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Improving Students' Competencies in Parallelogram Through Activity Theory Approach

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Abstract
Aim: This study aimed to explore the effectiveness of the Activity Theory Approach in improving the performance of Grade 9 students in a public secondary school in Mauban, Quezon in learning about parallelograms. Specifically, it sought to (1) determine the students' level of academic performance based on the pre-test results before using the Activity Theory Approach, (2) determine the students' level of academic performance based on the post-test results after the intervention, and (3) establish whether there is a significant difference between the pre-test and post-test results.
Methodology: The study employed a pre-experimental, one-group pretest-posttest design. A total of 34 Grade 9 students were selected through total enumeration. A self-made multiple-choice test was used to assess the students' academic performance. Descriptive statistics, such as frequency, percentage, and mean, were used to evaluate the pre-test and post-test results, while a paired sample t-test was conducted to determine the statistical significance of the difference between scores.
Results: The study revealed that all students initially scored below 75% in all competencies. After the Activity Theory-based intervention, a notable improvement was observed, with the mean score increasing from 10.74 to 19.09. The paired sample t-test showed a statistically significant difference ($t = 18.458$, $p = 0.000$) between the pre-test and post-test scores.
Conclusion: The study concludes that the Activity Theory Approach is highly effective in enhancing students' competencies in learning about parallelograms. It is recommended that mathematics teachers adopt activity-based strategies and develop exemplar lesson plans to address students' learning gaps.
Keywords: *Activity Theory Approach, IDEA Lesson Exemplar, Parallelogram, Academic Performance, Grade 9 Mathematics*

INTRODUCTION

Mathematics is fundamental in developing critical thinking, problem-solving, and analytical skills essential for both academic success and real-world applications. However, many students, particularly in rural areas, continue to struggle with mathematical proficiency, as evidenced by both national and international assessments. The 2022 Programme for International Student Assessment (PISA) revealed that the Philippines ranked among the lowest globally in mathematics, reading, and science, with less than a quarter of Filipino students achieving basic proficiency in these subjects. Similarly, local assessment reports, such as the School Monitoring and Evaluation Plan Adjustment (SMEPA) for the third quarter of School Year 2023–2024, highlight that the concept of parallelograms is among the least learned competencies in Grade 9 mathematics. These findings underscore the urgent need for innovative, student-centered teaching approaches that can bridge learning gaps and enhance students' mathematical understanding (Pangilinan, 2025; Sanchez et al., 2023).

To address these persistent challenges, alternative pedagogical frameworks, such as Activity Theory, offer promising ways to enhance mathematics instruction. Developed from the work of Soviet psychologist Lev Vygotsky and further expanded by Alexey Leont'ev and Yrjö Engeström, Activity Theory suggests that learning is a social and

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cultural process rather than an isolated cognitive activity (Engeström, 1987). Vygotsky's sociocultural theory further emphasizes that students learn best through meaningful, collaborative activities guided by a more knowledgeable individual, whether a teacher or a peer (Vygotsky, 1978). This principle aligns with the Zone of Proximal Development (ZPD), which describes the gap between what a learner can do independently and what they can achieve with appropriate guidance and support (Wertsch, 1991). Applied to mathematics education, these principles suggest that students' understanding of complex geometric concepts, such as parallelograms, can be significantly improved through interactive, tool-mediated, and socially constructed learning experiences (Abenojar et al., 2025).

One model of instruction that aligns with Activity Theory and facilitates an organized, student-led learning process is the IDEA Lesson Exemplar formulated in response to Region IV-A DepEd Memorandum No. 296, s. 2020. The IDEA model, which stands for Introduction, Development, Engagement, and Assimilation, is designed to promote active learning and enhance conceptual understanding. During the Introduction stage, prior knowledge is activated and the lesson goals are set. The Development stage offers teacher-guided instruction, where students are introduced to new ideas in discussions and problem-solving activities. The Engagement stage enables students to work cooperatively, apply learning to real-world situations, and explore mathematical concepts through interactive activities. Lastly, the Assimilation stage strengthens learning by having students introspect about their progress, conduct peer assessments, and demonstrate mastery of the key lesson concepts (Carvajal et al., 2025).

At the Grade 9 level, learners are expected to develop higher-order thinking skills as they engage with more abstract mathematical concepts, including algebra, geometry, and data analysis. The traditional teacher-directed methods, which rely heavily on lectures, memorization, and passive learning, are insufficient in developing a strong mathematical foundation (Koskinen & Pitkäniemi, 2022). Evidence suggests that student-centered pedagogy, which emphasizes collaboration, problem-solving, and contextualized learning, significantly enhances mathematical proficiency. The IDEA Lesson Exemplar, grounded in Activity Theory, provides a systematic yet flexible framework that encourages active student participation, collaborative problem-solving, and experiential learning (Amihan & Sanchez, 2023).

This study intends to determine the efficacy of Activity Theory, blended with the IDEA Lesson Exemplar, in enhancing the competencies of students in learning parallelograms. Specifically, it seeks to identify whether the implementation of Activity Theory-driven instruction, organized within the IDEA framework, can improve the learning outcomes of Grade 9 mathematics learners. The study examined how collaborative, tool-mediated learning could enhance student motivation, engagement, and conceptual understanding of parallelograms. The findings are expected to offer evidence-based recommendations that can improve classroom practice and inform educational policy for mathematics instruction in the Philippines.

Ultimately, this research aims to provide insights into how instructional models like the Activity Theory Approach and the IDEA Lesson Exemplar can transform mathematics education. By integrating structured collaboration, interactive tools, and real-world applications, the study hopes to help students not only meet expected learning competencies but also develop the critical thinking and problem-solving skills necessary for success in an increasingly complex and interconnected world.

Objective

This study aimed to determine the effectiveness of the Activity Theory Approach in improving the academic performance of students in the identified least learned competencies in Grade 9 Mathematics.

Specifically, it sought to answer the following questions:

1. What is the level of academic performance of the students based on the pre-test results before using the Activity Theory Approach?
2. What is the level of academic performance of the students based on the post-test results after using the Activity Theory Approach?
3. Is there a significant difference between the pre-test and post-test results after using the Activity Theory Approach?

Hypothesis

Given the stated research problems, the following null hypothesis was tested at the 0.05 level of significance:

- *H0:* There is no significant difference between the academic performance of Grade 9 Mathematics students before and after using the Activity Theory Approach.

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METHODS

Research Design

This study adopted a pre-experimental research design to investigate the impact of Activity Theory-based instructional activities on the academic performance of a single group of Grade 9 Mathematics students. This design is appropriate because it allows the observation, measurement, and comparison of students' academic performance through pre-test and post-test assessments, capturing changes that occur after implementing Activity Theory-based learning activities. Pre-experimental designs, such as the one-group pretest-posttest design, are commonly used in educational research to evaluate the effectiveness of interventions in real classroom settings where randomization or control groups are not feasible (Ishtiaq, 2019; Dulay et al., 2025). Employing this design also aligns with the recommendations for classroom-based research, as it provides teachers with actionable insights into instructional practices that can bridge learning gaps in mathematics (Carvajal et al., 2025).

Population and Sampling

The study involved 34 Grade 9 Mathematics students from barrio schools in the municipality of Mauban. These students were selected because they were directly involved in the implementation of the lesson intervention, making their experiences and academic performance highly relevant to the study's objectives. The study utilized total enumeration sampling, also known as a complete census, which involves including the entire small and well-defined population rather than drawing a sample. Canonizado (2021) notes that this method minimizes sampling bias, which is critical for small class sizes.

Inclusion criteria required that the students be officially enrolled in Grade 9 Mathematics for the school year 2024–2025 and that both students and their parents/guardians provide informed consent. Respondents were aged 14–16, representing diverse backgrounds and varying academic abilities. Ethical research practices were upheld, including voluntary participation, parental consent, and strict confidentiality of student data (Calderon et al., 2024).

Instrument

The researchers employed a self-made 40-item multiple-choice test to measure students' academic performance in the topic of parallelograms. The test was aligned with the Most Essential Learning Competencies (MELCs) and covered key areas:

1. Determining the conditions that make a quadrilateral a parallelogram;
2. Using properties to find measures of angles, sides, and other quantities;
3. Proving theorems about different types of parallelograms; and
4. Solving problems involving parallelograms.

To ensure content validity, the instrument was reviewed by external validators, including a Master Teacher and a Teacher III specializing in Grade 9 Mathematics, who assessed the alignment with MELCs and accuracy of the content. Additionally, an English teacher checked the grammar, structure, and clarity of instructions for student readability.

A pilot test was conducted with Grade 9 students from a nearby school to ensure that the items were clear and functioned effectively in a real classroom setting. Minor revisions were implemented based on the pilot test results. Subsequently, the instrument underwent reliability testing using the Kuder-Richardson Formula 20 (KR-20). Reliability coefficients were 0.795 for the pre-test and 0.824 for the post-test, both within the acceptable range, indicating strong internal consistency. Item analysis, including difficulty and discrimination indices, further improved the quality of the test items (Dulay et al., 2025).

Data Collection Procedure

The research process followed several sequential steps:

1. Approval and Consent – The researchers first secured approval from the school head and other relevant authorities. Informed consent forms were distributed to students and their parents/guardians, emphasizing voluntary participation and confidentiality.
2. Pre-Test Administration – Students answered the validated pre-test to establish their baseline understanding of parallelograms.
3. Intervention – The lessons were conducted over three weeks during regular 45-minute Mathematics classes using the Activity Theory Approach integrated with the IDEA Lesson Exemplar. Students worked in small groups with rotating roles (leader, recorder, presenter, checker) to ensure equal participation. Activities

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emphasized collaboration, tool-based problem solving, and real-life applications of geometric concepts. Weekly formative quizzes were also conducted to monitor progress.

4. Post-Test Administration – After the intervention, a parallel 40-item post-test was given to assess learning gains.

This systematic process ensured that the data collected accurately reflected the students' learning trajectory, aligning with best practices for classroom-based research interventions (Carvajal et al., 2025; Dulay et al., 2025).

Treatment of Data

Descriptive statistics such as frequency, percentage, and count were used to assess the students' performance levels in the pre-test and post-test. A paired sample t-test was performed to determine whether there was a statistically significant difference between pre-test and post-test scores at $p < 0.05$. By combining descriptive and inferential statistics, the study provided a comprehensive evaluation of the intervention's effectiveness in improving academic performance in mathematics.

Ethical Considerations

The study adhered to ethical standards to ensure participant safety, privacy, and data integrity. Student identities were anonymized, and all scores were treated with strict confidentiality. Participation was voluntary, and informed consent was obtained from both students and parents/guardians. These steps ensured the protection of the participants' rights and upheld research integrity (Calderon et al., 2024; Dulay et al., 2025).

Results and Discussion

This section presents, analyzes, and interprets the study's data on determining the effectiveness of the Activity Theory Approach in enhancing the academic performance level of students in Mathematics 9. The results are analyzed in relation to the research questions and interpreted in the context of the relevant literature.

Profile of the Respondents on the Performance before the use of Activity Theory Approach

The table presents the pre-test academic performance of Grade 9 students prior to the implementation of the intervention.

Table 1. Performance of the Students Before the Use of the Activity Theory Approach

Grading Scale	Competency 1		Competency 2		Competency 3		Competency 4		Verbal Indicator
	f	%	F	%	f	%	f	%	
90 – 100	-	-	-	-	-	-	-	-	Outstanding
85 – 89	-	-	-	-	-	-	-	-	Very Satisfactory
80 – 84	-	-	-	-	-	-	-	-	Satisfactory
75 – 79	-	-	-	-	-	-	-	-	Fairly Satisfactory
Below 75	34	100	34	100	34	100	34	100	Did Not Meet Expectations
Total	**34**	**100**	**34**	**100**	**34**	**100**	**34**	**100**	

The results revealed that all 34 students scored below 75 across all four competencies. This corresponds to the descriptor "Did Not Meet Expectations," indicating that no student achieved the minimum required level of proficiency in any of the assessed areas. The uniformity of low scores across all competencies strongly points to a significant gap in prior knowledge and understanding of the students. The results also revealed deeper challenges in students' reasoning and problem-solving skills. One notable example is the item that asked: *"In a rhombus, the diagonals measure 20 cm and 48 cm. If the diagonals bisect each other at right angles, what is the length of each side of the rhombus?"* Most students answered this item incorrectly, likely due to the complexity of the problem, which demanded both recognition of geometric relationships and the application of the Pythagorean Theorem. This suggests that students not only lacked the foundational understanding of geometric properties but also found it

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difficult to apply multiple concepts in a single task, especially when it involved multi-step calculations and spatial reasoning.

This situation reflects a broader concern in mathematics education: the limitations of traditional, lecture-based teaching methods, particularly when addressing abstract and spatial topics like geometry. These methods often promote surface-level learning and may not sufficiently support students in developing the kind of deep conceptual understanding that geometry requires. As highlighted by Juman et al. (2022), many students struggle to construct diagrams, recall theorems, or apply more than one property to solve a geometric problem. These difficulties are often rooted in passive instructional approaches and show that when students are engaged through activity-based learning, their comprehension and performance significantly improve.

Pre-tests serve a critical role in identifying specific learning gaps and informing the instructional design of interventions. The results provided a clear baseline of student performance and justified the implementation of the Activity Theory Approach. This approach, combined with the IDEA Lesson Exemplar, was introduced to offer a more dynamic and engaging learning experience to help students overcome these academic challenges.

Supporting this, Yee and Tasir (2023) emphasized the value of pre-tests in identifying students' baseline understanding prior to an intervention. Their study highlighted how diagnostic assessments provide meaningful insights into learners' academic readiness and serve as a foundation for evaluating the effectiveness of instructional strategies. Like the present study, their findings underscore that pre-tests are not merely formal requirements, but essential tools for identifying learning gaps, guiding instruction, and measuring future growth.

Profile of the Respondents on the Performance after the use of Activity Theory Approach

The table presents the pre-test academic performance of Grade 9 students prior to the implementation of the intervention.

Table 2. Performance of the Students After the Use of the Activity Theory Approach

Grading Scale	Competency 1		Competency 2		Competency 3		Competency 4		Verbal Indicator
	f	%	F	%	f	%	f	%	
90 – 100	-	-	-	-	-	-	-	-	Outstanding
85 – 89	-	-	1	3	-	-	-	-	Very Satisfactory
80 – 84	1	3	-	-	-	-	7	21	Satisfactory
75 – 79	9	26	4	12	1	3	-	-	Fairly Satisfactory
Below 75	24	71	29	85	33	97	27	79	Did Not Meet Expectations
Total	**34**	**100**	**34**	**100**	**34**	**100**	**34**	**100**	

The results reveal that a significant number of students remained within the "Did Not Meet Expectations" category across all four competencies, with the highest concentrations seen in Competency 3 (97%) and Competency 2 (85%). In Competency 4, 7 students (21%) reached the "Satisfactory" level, while Competency 1 had nine students (26%) achieving "Fairly Satisfactory" performance. A few students also reached satisfactory levels in Competencies 1 and 2, although in smaller percentages.

An analysis of the specific test items revealed that students most frequently answered correctly those related to basic properties of parallelograms, particularly those involving angles, diagonals, sides, perimeter, and area. Questions such as *"In a rectangle, if one angle measures 90°, what is the measure of its consecutive angle?"* and *"In a parallelogram ABCD, if ∠A = 70°, what is the measure of ∠C?"* were generally answered correctly, as they involved direct recall of familiar concepts. Similarly, many answered correctly the item *"A rectangle has diagonals measuring 10 cm and 24 cm. What is the length of each half of the longer diagonal?"* which involved simple division and required minimal computation. These outcomes suggest that learners were able to retain and apply foundational geometric concepts that were reinforced during intervention. One possible explanation for this pattern is that students tend to do better in collaborative and guided learning environments.

This is supported by Abd Algani (2021), who found that collaborative learning helps improve students' performance in mathematics. His study showed that when students work in groups, take on specific roles, and talk

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through problems together, they often become more confident and better at understanding and solving math tasks. Compared to traditional teaching methods, collaborative learning encourages both academic success and the development of important social and thinking skills, making it a valuable approach in math instruction. For instance, during the intervention, the Activity Theory Approach emphasized collaborative group work where students were given structured roles, such as researcher, recorder, verifier, and presenter. Each role encouraged active participation, critical thinking, and accountability. The researcher explored concepts and gathered information, the recorder documented group findings, the verifier ensured accuracy and logic, and the presenter shared the group's output with the class. These roles fostered peer support and collective problem-solving, helping students construct understanding in a shared context.

In contrast, more complex items proved challenging. For example, the question *"A parallelogram has sides measuring 9 cm and 12 cm. If the longer diagonal measures 15 cm, find the length of the shorter diagonal"* was correctly answered by only a few students. This item required multi-step reasoning and a conceptual understanding of the geometric relationships between sides and diagonals. The cognitive demand of spatial reasoning, abstraction, and the application of geometric principles likely contributed to students' difficulty in solving the problem. However, during the post-test, students had to work independently, without the support of their group or the scaffolding provided by the teacher. This shift from socially mediated learning to individual performance may explain why many struggled with higher-order problems. It suggests that while students were able to engage meaningfully in group activities, they may still require further practice and support to transfer those skills into independent work.

This outcome is supported by Nikou (2024), who emphasized the value of post-assessments in evaluating instructional effectiveness. His study highlighted how post-tests serve not only to measure learning outcomes but also to assess students' ability to apply newly acquired knowledge in meaningful ways. Consistent with his findings, this study demonstrates that activity-based, student-centered instruction can contribute to the development of mathematical understanding and performance, particularly when learning environments provide support for collaboration, exploration, and structured guidance.

Difference between Pre-test and Post-test Results Using Activity Theory Approach

This final section of the chapter presents the difference between pre-test and post-test results using Activity Theory Approach. The analysis highlights the extent to which Activity Theory Approach enhance the student's academic performance in parallelogram.

Table 3. Significant Difference Between Pre-test and Post-test Results Using Activity Theory

APPROACH	Pre-test		Post-test		t	df	Sig.(2-tailed)	Verbal Interpretation
	Mean	SD	Mean	SD				
Activity Theory Approach	10.74	2.6	19.09	2.81	18.458	33	0.000	Significant

Table 3 shows that the instructional strategy used had a meaningful impact on students' learning outcomes in geometry. The result confirms that the Activity Theory Approach contributed positively to students' academic performance, particularly in their understanding and application of the properties of parallelograms. It supported students not only in developing problem-solving skills but also in building confidence and a deeper understanding of key mathematical concepts.

What sets the Activity Theory Approach apart from conventional methods is its emphasis on active participation, collaboration, and real-world application. Instead of relying solely on lectures and passive notetaking, this approach placed students at the center of the learning process. Through assigned roles, students worked together to explore mathematical ideas, solve problems, and communicate their thinking. This structure gave them a sense of responsibility and helped them engage more meaningfully with the content.

Despite these benefits, it is important to recognize that some students still struggle with more complex tasks. One possible reason is that learning in a collaborative setting does not always easily translate into independent performance. When students are supported by their peers and the teacher, they often feel more confident. However, during individual tasks, particularly those requiring multi-step reasoning or abstraction, that support is no longer present, making it more difficult for some learners to apply what they've understood.

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These findings are consistent with the research of Oribhabor (2020), who found that students taught using activity-based strategies showed significant academic improvement, especially in mathematics. His study highlighted the effectiveness of learner-centered approaches in supporting achievement. Similarly, Çelik (2018) found that sixth-grade students who engaged in hands-on and interactive lessons outperformed those taught through traditional instruction. Both studies emphasize the importance of engaging students actively in the learning process to support deeper understanding and better results. Through the IDEA Lesson Exemplar, students moved through structured phases that helped them make sense of concepts step by step. These lessons provided not only content but also context, allowing learners to experience and apply geometry in ways that made sense to them. This kind of meaningful, structured exploration likely played a key role in the academic gains observed.

Conclusion

The study revealed a noticeable improvement in students' performance after the implementation of the Activity Theory Approach. The difference in results before and after the intervention indicates that the method made a positive impact on learning. This means the hypothesis claiming no significant difference was not supported, showing that the approach effectively enhanced students' understanding of the lesson.

Recommendations

Based on the findings and conclusion of the study, the following recommendations may be considered to sustain and enhance the effectiveness of the Activity Theory approach in improving student academic performance:

1. Based on the significant improvement in students' performance, the teacher may integrate the Activity Theory Approach into mathematics instruction, especially when teaching the least mastered topics, such as parallelograms, to enhance student understanding and academic performance.
2. It may be beneficial for teachers to explore student-centered and activity-based strategies that support engagement, collaboration, and critical thinking in mathematics instruction.
3. Teachers might consider designing and using learning materials that are relevant, interactive, and connected to real-life applications to help bridge the gap between theory and practice.
4. Schools may offer professional development opportunities that support teachers in enhancing their skills in designing and delivering activity-based lessons.
5. School leaders and curriculum developers could consider supporting innovative and research-informed teaching practices to better address learning gaps in mathematics.
6. The Activity Theory Approach might also be applied to other mathematical topics or subject areas to examine its potential effectiveness and adaptability across different learning contexts.

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