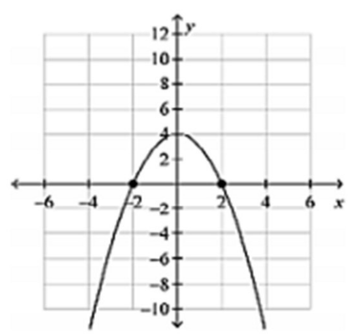


________15. What is the graph of the equation $y = x^2 - 8$?

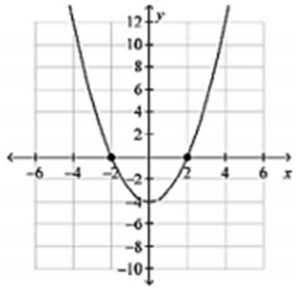
a.

c.

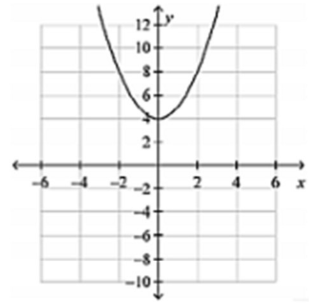




b.



d.



_______16. Given the equation $y = x^2 + 3x + 11$, what value of s and t make the table complete:

x	-3	-2	-1	0	1	2	3	4
y	11	s	9	11	15	21	t	39

a. 9 and 25 c. -13 and 29
b. 9 and 29 d. -7 and 23

_______17. What must be the value of ***b*** if $y = 5(x-1)^2 + 10$ is transformed into general form?

a. -5 b. 5 c. -10 d. 10

_______18. Express $f(x) = 5x^2 - 20x + 21$, in the form $f(x) = a(x-h)^2 + k$.

a. $f(x) = 5(x-2)^2 - 1$ c. $f(x) = 5(x+2)^2 + 1$
b. $f(x) = 5(x-2)^2 + 1$ d. $f(x) = 5(x+2)^2 - 1$

_______19. Express the quadratic function $y = 3(x-2)^2 + 1$ into general form.

a. $y = 3x^2 - 12x + 13$ c. $y = 3x^2 - 8x + 12$
b. $y = x^2 + 13x - 7$ d. $y = x^2 - 11x - 13$

_______20. The quadratic function $y = x^2 - 4x + 3$, is expressed in vertex form as:

a. $y = (x-2)^2 - 1$ c. $y = (x+2)^2 - 1$
b. $y = (x-2)^2 + 1$ d. $y = (x+2)^2 + 1$

_______21. What is the vertex in the quadratic form $y = a(x-h)^2 + k$?

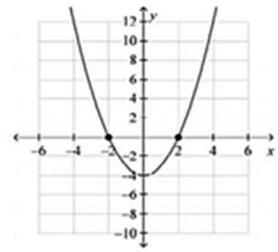
a. (h, k) b. (y, k) c. (a, x) d. (y, a)

_______22. It represents the minimum/maximum value of the graph of quadratic function.

a. Axis of symmetry b. Range c. Vertex d. Zeros

_______23. Which must be the value of (h, k) in the quadratic function $y = 3(x-2)^2 - 5$?

a. $(-2, -5)$ b. $(-2, 5)$ c. $(2, -5)$ d. $(2, 5)$



________24. Identify the vertex of the graph. Tell whether it is a minimum or maximum.

a. $(0,-4)$; minimum c. $(-4,0)$; minimum

b. $(0,4)$; maximum d. $(4,0)$; maximum

________25. What is the y-intercept of the parabola defined by the equation $y=(x+4)^2$?

a. $(-4,0)$ b. $(4,0)$ c. $(0,-16)$ d. $(0,16)$

________26. What is the x-intercepts of the quadratic function $y=3x^2+5x-2$?

a. $\left(\frac{1}{3},0\right),(2,0)$ b. $\left(\frac{1}{3},0\right),(-2,0)$ c. $(3,0),(2,0)$ d. $(3,0),(-2,0)$

________27. Which quadratic function opens downward and has a vertex of $(0,4)$?

a. $y=(x-4)^2$ c. $y=-(x+4)^2$

b. $y=-x^2+4$ d. $y=-x^2-4$

________28. Find the equation of the axis of symmetry and the coordinate of the vertex of the graph of $y=x^2+10x-3$?

a. $x=5; vertex(5,-28)$ c. $x=-5; vertex(-5,-28)$

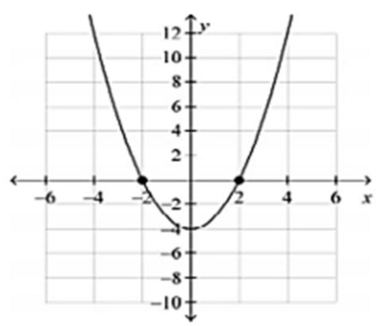
b. $x=-5; vertex\ (-5,28)$ d. $x=5; vertex(5,28)$

________29. Which quadratic function opens upward and has a vertex of $(3,4)$?

a. $y=-2(x-3)^2+4$ c. $y=-2(x+3)^2+4$

b. $y=2(x-3)^2+4$ d. $y=2(x+3)^2-4$

For items 30-31, refer to the graph at the right



________30. What is the domain of quadratic function?

a. $(-\infty,-4]$ c. $(-\infty,+\infty)$

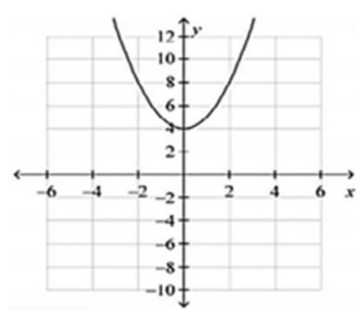
b. $(-\infty,4]$ d. $[4,+\infty)$

________31. What is the range of the quadratic function?

a. $(\infty,-4]$ c. $(-\infty,+\infty)$

b. $(-\infty,4]$ d. $[4,+\infty)$

________32. Which statement is correct for the quadratic function graphed below?



a. The graph of the function is $y=-x^2+4$ with a maximum value of 4.

b. The graph of the function is $y=-x^2-4$ with a maximum value of -4.

c. The graph of the function is $y=x^2+4$ with a minimum value of 4.

d. The graph of the function is $y = x^2 - 4$ with a minimum value of -4.

________33. In the quadratic function $y = a(x-h)^2 + k$, if $h < 0$ then the parabola moves:

a. h units downward c. h units to the right
b. h units upward d. h units to the left

________34. In the quadratic function $y = a(x-h)^2 + k$, if $k > 0$ then the parabola moves:

a. k units downward c. k units to the right
b. k units upward d. k units to the left

________35. The graph of $y = x^2 - 6$ is obtained by sliding the graph of $y = x^2$:

a. 6 units downward c. 6 units to the right
b. 6 units upward d. 6 units to the left

________36. Which of the following equations of parabola has a wider opening?

a. $y = \frac{1}{8}x^2$ b. $y = \frac{1}{4}x^2$ c. $y = x^2$ d. $y = 3x^2$

________37. What is the second difference of y-values of

x	-2	-1	0	1	2
y	5	2	1	2	5

a. -2 b. -1 c. 1 d. 2

________38. What are the zeros of the quadratic function $y = x^2 + 4x - 32$?

a. -8 and 4 b. 4 and 8 c. -4 and 8 d. -8 and -4

________39. Determine the quadratic function if the zeros are -1 and 6?

a. $y = x^2 - 5x - 6$ c. $y = x^2 + 5x + 6$
b. $y = x^2 - 7x + 5$ d. $y = x^2 + 6x + 11$

________40. Which quadratic function has no zeros?

a. $y = x^2 - 9$ c. $y = -x^2 - 9$
b. $y = -x^2 + 9$ d. $y = x^2 + 9x$

________41. Identify the zeros of the quadratic function $y = x^2 + 16x + 63$?

a. -9 and -7 b. -9 and 7 c. -7 and 9 d. 7 and 9

________42. Which quadratic function contain the point (2,5)?

a. $y = x^2 - 2x + 5$ c. $y = -x^2 - 4x + 7$
b. $y = -x^2 + 5x - 3$ d. $y = x^2 + x + 3$

________43. Determine the equation that represents the table of values below:

X	-2	-1	0	1	2
Y	4	3	4	7	12

a. $f(x) = x^2 - 6x - 4$ c. $f(x) = x^2 + 4x - 2$
b. $f(x) = x^2 + 2x + 4$ d. $f(x) = 2x^2 - 2x - 6$

________44. A farmer has 160 m of fencing. He wants to put a fence around three sides of a rectangular plot of land, with the side of a barn forming the fourth side. What dimensions give this area?

a. 30 m by 60 m
c. 20 m by 40 m
b. 20 m by 30 m
d. 40 m by 80 m

For numbers 45-46: A ball is launched upward at 14 m/s from a platform 30 m high. The height of the ball is given by the function $h(t) = -4.9t^2 + 14t + 30$.

________45. Find the maximum height the ball reaches?

a. 50 m b. 20 m c. 80 m d. 40 m

________46. How long will it take the ball to reach the maximum height?

a. 2.2 secs b. 1.81 secs c. 2 secs d. 1.43 secs

For numbers 47-48: Elaine shoots an arrow upward at a speed of 32 feet per second from a bridge that is 28 feet high. The height of the arrow is given by the function $h(t) = -16t^2 + 32t + 28$, where t is the time in seconds.

________47. How long does it take the arrow to reach its maximum height?

a. 1 sec b. 1.5 secs c. 2 secs d. 3 secs

________48. What is the maximum height that the arrow reaches?

a. 24 ft b. 30 ft c. 44 ft d. 32 ft

For numbers 49-50: A ball is launched from a point above the ground. The height at ground level is given by the equation $S(t) = -3t^2 + 24t$, where S(t) is the height in meters and t is the time in seconds.

________49. What maximum height it can be reach?

a. 40 m b. 35 m c. 24 m d. 48 m

________50. How long will it take to reach the maximum height?

a. 2 secs b. 4 secs c. 3 secs d. 5 secs

APPENDIX III

Observation Notes Form

Observer:____**Date:**__________________

Directions. Please give your general observations and feedback on the student's activities in the seven stages of Process-Oriented Guided Inquiry Learning.

General Observations:

Stages of Learning (Activities)	**Feedback**	**Suggestions for Improvement**
1. Elicit (Linking previous knowledge)		
2. Engage (Identify the need for learning)		
3. Explore (Exploration/Discovery)		

4. Explain (Understanding and concept formation)		
5. Elaborate (Practice of applying knowledge)		
6. Evaluate (Assessment and Reflection)		
7. Extend (Apply knowledge to new concepts)		