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Addressing Students Learning Gaps in Mathematics through Differentiated Instruction

[1]Hernalyn G. Aguhayon, [2]Roselyn D. Tingson & [3]Jupeth T. Pentang

Abstract

The study aimed to determine if differentiated instruction effectively addresses learning gaps in mathematics. In particular, it explored how it can improve the student's learning gaps concerning mathematical performance and confidence. The study employed a quasi-experimental design with 30 purposively-selected Grade 10 participants divided into differentiated (n = 15) and control groups (n = 15), ensuring the utmost ethical measures. The mean and standard deviation were used to describe the participants' performance and confidence. Independent samples t-tests were used to determine the significant differences in the performance and confidence between the two groups. In contrast, dependent samples t-tests were used to determine the significant differences in each group's pre and posttest performance and confidence. Findings bared that the differentiated instruction successfully addressed students' performance in mathematics even in a short period. It also increased the participants' confidence when answering fundamental problems. Continuing differentiated instruction activities are recommended since it benefits students who struggle in mathematics, particularly in answering fundamental operations. Differentiated teaching activities in mathematics can boost academic achievement and engagement and prepare students for future success while fostering a positive and inclusive classroom culture that values individual learning needs and preferences.

Keywords: *action research, confidence, instructional intervention, mathematics education*

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About the authors:

[1]Western Philippines University, Puerto Princesa City & Tabon National High School, Quezon, Palawan, Philippines
[2]Western Philippines University, Puerto Princesa City & Madarcos Elementary School, Balabac, Palawan, Philippines
[3]Corresponding author. Western Philippines University, Puerto Princesa City & Wesleyan University - Philippines, Cabanatuan City, Philippines. Corresponding email: jupeth.pentang@wpu.edu.ph

1. Introduction

Mathematics is a critical subject taught in elementary and secondary education that provides students with fundamental knowledge and skills to organize their lives (Ariyanti & Santoso, 2020). Unfortunately, the COVID-19 pandemic has exacerbated the current education crisis and widened the learning gap in mathematics among young students (Sooknanan & Seemungal, 2023). The situation has led to a decline in math learning, as students may need more remediation to progress to new lessons, leading to learning gaps (Torres, 2021). However, schools and teachers take steps to address this issue, such as implementing differentiated instruction, providing additional support to struggling students, and leveraging technology to facilitate remote learning. Despite the challenges, it is essential to prioritize efforts to close the learning gap in mathematics, ensuring that the students have the knowledge and understanding for their academic and future careers.

Differentiated instruction is a strategy that can effectively meet the diverse needs of all students, leading to improved student achievement (Parsons et al., 2018; Valiandes & Neophytou, 2018). This approach considers learners' unique strengths and differences in today's classrooms and provides them with hands-on learning opportunities (Civitillo et al., 2016). When teaching mathematics, differentiated instruction promotes greater student engagement and interaction among classmates (Mbugua & Muthomi, 2014). However, successfully implementing differentiated instruction is crucial to achieving the intended results (Deunk et al., 2018). Additionally, since differentiated lessons are organized from fundamental to complex competencies, it is essential to ensure learners have a firm grasp of fundamental skills before moving on to more advanced competencies. Failure to do so may create learning gaps that hinder students' ability to master new skills and concepts in future lessons (Torres, 2021). Despite these challenges, differentiated instruction remains valuable for improving student outcomes in mathematics and other subjects.

Mathematics plays a crucial role in developing students' logical thinking skills. To promote effective mathematical learning, teachers must consider various factors, including students' confidence in mathematics (Azucena et al., 2022; Kunhertanti & Santosa, 2018). However, capturing the necessary type of confidence in mathematics is challenging, as students' overall assessments of their confidence in mathematics or specific topics within the mathematics curriculum may not accurately reflect their actual confidence (Foster, 2016).

Many recent studies on children's mathematics success have focused on self-confidence, which is considered one of the most critical psychosocial factors affecting student performance (Hosein & Harle, 2018; Çiftçi & Yıldız, 2019). Before the pandemic, the Philippines faced challenges in mathematics education and ranked lowest in international assessments (San Juan, 2019). In the PISA 2018 International Report, Filipino students' average score in mathematical literacy was 353 points, significantly lower than the Organization for Economic Cooperation and Development (OECD) average of 489 points, indicating a below Level 1 proficiency (OECD, 2019). The Philippines also scored 297 in math in the 2019 Trends in International Mathematics and Science Study (TIMSS) by the International Association for the Evaluation of Educational Achievement (Mullis et al., 2019). It is necessary to deal with the problem of students' confidence in mathematics and develop effective strategies to enhance mathematics education in the Philippines.

By doing so, students can better develop their mathematical thinking and problem-solving skills, leading to improved performance in mathematics and other academic areas. Tabon National High School was founded in 2016, and the mean average from the start ranged from 82 to 85 percent before the pandemic. The mean average during the pandemic for the last two years was 84 percent. Students need help to answer their modules, but because modular distance learning was used, students can seek assistance from their parents or relatives while answering or browsing the internet. When there is a pilot test for face-to-face classes for the last month before the school year ends last S.Y. 2021-2022. During the one-month pilot testing, teachers worried about their interest in a particular topic. They need help remembering what lessons they have studied in their module. They cannot even grasp and recall their homework, but the school ensures their learning. Teachers are fully aware of the decline in education that has occurred to them when classes resume for the school year 2022-2023. Because of the pandemic, all students' learning gaps widened. Their learning gaps were most noticeable in mathematics, where most needed help solving integer-base problems or equations. Nevertheless, it can be addressed through an intervention (Azucena et al., 2022; Pentang et al., 2020; Pentang, 2021).

The school sought more interventions to bridge the gap and achieve students' learning outcomes, especially during the transition to face-to-face classes. The priorities and action steps include expanding the implementation of limited face-to-face classes, identifying

learning gaps, and profiling and clustering learners based on learning needs. Developing learning time is one of the strategies to address learning gaps and accelerate learning (Suprayogi, 2017). Other instructional strategies, such as peer tutoring, problem-based learning, and gaming, may be used in differentiated instruction (Altemueller & Lindquist, 2017; Smale-Jacobse et al., 2019). Differentiated instruction was chosen to help students recover quickly, bridge learning gaps, and improve academic performance. The confidence was added to understand the level of difficulty that they have while answering. Differentiated instruction was used because teachers knew how capable those students were; their potential could not be ignored. Even though 90 percent of the population is indigenous, they are potentially good academically. Due to several factors, including the pandemic, learning losses have grown and must be addressed. As a result, tailored interventions have been created to help students overcome the learners' academic difficulties and confidence in mathematics.

The study determined if the differentiated instruction intervention effectively addresses learning gaps in mathematics for Grade 10 students. The following null hypotheses were tested:

1. There is no significant difference in the pretest and posttest scores between the differentiated instruction group and the control group for Grade 10 students in mathematics.
2. There is no significant difference in the pretest and posttest scores within both the differentiated instruction group and the control group of Grade 10 students in mathematics.
3. There is no significant difference in confidence levels between the differentiated instruction group and the control group of Grade 10 students in mathematics.

2. Literature Review

2.1. Level of Mathematics Achievement

Mathematics is believed as the foundation of scientific-technological information, precisely dynamic in the economic growth of a nation. The most critical component relates to an individual's success (Tomlinson, 2014), yet, learners' achievement in mathematics has been declining over the years, as the results released by PISA and TIMMS (OECD, 2019; Mullis et

al., 2019). This has been attributed to many circumstances similar to insufficient teaching and learning facilities, learners' weak demeanor toward mathematics and student incompetence to relate and comprehend the problem in the time assigned to finish the task (Van Geel et al., 2019). Shifting from traditional instruction practices, mathematics educators share an idea of what methods are more practical to address the issue, like the constructivist approach, mastery learning, and systematic approaches. Studies have shown Filipino students' poor or unsatisfactory performance in mathematics (Azucena et al., 2022; Capuno et al., 2019; Pentang et al., 2020). Additionally, the National Achievement Test mean percentage score in Mathematics was below the standards (DepEd, 2019). The students' mathematics underachievement can be attributed to the COVID-19 pandemic, affecting both teachers and students. This study tried to address these concerns at Tabon National High School by employing differentiated instruction.

2.2. Differentiated Instruction in Mathematics

Different creative instruction techniques in the way that differentiated instruction are used to raise mathematics achievement (Kyriakides et al., 2018; Schleicher, 2016; UNESCO, 2017). Differentiation entails tailoring instruction to address the needs of each individual, where teachers have made a difference in subject matter, procedures, outputs, and student experience (Wilkinson & Penney, 2014; Smale-Jacobse et al., 2019). The idea behind differentiated instruction is that educational strategies should change and be tailored to the unique needs of each student in a classroom instead of expecting students to modify themselves for the curriculum (Roy et al., 2013; Tomlinson, 2014; Tomlinson, 2015). The differentiated instruction model calls for teachers to adapt and be flexible in teaching methods, curriculum, and informational delivery to learners (Mbugua & Muthomi, 2014).

The quality of differentiated instruction provided by the teacher and the systematic use of differentiated instruction methods in mixed-ability classrooms in promoting equity, optimizing quality, and teaching effectiveness significantly impact students' achievement (Peteros et al., 2020). With the implementation of the K-12 mathematics curriculum by the Department of Education, educators have created primary learning objectives for all students to help them think critically, logically, and positively; since differentiated instruction is planned and deliberated to enhance students' mathematics understanding and learning to improve their critical thinking skills (Bhagat et al., 2016; Janssen et al., 2015; Schmid & Petko,

2019; Tomlinson, 2014). This study has looked at the effects of differentiated instruction on learners' success in mathematics to close the learning gap, particularly with their performance and confidence. While there have been some studies on differentiated instruction in mathematics, more research is needed to explore the strategies and approaches used in differentiated instruction that are most effective for improving mathematical achievement specific to the locale of the study.

3. Methodology

3.1. Research Design

This research employed a quantitative research design, particularly the quasi-experimental design. This allowed the researchers to use a non-random selection of the participants from the total population and did not require random assignment of individual cases for the comparison of the outcomes of the pre-and posttest for the participants exposed to differentiated instruction and those not exposed to differentiated instruction (Mbugua & Muthomi, 2014).

3.2. Participants and Sampling Techniques

The study employed a purposive non-random sampling method to select 30 Grade 10 students from Tabon National High School based on their low academic performance in mathematics from the previous grading periods, specifically in the class of two teachers. Then, participants were divided into two groups: the experimental group (15 students) who received differentiated instruction and the control group (15 students) who did not receive differentiated instruction.

The participants were chosen based on specific criteria, which in this case was their low academic performance in mathematics. The purposive non-random sampling method allowed the intentional selection of participants who met the study's requirements, ensuring that the results accurately reflected the effects of the intervention on the targeted group. Additionally, the study divided participants into experimental and control groups to compare the effectiveness of differentiated instruction to traditional instruction, allowing for a precise evaluation of the intervention's impact.

3.3. Data Gathering Procedures

The researchers sent and secured an approval request letter and consent from the public school district supervisor, school heads, parents, and teachers concerned, as well as the participants' participation and cooperation. To maintain anonymity, the names of the participants were kept unknown throughout the study. In addition, all participants were made aware of the study's objectives. Data was collected in eight weeks, from November 4, 2022, to December 9, 2022.

Following Cabigao (2021), the researchers identified learning gaps in the participants' pretest scores during the first week of the studies. From the date the data was acquired, the researchers conceptualized and crafted materials for the intervention during the second week. The intervention was implemented using differentiated instruction such as:

Math hunting - a powerful way to facilitate independent and small-group learning. It aims to let the students use the mini-library to find essential mathematical words and examples related to their topic based on their prior knowledge.

Peer learning - the practice of students learning from and with one another. Activities for teaching and learning like student-led workshops, study groups, peer-to-peer learning partnerships, and group work are typically used to facilitate them.

Small group discussion - a student-centered methodology that enables students to actively participate and be partners in the teaching and learning process Students discuss and exchange ideas while interacting with professors and their peers. They can foster collective consensus, as well as play specific games.

Board work - Teachers can quickly assist students in learning by maintaining appropriate study habits. Making a clear record of the topic and the language learned on the board during the class will assist them in studying and recalling the lesson's language.

Bingo card games - allow students to choose different types of problems they prefer to have answered. Students in this strategy receive an extra point for each correct answer, giving them an additional opportunity to gain points if incorrect, helping to motivate learners, improve their strategic and problem-solving abilities, or increase their computational fluency. The third through sixth weeks of the study and the seventh and eighth weeks are the most important.

Culmination - students get to integrate the knowledge and experience they have acquired during their master's program of study during the culminating activity. Students will demonstrate their knowledge's depth and breadth in their primary emphasis area of study.

The results were compared between the participants' performance levels before and after the intervention's implementation phase to determine the improvement level they gained.

3.4. Research Instrument

The researchers used an adapted pretest and posttest from the published article by Foster (2016) to categorize the personal information and school details of the participants and determine their scores in the pretest and posttest through quizzes, with a Likert rating scale to determine the level of confidence of the participants, ranging from 0 to 5, to indicate how sure the participants were of their answer. On the scale, 0 is "completely unsure", and 5 is "completely certain." The test question consists of ten items requiring the use of directed numbers to calculate (positive and negative numbers, as well as zero). Since led numbers are covered in competency for students of various grade levels, it was thought that a helpful connection could be formed between mathematics and the student's responses. The researcher altered the test question from ten to twenty items to be more relevant to the participant's level of needs and difficulty. It sought to comprehend and identify how participants responded to each item to determine the most appropriate differentiated instruction.

3.5. Data Analysis

The collected data were screened and tabulated using M.S. Excel to ensure validity. Preliminary checks such as normality (using Shapiro-Wilk) and homogeneity (using Levene's) were also conducted to ensure no assumption violations. The data is normally distributed ($p > .05$), and the variances are equal ($p > .05$). Arithmetic mean, and standard deviation was employed for the participants' pretest and posttest performance and confidence in mathematics. Independent samples t-tests were computed to determine significant mathematical performance and confidence differences between the differentiated and control groups. On the other hand, dependent samples t-tests were calculated to determine significant differences between the participants' pretest and posttest performance and confidence. The test

of difference was conducted at a .05 level of significance. All descriptive and inferential statistics were calculated using jamovi software.

3.6. Research Ethics

The study followed ethical protocol by requesting consent from the school administration and the parents of the students since the study involved minors. A consent form was also provided to the students, which outlined the study's details and allowed them to participate. By doing this, the study ensured informed consent from all parties involved. The study also ensured the confidentiality and anonymity of the participants by not disclosing their personal information and school details to any third party. This is an essential ethical consideration in research studies as it protects the privacy and confidentiality of the participants.

Lastly, the study used purposive criterion sampling, a non-random sampling technique that involves selecting participants based on specific criteria. This type of sampling allows selection of participants most likely to provide relevant information for the study. Using this sampling technique, the study could make solid statistical inferences about the entire group since selected participants met specific criteria. However, it is essential to note that the study's results may not be generalizable to the entire population, as purposive criterion sampling does not involve random selection.

4. Findings and Discussion

4.1. Pretest Performance of the Control and Differentiated Group

Table 1

Pretest Performance of the Control Group and Differentiated Group

Pretest Performance	Mean	SD	t-value	p-value	Interpretation
Control Group	6.47	2.17	-1.18	.250	No Significant Difference
Differentiated Group	7.93	4.32			

No statistical differences were found in the pretest performance of the two groups (Table 1). The result shows that the control (6.47 ∓ 2.17) and differentiated (7.93 ∓ 4.32) groups statistically had the same mathematics performance ($t_{28} = -1.18$, $p > .05$). These two groups qualified to participate in the quasi-experimental study. As expected, these students have low

mathematics performance with the learning gaps brought about by the COVID-19 pandemic. This confirms Mahdy (2020) that the COVID-19 pandemic affected students' academic performance, yet it is opposite to Spitzer et al. (2021), where students increased their mathematics performance during the pandemic. The result also revealed that students have difficulty answering fundamental mathematics problems, manifesting a need for an intervention to address their learning gaps and increase their academic performance and confidence. Consistent with Pentang et al. (2020), an intervention must be done to address these gaps in mathematics emerging among students.

4.2. Posttest Performance of the Control and Differentiated Group

Table 2

Posttest Performance of the Control and Differentiated group

Posttest Performance	Mean	SD	t-value	p-value	Interpretation
Control Group	7.33	2.69	-8.87	.001	Significant Difference Exist
Differentiated Group	17.00	2.78			

The posttest performance between the control and differentiated groups showed a statistical difference (Table 2). The findings reveal a highly significant difference between the control (7.33 ∓ 2.69) and differentiated (17.00 ∓ 2.78) groups ($t_{28} = -8.87$, $p < .01$). The differentiated instruction dramatically impacts students' performances, where the students who received the intervention performed better in mathematics. The intervention program improved the mathematics performance of the differentiated group in a relatively short period. This means that the length of an intervention program does not necessarily entail one's improved performance. This is consistent with Azucena et al. (2022), where instructional intervention can effectively address students' mathematics performance. In a recent study by Valiandes (2015), compared to children in classes where differentiated instruction methods were used, it was discovered that students made higher progress in classrooms where differentiated instruction methods were used consistently.

4.3. Pre-and Posttest Performance of the Control Group

Table 3

Pre-and Posttest Performance of the Control Group

Control group	Mean	SD	t-value	p-value	Interpretation
Pretest	6.47	2.17	-2.23	.043	Significant Difference Exist
Posttest	7.33	2.69			

The data revealed that the pretest (6.47∓2.17) and posttest (7.33∓2.69) performance of the control group have a significant difference, $t_{14} = -2.23$, $p < .05$ (Table 3). The data shows that even without the intervention, students can perform well in answering mathematics problems, which supports the findings of Azucena et al. (2022) and Udofia and Uko (2018). The performance gap is not as large as in the other group that received differentiated instruction. However, it is still significantly lower than the performance of the differentiated group. The students may have employed other approaches independently despite not being exposed to an intervention. As Pentang et al. (2020) averred, any method can aid students in learning mathematics.

4.4. Pre-and Posttest Performance of the Differentiated Group

Table 4

Pre-and Posttest Performance of the Differentiated Group

Differentiated Group	Mean	SD	t-value	p-value	Interpretation
Pretest	7.93	4.32	-10.7	.001	Significant Difference Exist
Posttest	16.20	2.78			

Table 4 displays that the pretest (7.93∓4.32) and posttest (16.20∓2.78) scores of the differentiated group were statistically different ($t_{14} = -10.7$, $p < .01$). The result indicates that the intervention program significantly improved the learner's mathematics achievement, consistent to Azizah et al. (2021), Azucena et al. (2022), and Pentang (2021). The intervention through differentiated instruction was an effective measure to help students develop and improve their mathematical performance, which the school can retain. Still, further innovation can be made to reach excellent math qualities that are deemed among the students. The teachers concerned must understand the other factors that contributed to the student's improved performance must be conducted.

4.5. Confidence of the Differentiated Group

Table 5

Pre-and Posttest Confidence of the Differentiated Group

Differentiated Group	Mean	SD	t-value	p-value	Interpretation
Pretest	1.51	.40	-9.43	.001	Significant Difference Exist
Posttest	3.27	.75			

Differentiated instruction has a significant impact on students' academic performance. It also boosts the students' confidence in mathematics. As reflected in Table 5, the mathematics confidence of the students before (1.51∓.40) and after (3.27∓.75) is statistically different (t_{14} = -9.43, $p < .01$). The findings show that students become more confident after attending differentiated instruction, coinciding with Azucena et al. (2022), Cabigao (2020), Foster (2016), and Torres (2021). Addressing students' learning gaps was successfully achieved using differentiated instruction, even in a short period. It also increased the students' confidence in answering mathematics problems. Still, further research must be conducted to verify these results.

5. Conclusion

Based on the study's findings, differentiated instruction effectively closes students' mathematical learning gaps, particularly when tackling integer-related issues. This teaching approach allows educators to tailor their instruction to meet the individual needs of each student, taking into account their unique learning styles and abilities. Through the implementation of differentiated instruction, students in the intervention group were found to outperform the control group regarding math proficiency and self-assurance. This is likely since students in the differentiated group were able to receive instruction that was specifically targeted to their learning needs and styles, allowing them to engage more fully with the material and develop a deeper understanding of the concepts being taught.

In addition to improving math proficiency, differentiated instruction also increased student confidence when it came to solving integer mathematics problems. Students who had previously struggled with these problems were now more willing to participate in class and take on challenging math tasks, thanks to the additional confidence they had gained through the differentiated instruction approach. From a teacher's perspective, differentiated instruction can be a powerful tool for achieving goals and objectives in the classroom. By tailoring instruction to meet each student's unique needs, educators can better engage their students and promote a deeper understanding of the material.

Finally, it is essential to note that student confidence is a critical predictor of mathematics achievement. Research has shown that students who feel confident in their mathematical abilities are likelier to succeed in math courses, while those who lack confidence

may struggle to keep up. As such, differentiated instruction can play an essential role in helping to close the achievement gap in mathematics by providing targeted support to those students who may be struggling and boosting their confidence in the learning process.

6. Recommendation

The school has the opportunity to enhance the teaching and learning process by providing professional development training, seminars, and workshops for teachers in differentiated instruction. It is crucial to encourage and support teachers to implement differentiated instruction frequently to improve higher-order thinking skills in students, which can be achieved by exposing them to more complex problems. Teachers must focus on strategies that promote knowledge acquisition and content mastery to facilitate effective teaching and learning. It is recommended to design activities that cover various levels of Bloom's Taxonomy, a system of thinking skills that range from lower-order to higher-order thinking. Teachers can help students effectively understand the lesson's content by utilizing this framework. Both physical and psychological factors must be considered to create optimal learning conditions. A versatile classroom layout with different seating arrangements should be incorporated to support individual and group work. Teachers must also use effective classroom discipline techniques that promote a positive and safe learning environment from a psychological standpoint. Future researchers can benefit from this study's research findings and results, but they must consider the study's limitations and allocate sufficient time for their research to obtain more comprehensive results. The action plan below is recommended to facilitate the teachers in implementing a sustainable differentiated instruction program for students who struggle with mathematics.

6.1. Activities

Addressing students learning gaps in mathematics through sustainable differentiated instruction.

6.2. Objectives

1. To address students' learning gaps in mathematics using varied teaching and learning strategies to address students' learning gaps in mathematics using differentiated instruction.
2. To improve students' academic performance and boost their mathematical

confidence.

3. To aid and comprehend the program's effectiveness in the teaching and learning process in implementing the "Adopt a School Program".
4. To improve the school's performance on a school-mean achievement test and school average in math

6.3. Date of Implementation

Differentiated instruction will be implemented during mathematics class sessions, every new topic or lesson, and when necessary.

6.4. Persons Involve

Subject teachers, students, school heads, stakeholders (internal and external), and resource persons will work together to attain the aims of the intervention.

6.5. Budget Allocation

Funds needed for the program must be covered from the government-allocated fund for public elementary and secondary schools or any outsourcing fund, as well as donations from parents and stakeholders to provide the materials needed for the session.

6.6. Expected Output

1. Students have improved their performance in mathematics, evident through their class academic standing.
2. The students have shown confidence in dealing with their math subjects and are ready for STEM-related activities.

6.7. Future Directions

1. Continuous monitoring and evaluation of the intervention program will be conducted quarterly. Pre- and posttest will be utilized with focus-grouped discussion with the learners regarding their experience.
2. Impact assessments will be conducted yearly. Longitudinal studies will be proposed to capture the program's short- and long-term impact.

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