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Enhancing students' academic performance by making the mathematics learning experience meaningful through differentiated instruction

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ABSTRACT

Despite the great effort of mathematics teachers, many students felt that the mathematics experience needed to be more meaningful. So, differentiated instruction (DI) was implemented for two months to promote meaningful learning experiences. DI is a philosophy that caters to student diversity by providing various learning opportunities. This study was practical action research following the plan-do-study-act model aiming to enhance students' mathematical academic performance. The participants, composed of two hundred fifty-two grade 11 students from the academic track, voluntarily participated. Data collection tools such as test material, questionnaires, and interview guides were used and validated by experts. Test scores, responses from questionnaires, and interviews were considered evidence of meaningful learning experience. Quantitative data are analyzed statistically using median, inter-quartile range, Wilcoxon rank-sum test, and rank biserial, while thematic analysis was used for qualitative data. Findings revealed that DI strategies enhance the student's academic performance in examinations. Before DI, students were less engaged in math activities, could not connect prior knowledge to the new lesson, and treated math as a complex subject. However, it turned up during the DI implementation. DI made the learning experience meaningful by connecting prior knowledge with new learning and applying it in real-life situations. DI in mathematics classes improved the student's academic performance through a meaningful learning experience catering to student diversity. Making an enjoyable learning experience while focusing on concept development guaranteed the effectiveness of DI strategies like open questions, parallel tasks, and technology integration.

Keywords: academic performance, action research, differentiated instruction, experience, mathematics learning

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INTRODUCTION

Educational policy around the world includes inclusion, which means schools must cater to the diverse learning needs of students in classrooms (Westwood, 2018). An important aspect of inclusion is the implementation of differentiated instruction (DI) to foster more inclusive educational practices (Smets et al., 2020). The National Council of Teachers of Mathematics generally promotes using DI in teaching by considering student differences among students and prioritizing their interests, readiness, and learning preferences to ensure a thorough understanding of mathematics lessons (Smith et al., 2018).

In the Philippine context, the K-12 curriculum pedagogical approaches, as stated in Republic Act No. 10533 (2013), include constructivist, collaborative, differentiated, inquiry-based, integrative, and reflective. The curriculum mandates the use of DI as a pedagogical approach. Each basic education school must recognize its students' uniqueness, necessitating different instructional methods that consider student diversity. The teachers must cater to student diversity by establishing a learning environment that accommodates the needs of different students, making the learning experience meaningful and relevant (Department of Education [DepEd], 2016). To promote student diversity and meaningful learning experiences, teachers who wish to build a class harmoniously must modify their teaching strategies. As stated in the DepEd (2023) MATATAG agenda, teachers must prioritize their students' welfare, encourage inclusive education, and cultivate a conducive learning environment, which can be achieved by utilizing DI strategies to support the students' diverse learning needs.

Hence, the Philippine DepEd mandates that teachers employ DI to support students' varying learning abilities and needs. The DepEd has suggested implementing DI in lesson preparation to make learning more relevant and meaningful to the learners (Luistro, 2016). Teachers must modify teaching based on their students' varying levels of intelligence and learning preferences to make the learning experience meaningful (DepEd, 2019).

On the other hand, the San Pedro Relocation Center National High School, a public institution, started to offer the senior high school Program in 2012. The available academic strands are humanities and social sciences (HUMSS) and science, technology, engineering, and mathematics (STEM). The students from the said strands are expected to excel in mathematics. Nonetheless, these students need support in their math classes and a heightened level of involvement in mathematical concepts. They have various learning styles and individual characteristics that contribute to learning performance. They need motivation and passion to exert more effort. Unfortunately, the said students perform poorly in academic examinations, as seen from the previous grading period. They got a mean of 18.32 for HUMSS and 20.22 for STEM, which caught the teacher's attention. Furthermore, despite students being under academic strands, they show low interest in mathematics subjects. Hence, they found mathematics unmeaningful to their lives. Therefore, DI strategies are integrated by the mathematics teacher.

Consequently, the first grading periodical test results indicated that students enrolled in HUMSS and STEM failed to meet the 75% mean percentage threshold. This finding captured the interest of mathematics teachers. Therefore, mathematics teachers conduct research utilizing DI strategies to enhance students' academic performance by making learning meaningful through DI. By resolving this concern, DI will directly enhance students' academic performance, yielding good school performance.

LITERATURE REVIEW

Research indicates that DI improves student academic performance and school success compared to traditional teaching approaches (Awofala & Lawani, 2020; Chen & Chen, 2018; Sapan & Mede, 2022; Valiandes & Neophytou, 2018). The benefits of the DI are based on the premise that a high-quality education is accessible to every student via varied learning opportunities provided by the teacher. DI helps struggling students perform better by discovering their strengths and distinct learning styles in a diversified classroom context. Yavuz (2020) found that students regard DI as an enjoyable, engaging, and intriguing teaching technique.

A distinguishing feature of DI is teaching preparation based on student interests, learning profiles, and readiness to meet each student's particular learning needs (Aysin & Serap, 2017; Özer & Yilmaz, 2018). However, regardless of individual differences, students are expected to participate in learning concepts, principles, and skills under the supervision of their teachers (Awofala & Lawani, 2020). When teachers fail to consider individual differences, mathematics learning will suffer in mathematics education. The teachers can tailor numerous learning activities, materials, content, and evaluation approaches to each student's specific learning needs. This implies that the teacher should provide each student with learning opportunities to select what interests them the most while learning.

It is vital to explore how teachers differentiate their teaching practices to accommodate student diversity and make learning meaningful (Prast et al., 2018). Thus, applying DI in the post-epidemic period is crucial to enhance student performance since the students have learning gaps that must be addressed. Pozas et al. (2020) discovered that advanced secondary school teachers use DI methods less frequently due to their high workloads and lack of time for preparation. Due to the present situation, senior high schools must implement DI despite teachers' enormous workloads by practicing time management and trying to address diversity in the classroom.

Morallos (2018) discovered that using DI helps students perform better in math examinations and allows them to answer open-ended questions. DI transformed disengaged students into math voyagers, creating a motivating learning atmosphere in the classroom. Similarly, Geel et al. (2022) found that DI is the most often employed and successful strategy to assist students in developing their mathematical ability. The implementation of DI enhanced the appeal of the class, alleviated stress, and fostered collaboration among students, which made the lesson enjoyable (Awofala & Lawani, 2020). DI improves self-confidence, motivation to learn, and problem-solving ability, leading to better outcomes in mathematics education (Lai et al., 2020). Moreover, DI improves students' learning by giving them choices and a better learning climate (Goddard et al., 2019). Also, DI creates meaningful learning and increases student performance (Bulley-Simpson, 2018).

Educational institutions worldwide employ DI (Suprayogi & Valcke, 2016). However, little empirical study has yet to be conducted on how advanced secondary school teachers apply DI techniques effectively (Pozas et al., 2020). Surprisingly, there are few studies on the effectiveness of DI in secondary schools, and more studies are needed to investigate DI in secondary schools (Smale-Jacobse et al., 2019). Much research has been conducted on adopting DI in mathematics for elementary school pupils (Ismajli & Imami-Morina, 2018; Prast et al., 2018). Unfortunately, there has been very little research on DI in senior high school, particularly in mathematics. Therefore, the present study employed DI in senior high school students in mathematics classes to enhance students' academic performance by making the mathematics learning experience meaningful through various strategies like prior knowledge assessment, open questions, parallel tasks, and technological tool integration, which were not found in the previous studies. Previous studies focused on a single DI strategy to improve examination results (Awofala & Lawani, 2020; Bulley-Simpson, 2018; Morallos; 2018), teachers' practices (Geel et al., 2022; Pozas et al., 2020; Valiandes & Neophytou, 2018), and student diversity (Bondie & Dahnke, 2019; Qorib, 2024).

THEORETICAL AND CONCEPTUAL FRAMEWORK

DI is based on sociocultural theory (Miller, 2011; Seifert & Sutton, 2011, as cited in Ginja & Chen, 2020). Sociocultural learning theory posits that the learning experience is vital and influences the students' learning process. The social-cultural interaction between the students and teachers develops cognition that also requires the DI (Ginja & Chen, 2020). So, the learning experience must be designed to be relevant and exciting to the students, yielding better student achievement. Therefore, the teacher must consider the students' various learning experiences and needs to differentiate the lesson (Brevik et al., 2018).

Also, the meaningful learning theory of Ausubel (2000) claims that the student's prior knowledge is the starting point that influences learning (Agra et al., 2019). So, assessing students' prior knowledge was one DI strategy that built a meaningful learning experience. Unraveling the student's existing knowledge entailed identifying their

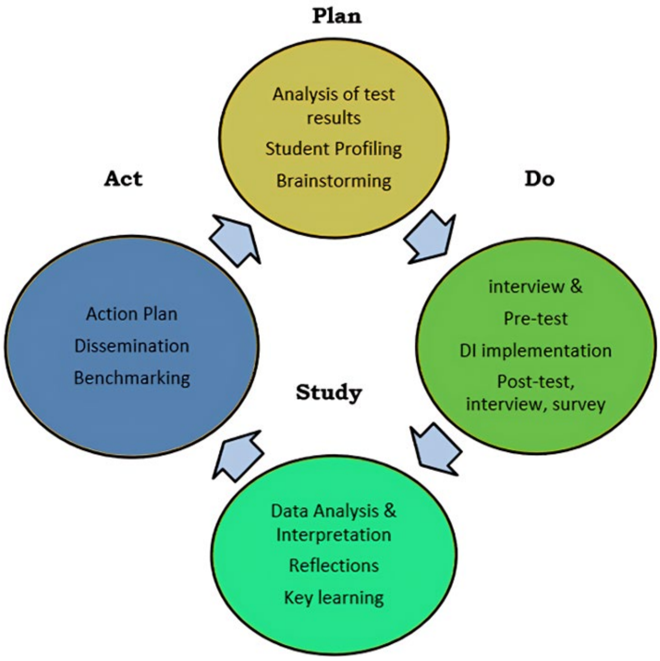

Figure 1. PDSA framework of the study (Source: Authors)

representations, thoughts, and ideas and how they express themselves physically, emotionally, and cognitively. However, most previous studies on meaningful learning used adult learning and non-formal education context but not formal schooling (Kostiainen et al., 2018).

Meaningful learning is a highly effective approach in formal education, characterized by the purposeful and direct integration of new information with existing knowledge that is relevant and applicable (Ausubel, 1963, as cited in Agra et al., 2019). Meaningful learning enhances students' comprehension and understanding of the subject matter, wherein they can apply their learning in daily activities (Harianto et al., 2019). The student's prior knowledge was linked with the newly acquired knowledge and applied to real-life situations, making the learning experience meaningful. The students must establish connections between new information and pertinent concepts that they are already familiar with. The acquisition of new knowledge necessitates the active engagement and integration of the learner's existing knowledge framework.

However, the teacher's ability to implement meaningful learning enriched the student's educational experience. So, teachers must tailor a practical approach to make the learning more relevant by considering students' characteristics and backgrounds, particularly in mathematics. Hence, DI is a pedagogical strategy that facilitates students' meaningful comprehension of complex and abstract mathematical concepts and promotes meaningful learning (Awofala & Lawani, 2020).

Meaningful learning experience is characterized by the construction of meaning by the students, engagement of students in various activities with active interaction, linking prior knowledge to new ones, and making good work relations with others (Kostiainen et al., 2018). Heddy et al. (2016) claim that meaningful learning transfers classroom learning into daily activities and engaging activities relevant to student's life. So, meaningful learning experiences made the learning relevant to the student's lives through various activities and classroom experiences provided by the teacher.

The study adopts the plan-do-study-act (PDSA) model for the action research of Edward Deming and Walter Shewhart (Kazzaz, 2023), as shown in **Figure 1**. The PDSA cycle requires implementing the proposed solutions (plan), executing them (do), analyzing the outcomes (study), and subsequently acting based on the acquired knowledge (act) (Worten, 2021). The model encompasses a methodical sequence of acquiring vital knowledge to enhance educational practices (Sagun & Prudente, 2021). Under the stage of plan, test results manifest the student's poor academic performance, which caught the teacher's attention. So, student profiling determines the learning styles, interests, and profiles. Also, brainstorming with the co-teacher is conducted on how to make mathematics learning meaningful through DI strategies and preparation for the learning materials.

In the do stage, interviews and pre-survey are conducted to elicit initial data regarding the students' mathematics learning. Then, a pre-test is administered to measure prior knowledge, and the results are kept for future comparison. The DI strategies have been implemented for two months. After that, a post-test, a post-survey, and an interview will be conducted. Data are analyzed and interpreted during the study stage following the reflections and key learnings. Then, the action plan, dissemination, and utilization plan are crafted for possible benchmarking.

The study uses varied DI strategies to deliver the lessons, such as prior knowledge assessment, open questions, parallel tasks, and technological tool integration. Tomlinson (2014), a proponent of DI, is the first to implement DI practices in mixed-ability classrooms. According to DepEd (2019), DI-based lessons are tailored to students' interests, readiness, and learning preferences. The DI-based lessons are implemented using review/drill to assess the student's readiness, open questions for motivation, a parallel task for a group activity, open questions for practice, and various performance task options with technology integration. The DI principles suggest that big ideas must be taught, choices must be provided, and regular prior assessments must be practiced (Small, 2020). Providing students with options motivates students to be involved in the learning process and produces meaningful learning experiences (Hapsari et al., 2018).

Research Questions

This study is intended to enhance the students' academic performance in examinations by making mathematics learning experiences meaningful through DI.

Specifically, it intended to light up the following questions:

1. How can the students' mathematical academic performance be described regarding pre- and post-test scores?
2. Does DI effectively improve student mathematical academic performance based on the student's pre- and post-test scores?
3. How is the learning experience described before and during the DI implementation?
4. In what ways can DI make the learning experience meaningful?
5. What are the students' suggestions to make the mathematical learning experience more meaningful for them?

METHODOLOGY

Research Design

The study's design was practical action research to enhance students' mathematical academic performance by making the learning experience meaningful through DI. Only some studies used action research for DI implementation because many used case study design (Bondie & Dahnke, 2019), so action research was timely to use to investigate the effectiveness of DI. The study utilized the pre- and post-test design to determine the increment in mathematical academic performance since randomization was impossible.

Participants of the Study

The participants were students from four sections of grade 11 HUMSS and two sections from grade 11 STEM with a total of two hundred fifty-two students at San Pedro Relocation Center National High School in Laguna, Philippines for the school year 2023–2024. Purposive sampling was used to choose the participants' sections based on the criteria that belong to academic track with low interest in mathematics subject and low academic performance. Hence, the number of participants produced a statistical power of 1.00 with an effect size of .80 for significant differences using the paired-sample t-test computed using G*Power version 3.1.9.7. Ninety-three male and one hundred fifty-nine female senior high school students were chosen since their response to DI implementation was better than elementary students (Domingo, 2021). Hence, profiling was used to classify the students based on their learning interests and styles based on Tomlinson's (2014) principles of DI in mixed-ability classrooms.

Even though the said participants were taking academic track, they showed low interest and motivation in mathematics classes, which caught the teachers' attention. The lack of motivation and passion for mathematics caused the students to exert less effort (Tuazon & Torres, 2022). Consequently, the participants aged 17 to 20 have different learning styles, intelligence, and interests, as shown by the profiling results. So, to have an inclusive but meaningful learning experience, the teacher implemented DI to cater to students' differences. Gervasoni et al. (2021) claimed that many students struggled with mathematics learning, which calls for DI implementation. Also, there was a great need to conduct a study for DI using secondary students rather than elementary students.

Instrumentation

The study used profiling instruments to understand the student's interests and learning styles, including multiple intelligences adapted from McKenzie (2017), learning interests adapted from Shumow and Schmidt (2013), and learning styles adapted from Reid (2005). The results of profiling the students served as bases for differentiating the mathematics lessons through prior knowledge assessment, open questions, parallel task activities, ICT integration, and differentiated assessment.

The study used pre- and post-test material to elicit the students' academic performance, a survey questionnaire to describe the student's learning experience, and an interview guide to collect the qualitative data that support the quantitative findings and elicit suggestions. The test material covering lessons from statistics and probability collected mathematics academic performance in terms of scores before and after the DI implementation. In contrast, the survey questionnaire collected students' perceptions about their learning experiences before and during DI implementation. Hence, the interview guide verified the responses from the questionnaire and dug deeper into how the DI made the learning experience meaningful, which led to better academic performance. Using multiple data collection tools addressed Bondie and Dahnke's (2019) claim that previous investigations on DI had deficient methodological rigor to prove its benefits on student academic performance. Data from quantitative and qualitative tools justified the effect of DI on the student's academic performance.

The mathematics head teacher, education program supervisor, and school head validated the 40-item teacher-made test material, questionnaire, and interview guide. The content of test materials covered the lessons in grade 11 statistics and probability, while the survey and interview guide were taken from the literature review. The survey questionnaire has ten items structured to elicit the learning experience before and during the DI implementation. On the other hand, the interview guide consisted of seven open-ended questions. Suggestions from the validators were strictly followed for the test materials, questionnaire, and interview guide, such as grammar correction, proper punctuation marks, diction, and sentence simplicity. Hence, content validation was considered by subject-matter experts (Ismail & Zubairi, 2022). After validation, the test material and questionnaire were pilot-tested on 40 non-participants to establish their reliability using the Kuder-Richardson formula 20 and Cronbach's alpha. The test materials obtained a reliability of .832, while the questionnaire obtained .876, which means it is a good instrument for collecting data. Also, 30 non-participants were used for a pilot interview to show if the questions were appropriate for the participants, which could lead to collecting the needed qualitative data.

Data Gathering Methods

Permission was secured first from the school head and head teacher, informing them of research plans. Then, informed consent and assent were secured by sending letters indicating the study's objective, how the students participated, benefits that the participants may get, and basic information about the parents and students like name, section, age, and address. After that, pilot testing of research instruments was done to establish their reliability in the last week of January 2024. Takeaways from the pilot testing were used to revise the instruments.

Pre-survey, interview, and pre-test were conducted before the DI implementation, and results were kept for future use. The teacher used DI strategies to deliver the lesson, such as previous knowledge assessment, open questions, parallel tasks, technological tool integration, and various evaluation formats. Through the said strategies, meaningful learning experiences were made, improving students' interest and motivation and manifested in their academic outputs, such as completed and creative performance tasks. Also, as observed by the teachers, student engagement increased, and the students worked on their assigned tasks even after class hours. Hence, meaningful learning experiences mean making the mathematics lesson relevant to students' interests and learning styles. After the implementation period, a post-test, post-survey, and interview were conducted in April 2024 to collect data in response to research questions. The data collection was conducted twice. The participants in January were also the participants in April 2024 because the data before were compared to the data after. However, the data and transcripts were returned to the participants to check their accuracy and completeness and to establish the credibility of the qualitative data for member checking (Candela, 2019).

The first researcher was a mathematics teacher for seventeen years and had published seventeen research papers in various international online journals. He was responsible for writing the proposal and report and validating instruments and communications. He believed that the students performed better academically if the lesson was meaningful in their eyes. On the other hand, the second researcher had been a

Table 1. Likert scale used to interpret the data from survey

Scale	Code	Verbal interpretation
1	NM	Not meaningful
2	SME	Slightly meaningful experience
3	MME	Moderately meaningful experience
4	ME	Meaningful experience
5	VME	Very meaningful experience
6	HME	Highly meaningful experience

Table 2. Levene's test for variance homogeneity and Shapiro-Wilk test for normality of data

Variable	Levene's test				Shapiro-Wilk		
	Statistic	df_1	df_2	Sig.	Statistic	df	Sig.
Pre-survey	7.065	1	250	.008	.921	252	.000
Post-survey	.447	1	250	.504	.916	252	.000
Pre-test	3.959	1	250	.048	.966	252	.000
Post-test	.696	1	250	.405	.976	252	.000

mathematics teacher for twenty-nine years. She was responsible for DI implementation and had direct contact with the participants. She believes that every student has a unique learning ability. However, personal biases like influence on the students, personal beliefs, and opinions were bracketed to ensure objectivity. Also, to accurately get the qualitative data, students from grade 12 were hired to conduct interviews twice and do member checking. The grade 12 interviewers had no contact or relation to the participants.

Ethical Considerations

Any research must consider ethical issues (Astaneh & Masoumi, 2018; Stockemer, 2019). So, school permission was secured through a formal letter signed by the school head. Also, parental consent and assent were elicited before DI implementation. Permission from the borrowed instruments was secured by sending an email. Meanwhile, participation was always voluntary, and the participants received no exchange or favor. However, they could withdraw participation at any time without any consequences. Furthermore, identities and data were kept confidential throughout the study by using pseudonyms to replace the participants' names and storing the data on a personal computer for two years only. Fortunately, research findings were disseminated through conference presentations, meetings, and journal publications.

Data Analysis

Cronbach's alpha and Kuder-Richardson formula 20 were used to establish the reliability of the questionnaire and test material, respectively. For the description of the score, mean, and standard deviation, the Shapiro-Wilk test and Levene's test as prerequisites (Horváth et al., 2020) were used. However, since the data did not resemble a normal distribution, the Wilcoxon signed-rank test and Rank biserial correlation were used for significant differences and practical significance of the DI strategies. For survey data, median (Md) and interquartile range (IQR) were used to describe the responses. Statistical computations were done using Jamovi version 2.4.11, a free statistical application.

For qualitative data, thematic analysis was used from the interview transcripts to produce patterns of experiences (Castleberry & Nolen, 2018). Kiger and Varpio (2020) claimed that thematic analysis was the standard way to analyze qualitative interview data. The researchers read the transcripts thrice and assigned codes for every statement. Codes were grouped into categories and combined to form big ideas or concepts called themes.

Table 3. Descriptive and inferential statistics of the pre- and post-test scores

T	MS	MXS	M	IQR	W	p	I	RB	I
PT	7	28	14	5	31,049	.000	Significant	.995	Very strong
POT	10	39	25	12					

Notes: T: Test; PT: Pre-test; POT: Post-test; MS: Minimum score; MXS: Maximum score; I: Interpretation; RB: Rank biserial.

Table 1 presents the Likert scale for interpreting the survey data. The 6-point scale represents how meaningful the students' mathematical experience is when the teachers integrate DI strategies. Number 1 stands for not meaningful, while the number 6 stands for highly meaningful experience.

Table 2 depicts the normality test results using the Shapiro-Wilk test and the variance homogeneity test using Levene's test. Both survey responses and test scores failed to resemble normal distribution (p = .000), having a significance level beyond .05. However, the post-survey responses and post-test scores have homogeneous variances ($p > .05$). In contrast, the pre-survey responses and pre-test scores did not have homogeneous variances ($p < .05$). It implies that non-parametric test of difference must be used to test the hypothesis particularly the Wilcoxon signed-rank test and Rank biserial correlation rather than paired sample t-test and Cohen's d.

RESULTS

Table 3 shows quantitative analysis using statistical tests. The pre-test scores ranged from 7 to 28, while the post-test scores ranged from 10 to 39. The pre-test scores had a median of 14 (inter-quartile range = 5), while the post-test scores had a median of 25 (IQR = 12). On the other hand, the Wilcoxon signed-rank test (W = 31,049, p = .000) signifies the existence of significant differences before and after. This means that the post-test scores were statistically significant compared with the pre-test scores. Similarly, the rank biserial correlation (.995) signifies the practical significance of DI in making the learning experience meaningful and improving the student's academic performance, supporting Bulley-Simpson's (2018) findings. A very strong effect size implies the significance of integrating DI strategies in lesson delivery. Overall, through DI, the students performed well in examinations similar to the findings of Awofala and Lawani (2020), Chen and Chen (2018), Valiandes and Neophytou (2018), and Sapan and Mede (2022) since their learning experience became meaningful.

Table 4 presents the learning experience before and during the DI implementation. Before, the students slightly experienced meaningful learning, wherein they seldom engaged in activities given because they needed help connecting the prior knowledge with the new lesson. Also, they found the practical application of math linked to their surroundings and other disciplines. Hence, they found math concepts irrelevant to their lives, causing unhappiness and low confidence in dealing with real-life applications of math lessons. However, during the DI implementation, students were highly engaged in math activities, leading to their confidence in collaborative work that parallels Kostiainen et al. 's (2018) findings. In addition, they enjoyed math class since they could apply their learning to solve real-life problems similar to Lai et al.'s (2020) findings and connect math learning with other

Table 4. Learning experience before and during the DI implementation

Statement	Before			During		
	Md	IQR	VI	Md	IQR	VI
1. I can connect my prior knowledge with the new knowledge I learned in math.	2	2	SME	4	1	ME
2. I am engaged in the math activities given by my teacher.	2	1	SME	5	1	VME
3. I am confident and happy to share my acquired knowledge with my classmates.	2	2	SME	4	2	ME
4. I collaborate with my classmates in doing math activities.	2	2	SME	5	2	VME
5. I can solve real-life problems given by my math teacher.	2	2	SME	4	2	ME
6. I can apply my math lessons to my daily living.	2	2	SME	4	2	ME
7. I can link my math lessons to my surroundings and other subjects.	2	2	SME	4	2	ME
8. I can construct the meaning of my math experience about my life.	3	2	MME	4	2	ME
9. I learn math concepts and principles relevant to my life.	2	2	SME	4	2	ME
10. I enjoy my math class since I can connect it with my plans.	2	1	SME	5	1	VME
Overall	2	2	SME	4	2	ME

Notes: Md: Median; VI: Verbal interpretation.

Figure 2. Themes on how the DI makes the learning experience meaningful (Source: Authors)

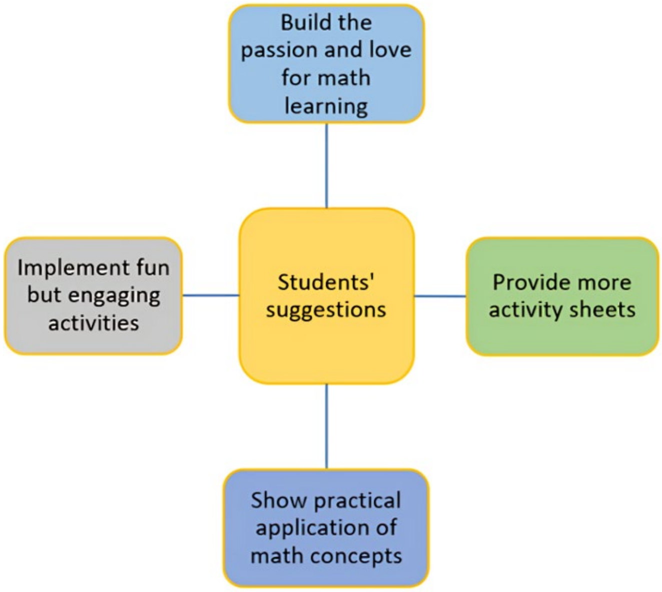

Figure 3. Themes on students' suggestions to make the math learning experience more meaningful (Source: Authors)

subjects. Overall, they had meaningful learning experiences (Md = 4) during the DI implementation.

Figure 2 presents the themes identified from the interview transcript analysis, explaining how the DI makes the math learning experience meaningful. The DI allowed the teachers to connect students' prior knowledge to the following lessons, where the teacher assessed the students' readiness. Through review and drilling, the teacher could check stock knowledge and how ready the students are. Also, the teacher considered the student's learning pace in lesson delivery but emphasized math idea development and concept retention. Hence, the lesson became enjoyable, parallel to Yavuz's (2020) findings, since individual interest and readiness were considered in teaching. Hence, real-life lesson applications ignited the student's passion for learning.

The participants' words support the findings above.

> "My teacher explained the importance of math lessons and connected them to everyday living" (student 7).

> "Even though she was teaching, I still seemed to enjoy learning since she was not strict with me" (student 12).

> "Like the past lessons from junior high school, we still need that lesson. We need that lesson even though we are in senior high. It seems like she is teaching us not to forget what we studied last year" (student 20).

Figure 3 presents the themes derived from the interview transcripts, showing the students' suggestions for making their math learning experience more meaningful. Students suggested having more activity sheets provided by the teachers so that they could practice solving problems and doing computations. Also, they want the practical application of math concepts during the discussion to motivate them. Moreover, they requested fun but engaging activities like games, simulations, and mini-contests. Hence, the teacher must first build the student's passion and love for learning math lessons before discussing the new lesson.

Excerpts from the interview supported the findings above.

> "First, the student must love math because I believe that if you love math, even if it is difficult, you can do it" (student 10).

> "To have activities related to the lesson that will be enjoyed like games because when there is something related that is fun, they seem more willing to learn" (student 11).

> "Just like when I answered, more real-life examples and further explanations of why mathematics matters to us" (student 14).

DISCUSSION

The study aimed to enhance students' academic performance in examinations by making the mathematics learning experience meaningful through DI. The participants were two hundred fifty-two from grade 11 STEM and HUMSS students. Based on the findings, the post-test scores are statistically different from the pre-test scores using the Wilcoxon signed-rank test since the data failed to resemble normal distribution. This means the DI strategies enhance the student's academic performance in the examinations. So, DI helps the students to perform better in math (Morallos, 2018). The substantial effect size justifies the practical significance of DI strategies in math classes.

Learning becomes meaningful when the DI is implemented in a math class since the student's prior knowledge is used as a springboard for the lesson. So, the students connect their prior knowledge to the new lesson delivered by the teacher. Also, engaging math activities are provided based on students' interests, which makes the students happy. Students were provided options to demonstrate their learning outputs that add to meaningful learning experiences (Hapsari et al., 2018). Moreover, collaboration among the students is highly seen since they are instructed to produce group outputs to manifest their learning. Students' collaboration makes learning enjoyable (Awofala & Lawani, 2020). Hence, real-life application of math concepts is expected as performance tasks vary based on the student's preferred outputs. Overall, the relevance of math lessons is shown to the students by connecting their learned competencies to real-life situations.

Through the lens of meaningful learning theory, DI connects students' prior knowledge as the starting point of the lesson to the new lesson to check the student's readiness. Also, it allows the students to apply their learning in real-life situations by providing options for the students' demonstration of competencies. The link of prior knowledge to newly acquired learning and applying it to real-life problems makes the learning meaningful (Agra et al., 2019). In addition, the students' enjoyable learning experience contributes a lot to meaningful learning while acquiring math concepts. The student's learning experience influences the learning process based on sociocultural learning theory (Ginja & Chen, 2020). So, the learning experience must be meaningful as perceived by the students. However, individual learning pace is considered in lesson delivery since every student has a learning style and speed.

The lesson delivery does not guarantee that all learning concerns are addressed. So, student suggestions are elicited to improve the following DI implementation. First, the teacher must build a passion and love for learning math so that every student falls in love with math and removes learning fear. Second, more activity sheets must be given to the students since textbooks are unavailable. Third, a more practical lesson application may be used as motivation or a springboard for the new lesson. Lastly, fun but engaging activities may be used as teaching strategies in delivering the lesson because these activities manifest meaningful learning experiences (Heddy et al., 2016).

For the reflection, the teacher admitted that the DI implementation could have been better due to insufficient time, which caused classroom management issues. She needed help monitoring and supporting each student effectively and was forced to finish the lesson on time. However, she plans to integrate flexible grouping with small group interaction so that the students will experience working with different peers and benefit from diverse perspectives. However, her class became more meaningful since the lessons always started with students' prior knowledge and connected to the new lesson, applying it in real-life situations considering students' interests and preferences.

This study is limited to one school since action research is used to address the problem. However, descriptive phenomenology may be used to understand the meaningful learning experiences that DI brings fully. Similarly, a proper experimental design may be used to test if DI positively increases students' academic performance. Furthermore, the PDSA model of the study clarifies the proper way of conducting practical action research to enhance the student's academic performance by making the learning experience meaningful through DI strategies. Therefore, if a practical action research design is used to address classroom-based problems, the PDSA model is the best to follow (Worten, 2021) because it includes a systematic approach to obtaining essential knowledge to improve educational processes (Sagun & Prudente, 2021).

CONCLUSIONS AND RECOMMENDATIONS

The pre-test scores were lower compared with the post-test scores. The increment of post-test scores from the pre-test scores proved the enhancement of students' academic performance through the DI strategies of the teacher. Also, the substantial effect size manifests the practical application of DI strategies in making a meaningful learning experience. Therefore, DI improved students' mathematical academic performance based on the students' pre- and post-test scores. On the other side, before the DI implementation, students engaged less in math class and treated math subjects as hard to understand. They need more meaningful learning because they need help to connect prior knowledge with the new lesson and find real-life applications. However, it all changed due to DI strategies used by the teacher. Students boosted confidence and enjoyed learning since collaboration was consistently observed in doing the activity. Students' interests were considered in lessons, and various activities were produced.

DI made the learning math experience meaningful since students' prior knowledge was connected to the new lesson while considering the individual learning pace. The learning became enjoyable while the teacher emphasized the formation of math concepts. Also, real-life situations were added to the students' meaningful learning. However, students suggested building the students' passion and love for math learning before the start of the lesson. The teacher must provide fun and engaging activities, provide more activity sheets for practice, and show the practical application of the lessons.

The study implied the importance of making the learning experience meaningful in the eyes of the students through DI strategies that give opportunities for the students to relate mathematics lessons to practical life, students' interests, and learning styles. The teacher determines the student's readiness through prior knowledge assessments and adjusts the mathematics lessons. By open questions, the teacher motivates the student to think of possible answers and reason out. Similarly, students can perform varied group tasks with the same level of difficulty based on their interests through the provision of parallel tasks. Lastly, integrating technology makes the lesson lively, engaging, and efficient.

The study was limited to action research using one school's Grade 11 STEM and HUMSS students. Future studies may be conducted parallel to this research, considering other grade levels in various schools to check the study's findings. Also, the teacher who wants to implement DI must constantly ask for student feedback to check its appropriateness in the local context. Hence, DI may be implemented in other school subjects to cater to student's individual learning needs and make learning meaningful

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