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Addressing student diversity to improve mathematics achievement through differentiated instruction

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ABSTRACT

Managing student diversity is one of the issues that occur in mathematics education. Students typically achieve poorly in school if it is not appropriately addressed. Therefore, differentiated instruction (DI) strategies were used in mathematics classes to address the issue. This study aimed to evaluate the efficiency of DI strategies in addressing student diversity and raising mathematics proficiency levels. DI was carefully implemented in one school using the plan-do-study-act methodology. Data were gathered via test scores, questionnaires, and interviews, and professionals in the field of mathematics education verified the content validity of the said instruments. The study discovered that more incredible mathematics achievement resulted from addressing student diversity. Mathematics classes were better delivered and adapted to students' learning styles using DI. However, mathematics teachers faced difficulties like lengthy preparation, poor classroom management, large class sizes, and a lack of resources.

Keywords: challenges, differentiated instruction, mathematics achievement, open question, parallel tasks, student diversity

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INTRODUCTION

Educators should consider the wide range of student backgrounds and experiences when planning lessons. Teachers are expected to design relevant teaching and learning experiences that fulfill the different learning needs of their students (Deunk et al., 2018). According to Philippine DepEd Order No. 035 s. 2016 (DepEd, 2016), the teacher must respond to student diversity by creating a learning environment that provides the student learning needs in diversity. Due to student diversity, teachers must differentiate learning material, process, output, and environment to respond to student characteristics. However, because each student is unique, teachers must improve their knowledge and competencies in creating a curriculum that addresses student diversity. As a result, teachers must use differentiated instruction (DI) to accommodate student diversity through individual differences (DepEd, 2016). According to the DepEd MATATAG agenda, teachers must care for students' well-being, provide inclusive education, and establish a pleasant learning environment (Department of Education, 2023), which can be accomplished through addressing student diversity in curriculum delivery.

Students learn school lessons differently, requiring teachers to adapt their teaching practices and employ a variety of activities and delivery methods based on their preferences. This means the teacher must adjust paradigms to give education relevant to the student's interests, learning style, and intelligence. However, DepEd Order No. 021, s. 2019 (DepEd, 2019) requires teachers in the Philippines to use DI based on multiple intelligences and learning styles to handle student diversity in the classroom. Furthermore, Republic Act No. 10533 (Enhanced Basic Education Act of 2013) required constructivist, collaborative, differentiated, inquiry-based, integrative, and reflective curricular pedagogical approaches for grades K-12.

A large body of DI literature discusses various teacher methods for student diversity (Pozas et al., 2020). DI techniques consider the student's specific learning demands as well as their unique learning capability. The assumption of DI is revealed by Tomlinson and Imbeau (2023), as follows:

(a) students have different readiness levels, interests, learning styles, experiences, and life situations,

(b) individual differences are significant to influence student learning, the learning process, and the supports needed from teachers, and

(c) student learning occurs best when the curriculum is connected to their interests, learning styles, experiences, and life situations.

As a result, it is the primary responsibility of teachers to make the curriculum relevant, responsive, and liberating to the lives of their students.

In contrast, San Pedro Relocation Center National High School-Main is a public institution in the Philippines offering nearly seven thousand students in junior and senior high school programs. However, students at this school still needed to meet the 75% mean percentage score cut-off in mathematics. As mentioned earlier, the students could perform better mathematically based on their learning demands and traits. Despite teachers' efforts to meet students' learning needs, students performed poorly in mathematics. As a result, mathematics teachers conducted a study using DI strategies to address student diversity and promote improved mathematical achievement. Students learn mathematics better with DI techniques because their learning experiences are diverse and reinforced by learning opportunities supplied by mathematics teachers.

The study is notable since DI strategies in mathematicseducation were used for the first time in Philippine public secondary schools following DepEd Order No. 021, s. 2019 (DepEd, 2019). This adds to the literature on how DI addresses student diversity from the perspective of mathematics teachers, leading to improved academic achievement. Additionally, challenges encountered during DI implementation are emphasized to influence future action to sustain DI implementation in addressing student diversity. Based on the findings, a continuous professional development program with available DI-matched lesson plans and constant monitoring and coaching sessions is required to improve mathematics teachers' DI implementation.

Literature Review

DI is a philosophy that recognizes student diversity and differentiates the learning content, process, product, and learning environment (Utama, n. d.). According to Ozer and Yilmaz (2018) and Sayi and Emir (2017), the distinguishing aspect of DI is developing lessons based on student interest, learning profile, and preparedness to suit the student's specific learning needs. DI gives students options for learning content, conducting processes, exhibiting results, and modifying the learning environment according to student preparedness, interest, and learning profile (Tomlinson, 2014). Furthermore, DI enables teachers to employ a variety of learning materials, content, activities, and evaluation forms to meet the needs of their students. It implies that teachers must provide learning chances for students by providing options for them to learn based on their preferences, which necessitates rigorous lesson design (Suprayogi & Valcke, 2016). However, few teachers use DI in their regular teaching practices (Suprayogi et al., 2017).

DI improves students' academic performance (Chen & Chen, 2018; Muthomi & Mbugua, 2014; Ozer & Yilmaz, 2018; Valiandes & Neophytou, 2018), school performance (Sapan & Mede, 2022), and maximizes student learning potential (Wilujeng, 2012). DI is based on the notion that every student deserves to learn more effectively through the various learning opportunities provided by the teacher. It assists struggling students in performing academically based on their strengths while recognizing individual differences in a diverse context. However, there is an urgent need to explore teacher differentiation strategies to accommodate student diversity (Prast et al., 2018; Ritzema et al., 2016). Furthermore, there is a strong need to research the impact of DI on students' mathematics achievement in secondary school (Muthomi & Mbugua, 2014).

Many educational institutions from many nations used DI (Suprayogi et al., 2017). Even so, more empirical research has investigated implementing teachers' DI strategies, particularly in secondary schools (Pozas et al., 2020). Due to teachers' excessive workload, there is also a minimum application of DI strategies among secondary school teachers. However, there has been research on adopting DI at the primary level (Ismajli & Imami-Morina, 2018; Mainini & Banes, 2017; Prast et al., 2018). On the other hand, Smale-Jacobse et al. (2019) undertook a secondary-level systemic review of DI. They discovered that there needs to be more high-quality empirical investigations on the usefulness of DI in secondary education. They proposed future studies to evaluate DI interventions in secondary schools. As a result, it is incredibly timely to address the literature gap on DI to improve secondary school student performance. Following the epidemic, it is time to use DI to improve student learning results, particularly in mathematics.

Previous research shows how DI enhances student achievement (Smale-Jacobse et al., 2019). For example, Magableh and Abdullah (2020) employed a quasi-experimental approach. They discovered that DI has a significant impact size in addressing class diversity, resulting in higher student accomplishment in the mixed-ability group. Abdul Al-Bar (2018) said DI improved students' mathematical achievement and problem-solving ability. Similarly, Prast et al. (2018) discovered that DI as a professional development program for teachers had a favorable influence on students' mathematics achievement due to increased teachers' competency and DI implementation. Balgan et al. (2022), on the other hand, explored DI for science, technology, engineering, and mathematics students in Mongolia using learning styles and multiple intelligences. Because of the close association between students' intelligence, learning style, and personality type, they discovered that if teachers effectively utilized DI, students learned.

Teachers perceive DI as time-consuming and challenging to implement (Lunsford, 2017; Njagi, 2014; Siam & Al-Natour, 2016). Merawi (2018) listed teachers' obstacles when implementing DI, such as fewer instructional materials, insufficient leadership support, too much workload, and a lack of teachers' understanding and dedication to implementing DI. Merawi (2018) proposed capacity building for teachers to aid with DI implementation. However, Geel et al. (2022) discovered that time management, lack of experience, and lack of knowledge and skills were the most significant barriers to DI implementation. On the other hand, Al-Shaboul et al. (2020) discovered that the hurdles inhibiting DI implementation were class size, time, and teaching load. In addition, more resources and assistance from the school administration could have improved teachers' development of DI implementation skills. Similarly, more proper resources or utilization of limited materials is needed for DI implementation (Sprott, 2019). On the other hand, teachers are resistant to evolving their teaching practices (Aldossari, 2018; Heacox, 2014; Joseph, 2013; Nicolae, 2014) and need to gain experience in DI implementation (Aldossari, 2018; Dixon et al., 2014).

Theoretical & Conceptual Framework

The study relied on Edward Deming and Walter Shewhart's plan-do-study-act model (Taylor et al., 2014). This methodology was extensively employed in classroom-based action research, resulting in well-organized procedures for researchers. Mathematics teachers examined the students' mathematical problems based on the results of the first and second grading examinations during the planning stage. They then gathered evidence to discover the underlying cause and potential interventions. According to the findings, the two-year distance learning caused a significant learning gap, leading to low mathematics achievement. Aside from the learning gap, students differ in learning interests, learning styles, and preferred intelligence.

In-service professional development for DI is critical to assisting teachers in appropriate implementation and ensuring guided teaching practices (Smets, 2017). Kahmann et al. (2022) stated that teacher professional development programs are critical for DI adoption. As a result, the researcher provided mathematics teachers with a professional development regarding DI via learning action cells (LAC) training to address diversity. Mathematics teachers attended seven LAC sessions to gain competencies for implementing DI strategies. LAC sessions mentioned above began in November 2022 and finished in January 2023. The teacher participants were required to provide outputs as expressions of their newly acquired competencies. School-wide professional development of DI methods for teachers favors teaching practices (Prast et al., 2018). DI is a sophisticated teaching skill requiring mathematics teacher training (Gaitas & Martins, 2017; Smets, 2017; van Geel et al., 2019). As a result, teachers' issues with DI implementation necessitate establishing a professional development program (Kahmann, 2022) to provide teachers with critical attitudes, knowledge, and abilities (Mills et al., 2014).

Following the training, DI strategies were implemented for three months, from February to April 2023, to improve students' mathematical skills. However, teachers may need help to apply DI honestly (Gheyssens et al., 2020; Prast et al., 2018) and may face obstacles during implementation (Gheyssens et al., 2020; Mills et al., 2014). DI lesson was centered on the student's interests, intelligence, and learning styles, as supported by Gardener's (1989) theory of multiple intelligences and Vygotsky's (1978) constructivism principles, as mentioned by Al-Shaboul et al. (2020). Review/drill, open questions for motivation, a parallel task for a group activity, open questions for practice, contextualized challenges, and performance task alternatives with technology integration were all part of DI-based lessons. According to the study, effective technology integration is one of the most effective DI techniques in the 21st century that benefits students (Morgan, 2014). As a result, classroom observation, mentorship, and coaching sessions were held to ensure that DI strategies were appropriately implemented.

During the study phase, teachers' perceptions of how DI addressed student diversity resulted in improved mathematics achievement, and the results of pre-test and post-test exams were analyzed and interpreted to determine the aspect of implementation that required improvement. Key learnings were highlighted through reflection during the act stage, and the research result was shared in professional gatherings, conferences, and fora. As a result, a sustainability plan was developed for future action (**Figure 1**).

Research Questions

This study sought to address student diversity to increase mathematics achievement using DI strategies. It specifically answered the following questions:

1. How do DI strategies handle student diversity, as viewed by mathematics teachers, to promote mathematics achievement?
2. Does DI enhance student mathematics achievement as measured by test scores?
3. What difficulties do mathematics teachers face when addressing student diversity to improve mathematics achievement through DI strategies?
4. What are the recommended courses of action based on teacher ideas that can be provided to sustain the increase of student mathematics achievement using DI?

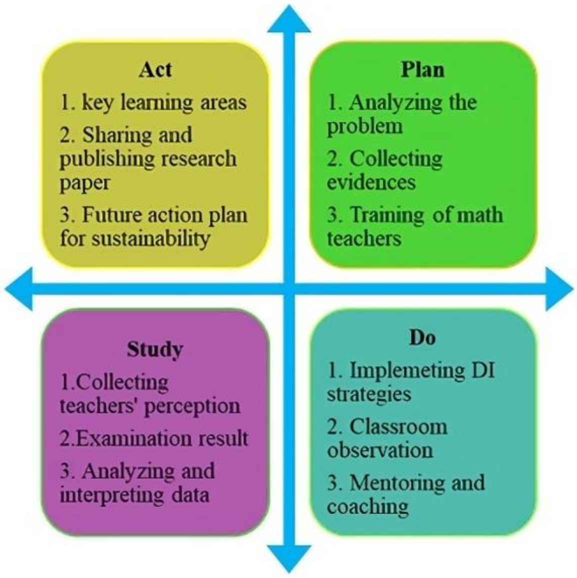

Figure 1. Study's paradigm (Source: Author)

METHODOLOGY

Research Design

The study's design was practical action research to address student diversity to increase mathematics achievement through DI strategies. Lessons were delivered using DI strategies, such as assessing prior knowledge, open questions, parallel tasks, performance task options, and technology integration. Because the study investigated the school problem, a practical action research approach was the most appropriate. Teacher practitioners conduct practical action research to examine current issues/problems in education (Chen & Lin, 2019). A teacher used practical action research to address classroom concerns, school issues, and practices. However, according to Bondie and Dahnke (2019), most DI studies employed a case study design, and only a handful conducted action research to assess DI's effectiveness.

Participants of the Study

17 mathematics teachers and five thousand three hundred one students from grade 7 to grade 11 at San Pedro Relocation Center National High School-Main participated in the 2022-2023 school year. Teachers and students at the institution mentioned above hailed from various areas and possessed distinct qualities. This school's students have diverse learning interests, styles, and intelligence preferences. However, many students struggle with mathematics learning, requiring teachers to use DI to improve equitable and inclusive mathematics education (Gervasoni et al., 2021). Furthermore, according to Bondie and Dahnke (2019), there have been few studies on secondary students as DI participants, notably in mathematics.

Research Instruments

The study employed self-report survey questionnaires, test materials, and interview guide questions as data collection instruments. The researcher believes in using multiple data collection tools to answer Bondie and Dahnke's (2019) argument that previous DI studies had inadequate methodological rigor to investigate its favorable effect on student academic achievements. Using multi-method data collection tools allowed the researcher to see different implementation aspects, resulting in a more accurate depiction of practices. Data gathered through many methodologies provide a detailed overview of the success of DI strategies in addressing student diversity.

The survey questionnaire was administered to teachers to determine how DI addresses student diversity and enhances student mathematical achievement. The initial draft included demographic data such as gender, age, highest educational attainment, years of teaching mathematics, and grade level taught, as well as fifteen-item judgments on a Likert scale ranging from one strongly disagree to six strongly agree. The statements were modified from the work of Al-Shaboul et al. (2020), Handa (2020), and Prast et al. (2018) to be more appropriate for the study. As a courtesy, the researcher emailed the authors asking permission to use it. Then, the initial draft was given to three mathematics education validators, including the head teacher, education program supervisor, and senior education program specialist, for feedback on the questionnaire's substance and usability. As a result, content validation was performed by a committee of experts meticulously reviewing the items (Ismail & Zubairi, 2022). The suggestions were then considered in the revision of the questionnaire mentioned above. Following the establishment of content validation, internal consistency was calculated using Cronbach's alpha. The survey questionnaire's reliability index of .976 indicates a good data collection tool consisting of fifteen structured items and six open-ended questions.

In the third grading period for grade 7 to grade 11, 50 item-tests for pre-test and post-test were developed to assess prior and acquired mathematical knowledge. The test materials were created using the curriculum guide for mathematics subjects and validated by mathematics department's head teacher. Furthermore, seven-item interview guide questions were designed to elicit qualitative comments from teachers as a supplement to quantitative data vetted by mathematics education field experts.

Data Gathering

As part of the protocol, permission from the school head was obtained first. The students were then given a pre-test to assess their prior knowledge. The pre-test result was saved for future reference. For three months, DI strategies were employed, such as assessing prior knowledge, open questions, parallel tasks, performance task alternatives, and integration of technology tools. Following implementation, a post-test was given to the students to determine their acquired competencies. The post-test score was compared to the pre-test score. On the other hand, the survey questionnaire was distributed to mathematics teachers to elicit responses on how DI strategies contribute to mathematics achievement for their students and elicit their challenges. However, an interview was conducted to collect qualitative data to check the accuracy of responses.

The researcher taught mathematics at the same school for seven years. To promote objectivity, he withdrew himself as a participant. Personal prejudices were left aside, and bracketing was used to separate his assumptions that the teachers sincerely execute DI procedures to prevent data contamination and ensure data purity. Hence, he did not influence the teacher to participate in the study.

Table 1. Homogeneity of variances & normality test results

Test	Grade level	Levene's test		Shapiro-Wilk		
		Statistic	Sig.	Statistic	df	Sig.
Pre-test	7	1.606	.223	.987	18	.634
	8	.064	.803	.982	18	.558
	9	.434	.517	.946	18	.371
	10	.034	.856	.942	18	.316
	11	.924	.348	.932	18	.208
Post-test	7	.379	.547	.955	18	.510
	8	1.583	.220	.908	18	.080
	9	.146	.705	.932	18	.226
	10	.009	.925	.952	18	.464
	11	1.111	.304	.951	18	.436

Ethical Considerations

Research must adhere to ethical principles (Astaneh & Masoumi, 2018; Stockemer, 2019). The researcher first obtained authorization from the school head to adhere to moral norms, followed by adequate communication with mathematics teachers via training, coaching, and mentoring. In addition, approval from the questionnaire's original writers was obtained beforehand. As a result, participants' engagement was entirely voluntary, with no benefit in exchange. They may, however, withdraw their participation at any moment. Similarly, their identities were concealed, and the information gathered from them was kept private to avert potential harm. Furthermore, the research report and data were only saved on the researcher's computer and were erased two years later. Professional conferences, faculty meetings, and journal publishing were the only venues for dissemination.

Data Analysis

As part of descriptive statistics, the statistical package for the social sciences (SPSS) version 23 was used to compute mean, median, standard deviation, interquartile range, Shapiro-Wilk test for data normality, and Levene's test for variances homogeneity. For hypothesis testing, the study used the paired sample t-test for a significant difference in academic performance before and after the deployment of DI strategies (Rietveld & van Hout, 2017) and Cohen's d to determine practical significance when the data distribution was normal (Goulet-Pelletier & Cousineau, 2018).

Table 1 displays tests for variance homogeneity and normality, which are required for applying inferential statistics (Hanusz & Tarasińska, 2015). Shapiro-Wilk significant values ($p>.05$) indicate that the data was normally distributed because they are more significant than the .05 significance level. Similarly, the value of Levene's test suggests that the variances are homogeneous because they all exceed the significance level of .05 alpha. Because the data were ratio and resembled a normal distribution, the parametric test of difference was performed for pre-test and post-test scores (Grech & Calleja., 2018). **Table 1** justifies using a parametric test of difference, namely the paired sample t-test, rather than its non-parametric counterpart.

Thematic analysis was used to get accurate data from qualitative data. The researcher transcribed and read the interview responses twice. As a representation of responses, codes were assigned to every sentence. The codes were then grouped into more significant concepts, and the categories were grouped into themes. Thematic analysis transformed qualitative data into a pattern of ideas known as themes (Castleberry & Nolen, 2018; Kiger & Varpio, 2020). As a result, transcripts and data analysis were returned to participants to inquire

Table 2. Mathematics teachers' perception of addressing student diversity

Statement	Median	IQR	VI
1. Applying differentiation in my mathematics lessons has a positive effect on my students' motivation	5	1.50	Strongly agree
2. Applying differentiation in my mathematics lessons has a positive effect on my students' achievement	5	1.00	Strongly agree
3. Differentiated instruction achieved effective learning by addressing student diversity.	5	1.50	Strongly agree
4. Differentiated instruction allows students to brainstorm ideas & explore possible solutions to mathematical problems.	5	1.00	Strongly agree
5. Differentiated instruction makes the students feel involved in learning.	5	.50	Strongly agree
6. Differentiated instruction produces students' interaction by requiring them to work as a team.	5	1.50	Strongly agree
7. Differentiated instruction allows the students to do various learning activities.	5	2.00	Strongly agree
8. Differentiated instruction caters to my student's learning needs with mixed learning abilities.	5	2.00	Strongly agree
9. Differentiated instruction allows the students to understand mathematics concepts and ideas better.	5	2.00	Strongly agree
10. Differentiated instruction allows the students to think in different ways about mathematics problem	5	1.50	Strongly agree
11. Differentiated instruction allows the students to become imaginative and creative in solving mathematical problems.	5	2.00	Strongly agree
12. Students can select their preferred tasks and activities through differentiated instruction.	5	2.00	Strongly agree
13. Students have the opportunity to participate in planning processes and select activities and tasks	5	2.00	Strongly agree
14. Students can express their creativity in delivering their outputs.	5	1.50	Strongly agree
15. Students learning interests and styles are considered in classroom activities.	5	2.00	Strongly agree

Note. IQR: Interquartile range & VI: Verbal interpretation

Table 3. Descriptive statistics of pre- & post-test scores

Test	Grade level	Minimum score	Maximum score	Mean	Standard deviation
Pre-test	7	2	34	11.15	4.24
	8	2	33	11.81	3.54
	9	2	34	13.34	3.42
	10	4	33	12.02	3.11
	11	3	35	11.71	3.47
Post-test	7	6	50	21.77	7.19
	8	4	49	25.18	7.76
	9	7	50	19.13	5.51
	10	4	46	22.01	5.84
	11	7	50	24.96	6.33

about the completeness and accuracy of data to establish member checking for trustworthiness (Candela, 2019).

RESULTS

Table 2 displays mathematics teachers' perceptions about using DI to address student diversity. Mathematics teachers concluded that DI results in more significant learning because it addresses student diversity, ultimately boosting student motivation and accomplishment. It allows students to collaborate and brainstorm with one another, as well as express themselves as team members. It also accommodates students' diverse learning styles and allows them to develop their abilities. DI enabled students to think creatively and imaginatively to solve mathematical challenges. Students learned better due to DI implementation by mathematics teachers because learning style, multiple intelligences, and student motivation were considered in lesson planning, comparable to the finding of Balgan et al. (2022).

Students can pick their preferred learning activities and demonstrate learning results depending on their skills. Learning styles and interests were addressed while developing the competencies, validating Tomlinson and Imbeau's (2023) argument. Since student diversity was acknowledged, student motivation and participation were evident in the mixed-ability classroom. Overall, mathematics teachers believed that DI addressed student diversity, resulting in superior learning experience and mathematical achievements, which supports Abdul Al-Bar's (2018) findings.

Table 3 summarizes students' pre-test and post-test scores in grade 7 through grade 11, using the maximum, minimum, mean, and standard deviation as the most meaningful metrics of central tendency and variability (Lydersen, 2020). According to **Table 3**, the minimum score for the pre-test was two, and the minimum score for the post-test was four. However, the maximum score for the pre-test was 35, while the post-test was 50. Regarding pre-test mean and standard deviation, the lowest was 11.15 from grade 7 and 3.11 from grade 10. The highest, however, was 13.34 from grade 9 and 4.24 from grade 7. The lowest post-test means, and standard deviation were 19.13 from grade 9 and 7.76 from grade 8. However, the highest scores were 25.18 in grade 8 and 7.76 in grade 8. It signifies that different grade levels have different averages and standard deviations, indicating that the data is realistic.

Table 4 depicts the outcomes of hypothesis testing with the paired sample t-test and Cohen's *d*. For grade 7, there is a significant difference between pre-test and post-test mean scores (t=-5.96, p=.00), with an effect size of 1.80. Similarly, the post-test mean score for grade 8 was highly significant from the pre-test (t=-18.00, p=.00), with an effect size of 2.22. On the other hand, the grade 9 post-test mean score was substantially different from the pre-test (t=-5.42, p=.00), with a 1.26 effect size. For grade 10, a t-value of -13.38 (p=.00) indicates a statistical difference between the pre-test and post-test mean scores, with an effect size of 2.14.

Finally, the t-value of -8.22 (p=.00) demonstrates that the post-test scores differed significantly from the pre-test scores, with an effect size of 2.60. To summarize, because statistical differences in student scores were established before and after DI implementation, it can be stated

Table 4. Paired sample t-test & effect size

Test	Grade level	Paired differences			t	df	Sig. (2-tailed)	Cohen's *d*
		Mean	Standard deviation	Standard error mean				
Pre-/post-test	7	-6.73	4.79	1.13	-5.96	17	.00	1.80
	8	-13.68	3.88	.76	-18.00	25	.00	2.22
	9	-5.78	5.33	1.07	-5.42	24	.00	1.26
	10	-8.63	3.23	.65	-13.38	24	.00	2.14
	11	-9.69	5.53	1.78	-8.22	21	.00	2.60

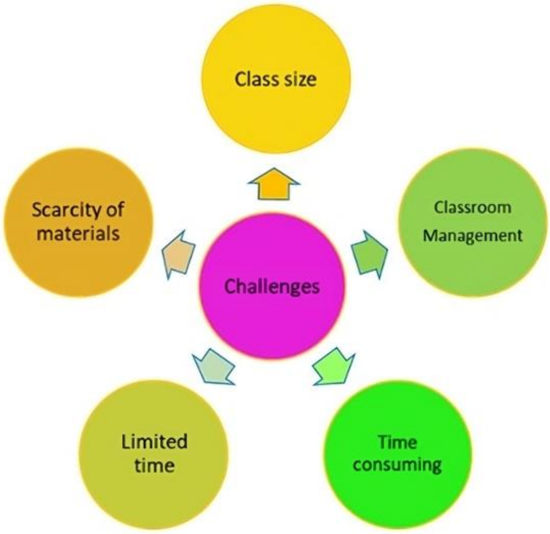

Figure 2. Challenges experienced by mathematics teachers (Source: Author)

that DI strategies used by teachers improved student achievement, supporting the findings of Balgan et al. (2022), Magableh and Abdullah (2020), and Prast et al. (2018). Furthermore, the effect size accurately reflects the practical importance of DI strategies. The effect size is critical for demonstrating the practical relevance of experimentally obtained values for the test of difference (Lovakov & Agadullina, 2021).

Figure 2 depicts mathematics teachers' difficulties while implementing DI to address student diversity. Mathematics teachers frequently reported needing more time to design DI-aligned activities due to the extensive time necessary for preparation (Njagi, 2014; Siam & Al-Natour, 2016). They require additional time and effort to produce educational materials appropriate for varied learning styles and interests. They also had trouble acquiring the supplies needed to create exercises and instructional aids, like Merawi's (2018) findings. Furthermore, as Al-Shaboul et al. (2020) discovered, class size significantly impacts DI implementation. It took much work for teachers to plan diverse learning activities and monitor each student while implementing DI in a classroom with more than fifty students. Managing a large class increases the strain on mathematics teachers to manage lesson delivery. Considering Lunsford's (2017) results, DI is difficult to implement in public schools due to its large class size.

The words of the participants support **Figure 2**.

> "The challenge I have encountered during the implementation is that most activities consume more time than expected. It is also taking me more or extra effort to integrate DI" (participant 4).

> "Classroom management, time management, and looking for different activities and tasks to be integrated into DI implementation are the challenges I encountered" (participant 6).

> "I observed that it takes much time to prepare for the kind of act for each type of learning style. Considering the learners' interest, the tiered act needed more effort. Materials are also one of factors to be considered as challenges" (participant 9).

Figure 3. Recommended courses of action to sustain improvement of student mathematics achievement (Source: Author)

Figure 3 depicts the courses of action suggested by mathematics teachers to sustain DI's effect on student achievement in mathematics. Mathematics teachers advocated for more training and seminars on effectively integrating DI through LAC to prepare them better to plan lessons with various activities that address student diversity. They also want DI-aligned teaching resources and lesson plans, so they know how to deliver DI classes effectively. Also, they demanded that master teachers continuously monitor DI implementation to remind them to differentiate their teaching religiously and guidedly. To summarize, in coming school year, there will be continuous professional training on DI implementation and the development of learning materials, as well as practical implementation monitoring, to ensure the long-term viability of addressing student diversity through DI.

The participants support the courses of action.

> "Conduct training and seminars about the concepts and implementation of DI in classes" (participant 1).

> "I suggest providing multiple texts and types of learning materials. The lesson plan must be ready-made" (participant 3).

> "I think the Master teachers of our department continue to monitor the implementation. Because honestly, if the Master teacher does not remind me, I forget to involve it in my lesson" (participant 10).

DISCUSSION

DI handles student diversity by considering students' interests and preferences to respond to specific learning needs (Ozer & Yilmaz, 2018; Sayi & Emir, 2017). Teachers used DI techniques in mathematics education to provide students with options for learning the curriculum, going through the learning process, producing learning outputs, and interacting in a learning environment appropriate for their learning needs. Through DI class design, they provided learning opportunities by delivering diverse activities based on students' choices (Suprayogi & Valcke, 2016). Furthermore, DI increases students' academic performance, as evidenced by improved examination scores, which leads to improved school performance (Sapan & Mede, 2022). DI believes that every student deserves to improve their mathematics skills through the different learning possibilities mathematics teachers offer. The favorable impact of DI on students' mathematics achievement is due to teachers' increased competency and incorporation of DI into the curriculum (Prast et al., 2018). However, mathematics teachers acknowledge that DI cannot be incorporated into every lesson. DI was not routinely utilized in their teaching techniques (Suprayogi et al., 2017).

Due to limited preparation time and resources in public schools, mathematics teachers find methods to incorporate it twice a week. Mathematics teachers often need help managing large class sizes. As a result, time management, insufficient learning materials, and a lack of experience were barriers to correctly implementing DI, aligned with the findings of Aldossari (2018), Dixon et al. (2014), and Geel et al. (2022). On the other hand, DI-aligned activities helped students feel valued and appreciated by their peers. Students gain confidence and a desire to learn.

To sustain the implementation of DI, a continuous professional development program was proposed to increase teachers' knowledge and skills in DI implementation because teacher continuous professional development (CPD) results in higher student achievement (Prast et al., 2018). CPD aims to improve teachers' DI implementation competencies while encouraging personal growth (Ostinelli & Crescentini, 2021). Mathematics teachers still needed more knowledge and expertise to utilize DI properly. DI lesson plans must also be available to be directed in their class delivery. Furthermore, constant monitoring and coaching remind mathematics teachers to religiously integrate DI strategies such as assessing prior knowledge, open questions, parallel tasks, performance task options, and integrating technology tools in teaching mathematics lessons suited to students' diverse learning needs.

The lens of multiple intelligences theory supports DI principle that provides students with various learning opportunities based on their preferred intelligence, resulting in enhanced learning. If mathematics teachers consider student diversity, they must carefully arrange every task in the session so that students use diverse intelligence. On the other hand, constructivism emphasizes how learning occurs when students develop their understanding of things by discovering independently. Since different learning styles and interests were incorporated into lesson planning, DI students were active knowledge creators through varied activities they encountered in the classroom supplied by mathematics teachers.

CONCLUSIONS & RECOMMENDATIONS

According to teachers' perceptions, DI addressed student diversity by considering student interests and learning preferences, resulting in improved mathematical achievement. Furthermore, it boosted students' exam scores since they increased their mathematical competence through varied learning activities tailored to their capacities. Addressing student diversity improved learning experiences, raising students' eagerness to study and love of learning. However, putting DI into action took a lot of work. Mathematics teachers faced issues such as taking a long time to prepare lessons and teaching materials, having fewer materials available, having less time to prepare, and having a big class size, which affected classroom management. Furthermore, to continue DI implementation, mathematics teachers needed a constant professional development program that taught them how to execute DI strategies successfully and efficiently and create DI lesson plans considering students' preferences. They also requested ongoing monitoring and mentoring of DI implementation to ensure effective deployment.

As school-based action research, the study was limited to one school. However, it did not consider the students' experiences, so future researchers may consider it a potential issue to examine. Future researchers may also create a DI implementation model for basic mathematics education to serve as a reference for proper implementation. On the other hand, school administrators must support mathematics teachers' professional development in upgrading pedagogical abilities in handling student diversity through DI so that students stay caught up.

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