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Exploring the Impact of Activity-Based Teaching on Conceptual Understanding and Procedural Skills in Algebra

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Abstract: *Understanding mathematics is crucial for students as it builds a foundation for advanced academic pursuits and cultivates essential problem-solving skills applicable to real-life situations. However, many students perceive mathematics as challenging in understanding the concepts and applying the procedures. This research explores activity-based teaching and its impact on the conceptual understanding and procedural skills of algebraic concepts, specifically laws of exponents, to Grade 7 students at Daan Taligaman Integrated Secondary School, Butuan City, Philippines. Participants underwent a pretest after the traditional teaching and a post-test after an activity-based teaching, which involved Round Robin, Damath, and Maze activities. Results indicate a significant improvement in Mean Percentage Scores (MPS) after the intervention, rising from 41.08% to 80.38% in conceptual understanding and from 34.83% to 74.13% in procedural skills. The Paired Samples t-test confirms the effectiveness of activity-based teaching, emphasizing its potential to deepen conceptual understanding and improve procedural skills in algebraic concepts, specifically laws of exponents.*

Key Words: *Activity-Based teaching, Conceptual understanding, Procedural skills, Intervention, Mean Percentage Score, Algebra.*

1. INTRODUCTION:

Mathematics is a systematic and abstract field of study that involves the exploration of patterns, structures, relationships, and quantities using symbols and numbers. It includes many areas, such as geometry, calculus, statistics, arithmetic, and algebra. It offers a foundation for thinking critically, finding solutions, and understanding the underlying ideas underpinning the world's quantitative and spatial aspects. In mathematics education, Jerome Bruner's educational philosophy aligns with the notion that true learning in mathematics involves more than mere recall of facts; it requires a profound comprehension of concepts and the underlying principles governing mathematical phenomena. He emphasized the importance of understanding concepts and knowledge of procedures aligned with the nature of mathematics as a subject involving conceptual understanding and procedural fluency (Bruner, 1960). Hence, mathematics educators continually seek innovative methodologies to enhance students' learning experience with conceptual and procedural skills. The efficiency of teaching methodologies becomes essential as educators strive to convey mathematical knowledge, especially in algebra. Algebraic proficiency is fundamental to students' mathematical literacy and cognitive development (Ferrini-Mundy, 2000; Boaler, 2008). One of the fundamental ideas of algebra, the laws of exponents, is vital to the growth of analytical and problem-solving abilities. These rules are fundamental to mathematical literacy because they are widely applied in many mathematical fields, highlighting how important it is to understand them. (Ferrini-Mundy, 2000).

Junior high school students are at a critical juncture in their academic lives, where a solid algebraic foundation will be essential to their future success. The laws of exponents, which govern the modification and simplification of equations containing powers, are a fundamental component of algebraic knowledge. Traditional methods of instruction, however, could occasionally fall short of actively involving students and encouraging a thorough comprehension of these abstract ideas. In the process, activity-based teaching and learning become apparent as an effective method that changes the traditional model of rote instruction to a more participatory and interesting approach. The activity-based teaching strongly emphasizes integrating students into practical, hands-on tasks to promote active learning. This teaching method enables students to explore, assess, and apply what they have learned to real-life situations through various tasks and experiences (Dewey, 1986). Activity-based teaching has drawn much attention in education research. Numerous studies have been conducted on its effect on student's conceptual understanding of algebraic concepts. In this study, he has shown how helpful activity-based teaching can be for students learning mathematical procedural skills.

Students' problem-solving skills and capacity to apply algebraic concepts to practical contexts are enhanced when they participate in hands-on tasks (Prince, 2004). Furthermore, much research has demonstrated that implementing activity-based teaching in algebra classes enhances student motivation and involvement by creating a stimulating learning environment that grabs students' interests and draws them in (Bonwell & Eison, 1991; Johnson, 1994).

This study explores activity-based teaching and its impact on students' understanding of algebraic concepts and procedural skills, particularly pertaining to laws of exponents, focusing on the unique setting of Daan Taligaman Integrated Secondary School (DTISS) in Butuan City, Philippines.

2. RESEARCH QUESTIONS:

This study's primary goal is to evaluate students' ability in conceptual understanding and procedural abilities associated with the laws of exponents. The specific research questions that motivate this study are the following:

1. What are the students' conceptual understanding and procedural skills in the laws of exponents before and after activity-based teaching?
2. Is there a significant difference between the student's conceptual understanding before and after activity-based teaching?
3. Is there a significant difference between the student's procedural skills before and after activity-based teaching?

The hypotheses that follow were tested at the 0.01 alpha level of significance:

$H_0{}^1$: There is no significant difference between students' conceptual understanding before and after the activity-based teaching.

$H_0{}^2$: There is no significant difference between students' procedural skills before and after the activity-based teaching.

3. MATERIALS AND METHODS:

- **Research Design:** This research study implemented a quantitative research design. Descriptive statistics, such as means and mean percentage scores (MPS), are employed to summarize and describe the main features of the data. Additionally, inferential statistics, such as paired samples t-tests, were used to measure whether there was a significant difference between students' conceptual understanding and procedural skills before and after the activity-based teaching.
- **Participants:** As its participants, the study involved Grade 7 students from Daan Taligaman Integrated Secondary School (DTISS) located in Butuan City, Philippines.
- **Data Collection:** The researchers designed a questionnaire on the Laws of Exponents, adhering to the Department of Education's Learning Competencies and utilizing a table of specifications. The questionnaire comprised a 48-point test that allocates 24 points for evaluating conceptual understanding and an additional 24 points for assessing procedural skills. Figure 1 provides a sample of test items, with Part I measuring conceptual understanding and Part II evaluating procedural skills.

PRE-TEST & POST-TEST

LAWS OF EXPONENTS

Name: _____ **Grade:** 7 **Score:** _____

Part I. Multiple Choice: Encircle the letter of the correct answer. Each correct answer is worth 2 points.

1. What is the base of the expression x^n?
   a. x b. n c. nx d. n^x
2. What is the equivalent expression of the form $x^m \cdot x^n$?
   a. x^{mn} b. $x^{m/n}$ c. x^{m+n} d. x^{m-n}
3. What is the exponent of the expression x^n?
   a. x b. n c. nx d. n^x

Part II. Solving: Simplify the following expressions. Show your complete solutions neatly and legibly. The items #1-4 are worth 3 points each and #5-6 are worth 4 points each.

1. $(-3x^3y^4)(5x^5y^6)$ 2. $\frac{30a^5b^{10}c^9}{10b^4c^{-8}d^{12}}$

Figure 1. *Sample Conceptual and Procedural Test Item*

Both the head of the DTISS school and the district coordinator for mathematics attested to the reliability and validity. This thoroughly constructed questionnaire was the instrument for both the pretest and post-test stages. Before any kind of intervention, the pretest measured students' baseline knowledge, and the post-test, given after the intervention, evaluated the effect of the teaching strategy. Permission to conduct the study was diligently acquired from the school administration, and parental consent was thoughtfully sought and obtained. The initial set of instructions was delivered using traditional methods of instruction, and the student's prior understanding of exponent-related concepts was assessed during a one-hour pretest. The researchers then implemented activity-based teaching as an intervention. This innovative method included several activities, such as Maze, Damath, and Round Robin. Round Robin encouraged small groups to work together to solve exponent-related problems, emphasizing cooperative learning. The strategic board game Damath was skillfully utilized to strengthen knowledge related to the laws of exponents. Students were given various interesting problems connected to exponents in the Maze activity, which combined problem-solving with navigational skills. After the session, a post-test was given once more to evaluate the effectiveness of activity-based teaching. The pretest and post-test scores were tabulated and consolidated to prepare for further data analysis.

4. RESULTS AND DISCUSSION:

The scores of the students in conceptual understanding and procedural skills before and after the activity-based teaching are presented through tables. The student's performance is then compared to determine if there is a significant difference between conceptual understanding and procedural skills scores before and after the intervention.

Before Activity-Based Teaching

Table 1. *Descriptive Statistics in Conceptual Understanding and Procedural Skills Scores Before Activity-Based Teaching*

	Mean	Mean Percentage Score (MPS)
Conceptual Understanding	9.86	41.08%
Procedural Skills	8.36	34.83%

The findings presented in Table 1 offer insights into the student's performance in conceptual understanding and procedural skills before implementing activity-based teaching. The conceptual understanding mean score is 9.86, a 41.08% Mean Percentage Score (MPS). Comparatively, procedural skills have a slightly lower mean score (8.36) and an MPS of 34.83%. Students demonstrated a marginally stronger grasp of conceptual understanding than procedural skills.While the scores suggest a relatively higher performance in conceptual understanding, it is essential to note that both mean scores fall below half of the total possible score. This implies that, on average, students had not yet achieved a satisfactory level of mastery in the laws of exponents before introducing the activity-based teaching intervention.

After Activity-Based Teaching:

Table 2. *Descriptive Statistics in Conceptual Understanding and Procedural Skills Scores After Activity-Based Teaching*

	Mean	Mean Percentage Score (MPS)
Conceptual Understanding	19.29	80.38%
Procedural Skills	17.79	74.13%

After activity-based teaching was implemented, scores for both procedural skills and conceptual knowledge showed a significant improvement, as shown by the data in Table 2. After the post-test, the conceptual understanding mean score rose to 19.29, resulting in a Mean Percentage Score (MPS) of 80.38%. Procedural skills similarly demonstrated an increase in mean score to 17.79 and an MPS of 74.13%. Consistent with the pretest results, students' conceptual knowledge performance was again marginally more significant than their procedural skills performance. Both mean post-test scores above the 50% threshold indicated a significant improvement in the student's comprehension

of the laws of exponents. This demonstrates how the activity-based teaching intervention has effectively contributed to students' increased comprehension and competency in exponent-related subjects.

Particular MPS statistics show a significant increase in students' conceptual understanding: 41.08% in the pretest to 80.38% in the post-test. Additionally, procedural skills improved significantly from 34.83% to 74.13%. These findings demonstrate how effectively instruction focused on activities enhances conceptual knowledge and procedural skills.

Paired Samples t-test between the Means:

Table 3. *Paired Samples T-test in Conceptual Understanding and Procedural Skills Before and After Activity-Based Teaching*

	Mean Difference (posttest-pretest)	**t-value**	**p-value**	**Decision**
Conceptual Understanding	9.43	13.93	0.00*	Reject $H_0{}^1$
Procedural Skills	9.43	26.28	0.00*	Reject $H_0{}^2$

**significant at 0.01 level of significance*

The results of the paired samples t-test, displayed in Table 3, provide sufficient proof of the impact that activity-based teaching has on students' procedural and conceptual understanding of the laws of exponents. There is an increase in the mean differences between the pretest and post-test scores, with procedural skills and understanding of concepts showing an average rise of 9.43 points. This significant improvement indicates that each student performed better on average after activity-based learning was implemented. The statistical significance indicated by the p-values of 0.00 for conceptual comprehension and procedural skills demonstrates a significant difference in the scores before and after the intervention. The statements that the activity-based teaching of instruction significantly improved the performance of students in school in the laws of exponents are supported by the rejection of the null hypotheses ($H_0{}^1$ and $H_0{}^2$).

5. CONCLUSION:

This study investigated how students' conceptual understanding and procedural skills in the laws of exponents are impacted by activity-based teaching. The quantitative analysis, including pretest and post-test assessments, paired samples t-tests, and descriptive statistics, provided valuable insights into the effectiveness of activity-based teaching. Pretest findings showed that students demonstrated a low to average knowledge level in the laws of exponents, with conceptual comprehension scoring higher than procedural skills. However, activity-based teaching produced an improvement, as seen by the significant increase in the mean scores for procedural skills and conceptual understanding. The results of the paired samples t-test, which were supported by statistically significant p-values, further highlighted the effectiveness of the activity-based teaching strategy. The positive mean differences between pre and post-test results showed the significant impact of involving students in interactive learning activities. With these results, activity-based teaching improved students' conceptual understanding and procedural skills in the laws of exponents. The results of this study align with the findings of the work conducted by Rubin et al. (2014). They concluded that engaging in activities utilizing integer models significantly enhanced students' conceptual understanding and procedural skills. Another study by Celik (2018) and Oribhabor (2020) revealed a positive rise in students' academic achievement following activity-based teaching compared to traditional teaching.

This research highlights the significance of using activity-based teaching methods, such as Damath, Round Robin, and Maze activities, to engage students in their studies. The results encourage teachers and curriculum designers to look into more innovative techniques that actively involve students in learning and promote an understanding of mathematical ideas.

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