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Enhancing students' numeracy skills through differentiated instruction strategies by considering student diversity

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ABSTRACT

Students can only perform well in the mathematics subject if student diversity is appropriately handled. However, limited studies in Philippine schools address student diversity to improve student numeracy skills through differentiated instruction (DI). So, DI strategies were applied in mathematics classrooms to address student diversity for improving numeracy. The study aimed to enhance the numeracy skills of secondary school students through DI strategies such as assessing prior knowledge, open questions, parallel tasks, and technology integration by considering student diversity. A practical action research design with the plan-do-study-act model was used to implement DI strategies for three months in one school. Twenty mathematics teachers who underwent training via learning action cell sessions for five months and five thousand three hundred students from grade 7 to grade 11 served as participants. Teacher-made test material, an adapted questionnaire, and interviews were used to collect data validated by mathematics experts. The results showed that DI strategies addressed student diversity by delivering lessons based on the students' interests, readiness, and learning preferences. Students' numeracy skills increased after integrating DI strategies, as shown by the test scores. However, teachers' challenges arose, like limited pedagogical skills, a shortage of resources, a time-consuming approach, and poor classroom management. The study proved that DI strategies were effective in addressing student diversity to improve the students' numeracy skills. Therefore, mathematics teachers may integrate DI strategies to consider student diversity to produce better learning outcomes.

Keywords: differentiated instruction, numeracy, strategies, student diversity

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INTRODUCTION

Students learn differently (Shukhratovna, 2024), necessitating teachers to adapt their teaching practices and utilize a range of activities to deliver instruction based on student preferences. So, teachers should consider students' diverse backgrounds and experiences to cater to student diversity (Rijal et al., 2025). Also, teachers must provide meaningful learning experiences that meet students' diverse learning needs (Deunk et al., 2018). Hence, a meaningful and joyful learning experience happens if differentiated instruction (DI) is implemented (Anggoro et al., 2024).

In the Philippine context, DepEd Order No. 035 s. 2016 (2016) requires teachers to provide a learning environment that satisfies student diversity needs. Teachers must tailor learning content, procedure, output, and atmosphere to student diversity. Teachers must develop their skills in providing a diverse curriculum because each student is unique. Teacher-varied strategies must accommodate student diversity by considering individual differences (DepEd Order No. 035 s. 2016, 2016). Meanwhile, the DepEd MATATAG agenda requires teachers to address student diversity in curriculum delivery to care for students, provide inclusive education, and create a pleasant learning environment (Department of Education, 2023).

The teacher must change paradigms to provide education relevant to students' interests, learning styles, and intellect. DepEd Order No. 021 s. 2019 (2019) mandates basic education teachers in the Philippines to adopt DI based on multiple intelligences and learning styles to address student diversity in the classroom. Furthermore, for grades K-12, Republic Act no. 10533 (Enhanced Basic

Education Act of 2013) mandated constructivist, collaborative, differentiated, inquiry-based, integrative, and reflective curricular pedagogical approaches. However, teachers must change their teaching approaches and require more expertise in DI implementation (Aldossari, 2018). DI is a solution to student diversity that promotes inclusive education. However, a significant number of teachers failed to use DI in teaching (Qorib, 2024). Eventually, limited studies have been conducted in secondary schools about DI strategies used by teachers to address student diversity.

On the other hand, numeracy is the capacity to use mathematical ideas in daily activities with logical thinking (Samad et al., 2021). Mathematics teachers must develop the numeracy skills of the students through various strategies. Chavez (2019) concluded that DI enhances students' numeracy skills in mathematics. She recommends a more extensive method and design for the study to assess the efficacy of DI in mathematics instruction. Similarly, several prior researchers have attempted various methods to improve student numeracy (Andika et al., 2019; Rohendi, 2019; Samad et al., 2021). However, few studies use DI strategies to improve numeracy skills at secondary schools.

In the local Philippine context, San Pedro Relocation Center National High School is a public institution in the local community that serves about 6,300 diverse students in junior and senior high school programs. Students at this institution must still satisfy the 75% mean (M) percentage score cut-off in mathematics examinations as a manifestation of their improved numeracy skills. As previously said, students might do better numerically based on their learning needs and characteristics. In contrast, students performed poorly in mathematics examinations despite teachers' efforts to meet their learning needs. Therefore, DI is recommended to enhance student learning outcomes. Consequently, math teachers integrate DI strategies to handle student diversity and improve numeracy. Eventually, the students learn mathematics more effectively when DI strategies are used because their learning experiences are varied and reinforced by learning opportunities provided by math teachers.

The study is noteworthy since DI strategies for mathematics instruction are novel in Philippine public secondary schools, aligned with DepEd Order No. 021 s. 2019 (2019). Also, it contributes to the body of knowledge about how DI handles student diversity from the perspective of mathematics teachers, resulting in higher numeracy skills. Furthermore, difficulties experienced during DI implementation are highlighted to impact future action to sustain DI implementation in addressing student diversity. Hence, limited studies investigated the teachers' challenges in DI implementation (Rahmaniar et al., 2024).

LITERATUREREVIEW

DI is a philosophy for an inclusive approach catering to student diversity (Nepal et al., 2024). DI means meeting the needs of diverse mathematics learners (Tabor et al., 2020). On the other hand, many DI studies examine teachers' student diversity techniques (Pozas et al., 2020). DI approaches consider the student's personal learning needs and unique learning potential. Tomlinson and Imbeau (2023) reveal the DI assumptions, such that individual differences significantly influence student learning, the learning process, and the support required from teachers. Student learning occurs best when the curriculum is connected to student interests, learning styles, experiences, and situations. As a result, it is the primary job of teachers to make their students' education relevant, responsive, and empowering. DI is advocated as a pedagogical strategy that fosters emotional, social, and academic success for all students within heterogeneous classes (Gaitas et al. 2022).

DI enhances the academic achievement of students (Chen & Chen, 2018; Özer & Yilmaz, 2018; Saif et al., 2024; Valiandes & Neophytou, 2018) and school performance (Sapan & Mede, 2022). DI is founded on the idea that every student deserves to learn more effectively by using the teacher's many learning opportunities. It helps struggling students excel academically, depending on their talents, while also acknowledging individual differences in a varied setting. However, there is an urgent need to investigate teachers' differentiation practices to accommodate student diversity (Prast et al., 2018). By embracing DI, teachers can construct learning environments where learners feel respected, encouraged, and empowered to attain their maximum potential (Shukhratovna, 2024). DI is the most effective pedagogical method for addressing student diversity to ensure the students' learning outcomes (Saif et al., 2024). Hence, students taught using DI surpassed the academic performance of those students exposed to traditional teaching (Magableh & Abdullah, 2020; Sapan & Mede, 2022).

More empirical investigations are needed to explore implementing teachers' DI practices, specifically focusing on secondary schools (Pozas et al., 2020). The limited use of DI strategies among secondary school teachers might be attributed to their overwhelming workload. Nevertheless, previous studies have investigated the use of DI in elementary education (Ismajli & Imami-Morina, 2018; Mainini & Banes, 2017; Prast et al., 2018). Despite various studies concluding the impact of DI on students' learning, limited studies have been conducted on the benefits of DI (Graham et al., 2021). So, it is timely to investigate the effectiveness of DI strategies in improving the students' numeracy skills. Due to significant disparities in students' skills, prior knowledge, and learning strategies, DI is essential in classroom environments (Iqbal & Muhammad, 2020; Saif et al., 2024). In addition, the application of DI enhances the academic performance of students (Padmore & Ali, 2024).

Smale-Jacobse et al. (2019) reviewed DI systemically at the secondary level. They found that secondary education DI requires additional high-quality empirical research due to the limited studies conducted before. They suggested that more secondary school DI intervention research must be conducted. Thus, addressing the DI literature gap to increase secondary school student performance is crucial. On the other hand, Magableh and Abdullah (2020) used quasi-experimentation and found that DI significantly improves class diversity and mixed-ability student achievement.

Meanwhile, Balgan et al. (2022) examined DI for Mongolian STEM students utilizing learning styles and multiple intelligences. They found that students learned if teachers used the DI since IQ, learning style, and personality type are linked. However, teachers view DI as time-consuming and difficult to apply (Lunsford, 2017; Siam & Al-Natour, 2016). Similarly, Merawi (2018) enumerated the teachers' hurdles to adopting DI, including a lack of teaching resources, insufficient leadership support, an excessive workload, and a lack of teachers' understanding and devotion to applying DI. On the other hand, DI as a teacher professional development program improved students' math achievement by improving teachers' competency (Prast et al., 2018).

In an inclusive classroom setting, DI has been established as the most successful technique for teaching (Onyishi & Sefotho, 2020). However, van Geel et al. (2022) reported that the most critical impediments to DI adoption are time management, a lack of experience, and a lack of knowledge and abilities. Moreover, Al-Shaboul et al. (2021) observed that the barriers to DI implementation were class size, time, and teaching load. Furthermore, resource availability and guidance from the school administration have aided teachers in developing DI implementation. In line with this, Gibbs (2023) concluded that teachers' challenges in implementing DI include few school resources, student behavioral difficulties, and insufficient time for planning and implementation.

Similarly, more appropriate resources or better use of limited materials are required for DI deployment (Sprott, 2019). On the same side, Onyishi and Sefotho (2020) found that big class sizes, availability of resources, learning space, and congested curriculum are challenges for teachers in implementing DI strategies. However, Saif et al. (2024) found the primary impediments to the implementation of DI are high student-to-teacher ratios, limited resources, and, most critically, the extensive training requirements for teachers. Hence, limited international studies have investigated teachers' challenges in integrating DI for decades (Gibbs, 2023; Whitley et al., 2019). So, it is timely to include teachers' challenges in implementing DI when conducting the present study.

THEORETICAL AND CONCEPTUAL FRAMEWORK

DI strategies in this study are assessing prior knowledge, open questions, parallel tasks, and technology integration, which provide a learning experience catering to student diversity. An advocate for DI, Tomlinson (2001), proposed the above practices in mixed-ability classes. As indicated by Al-Shaboul et al. (2021), the lesson was situated on the student's interests, intellect, and learning styles, as supported by Gardner and Hatch (1989) theory of multiple intelligences and Vygotsky's (1978) constructivist principles. The DI-based lessons included a review/drill to assess the previous knowledge, open questions for motivation, parallel tasks for a group activity, open questions for practice, and performance task alternatives with technology integration. According to Pozas et al. (2020), effective technology integration is one of the 21st century's most successful DI approaches for students. Integrating technology tools and online resources enhances DI effectiveness (Hu, 2024). Likewise, DI strategies are beneficial in encouraging and boosting students' mathematical achievement (Awofala & Lawani, 2020).

Figure 1 shows the sample lesson log with DI strategies. Prior knowledge is assessed before the start of the lesson to ensure the students' readiness. Then, open questions are used to motivate the students to think deeply, while parallel tasks are used for group activity so that the students demonstrate creativity and critical thinking. In addition, technology integration is seen in the lesson by using online resources, video clips, and lesson presentations.

The study is based on the plan-do-study-act paradigm developed by Edward Deming and Walter Shewhart (Taylor et al., 2014). This method is widely applied in classroom-based action research, leading to the development of systematic processes for researchers. During the planning stage, the mathematics teachers evaluate the mathematical problems of the students by considering the outcomes of the initial and subsequent grading examinations. Subsequently, the researcher collected empirical data to determine the root causes of students' poor numeracy skills. Then, student profiling is conducted to determine the students' diverse learning styles, intelligence, and interests. Based on the results, the learning gap and student diversity yield diminished numeracy skills. In addition to low numeracy, students exhibit diverse characteristics in their learning preferences, interests, and preferred cognitive abilities.

Figure 2 depicts the study's paradigm. DI strategies in mathematics education are used to address student diversity and improve numeracy skills. The DI strategies used are assessing prior knowledge, open questions, parallel tasks, and technology integration. However, the numeracy skills are measured based on the pre-and post-test results. Also, challenges experienced are elicited to determine the loopholes in DI implementation.

On the other hand, providing in-service professional training for DI is crucial (Saleem et al., 2021, 2023) in supporting teachers in effectively implementing DI strategies and promoting guided teaching practices (Smets, 2017). There is a great need to train teachers on how to apply DI to ensure that the students' needs are met (Qorib, 2024).

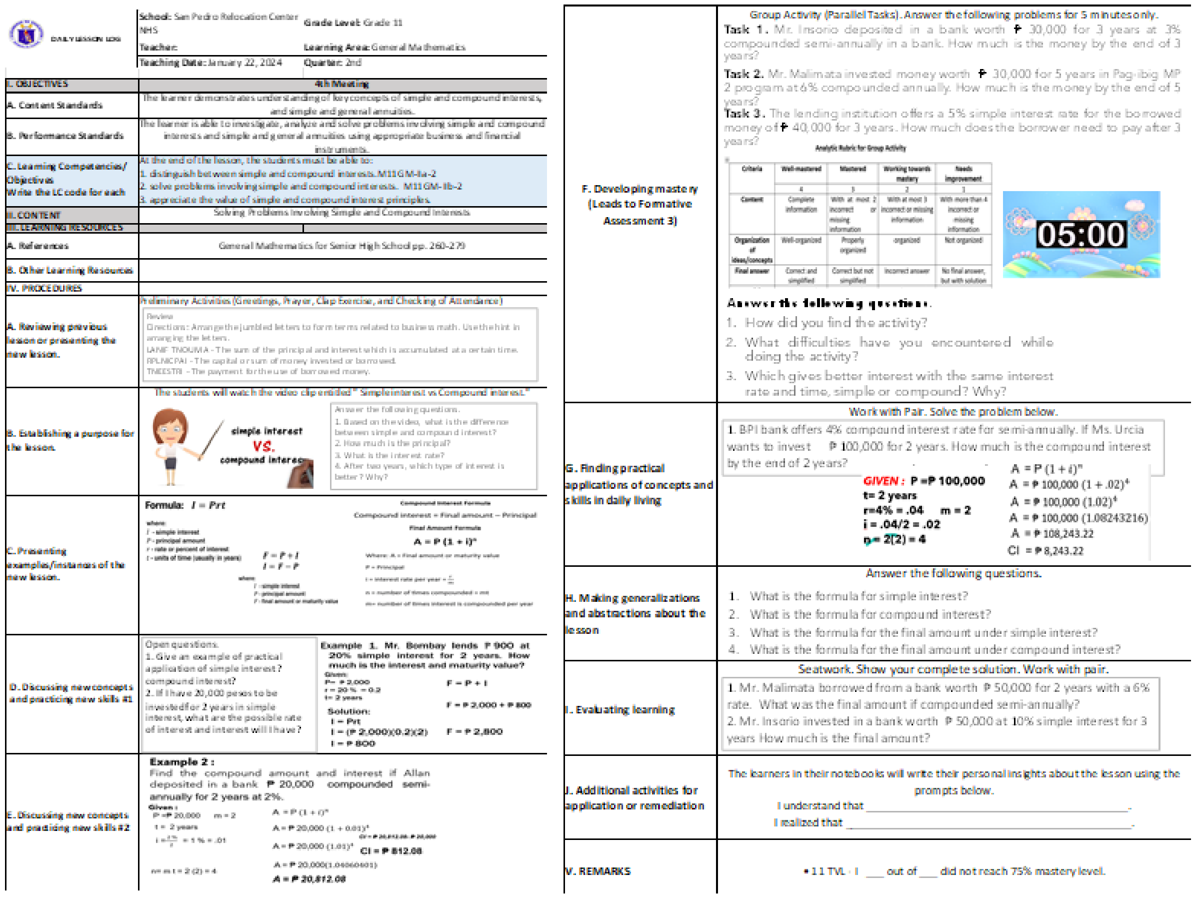

Figure 1. Sample daily lesson log with DI strategies (Source: Author)

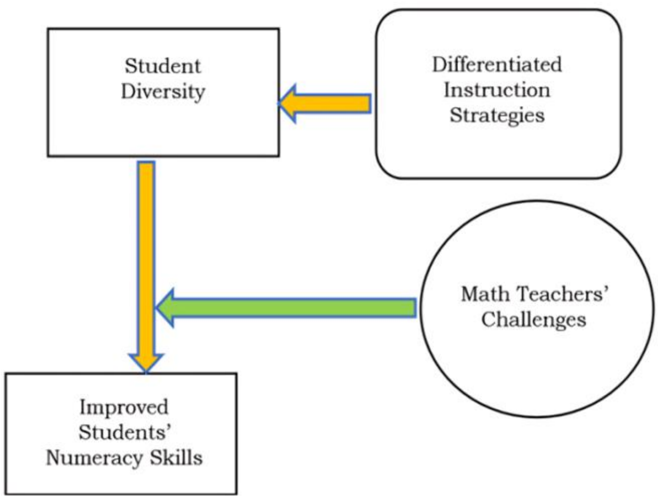

Figure 2. Conceptual paradigm (Source: Author)

According to Kahmann et al. (2022), teacher professional development training is essential in adopting DI. Consequently, the researcher delivers professional development training on DI in mathematics instruction to mathematics teachers by utilizing learning action cells (LAC) sessions to address student diversity as part of the do stage. The mathematics teachers participated in five LAC sessions to gain the necessary skills and knowledge to apply DI strategies effectively. The purpose of these sessions was to enrich their courage and proficiency in applying DI strategies in their teaching practice because the teachers need to be guided in developing DI competence (Eysink et al., 2017; Matsko et al., 2024; van Geel et al., 2019).

Table 1 displays the LAC sessions that commenced in September 2023 and concluded in January 2024. The participants, who were math teachers, had to produce expected outputs demonstrating their recently gained competencies. The five-day training was attended by the math teachers to capacitate them in applying the DI strategies. Implementing school-wide professional development training focusing on DI strategies has been found to enhance teaching practices (Prast et al., 2018). DI is a pedagogical approach that necessitates specialized training for mathematics teachers (Gaitas et al., 2022; Smets, 2017; van Geel et al., 2019). Consequently, the challenges teachers face in implementing DI underscore the need for establishing a professional development initiative (Kahmann, 2022).

After completing the training, DI strategies were implemented for three months, specifically from February to April 2024, to enhance students' numeracy skills. Then, the pre- and post-test scores from examinations are used to determine the numeracy skills of the students. Nevertheless, teachers may require assistance to implement the DI effectively (Gheyssens et al., 2020; Prast et al., 2018) and may encounter challenges throughout the implementation process (Gheyssens et al., 2020). Consequently, various measures were undertaken to ensure the proper application of DI strategies in secondary

Table 1. LAC session topics for mathematics teachers' training

No	Topic	Date	Expected output
1	Revisiting differentiated instruction in mathematics education	3 September 2023	Action plan
2	Developing critical thinking through open questions & parallel tasks	20 September 2023	Samples of open questions & parallel tasks
3	ICT integration in mathematics education	18 October 2023	Activity sheets
4	Assessment: Proof of student learning	15 November 2023	Assessment tasks
5	Contextualization: Making the curriculum relevant and responsive	6 January 2024	Lesson plan

mathematics education, including classroom observation, mentorship, and coaching sessions.

During the study stage, collected data are analyzed statistically and thematically. Reflections are made by reviewing the whole process and identifying the lapses and loopholes of the study. Then, a research report is written carefully following the prescribed parts, including the action plan for the following action research cycle as part of the act stage. The report is submitted to the school administrator and supervisor to critique the content and give suggestions. Hence, dissemination is done at research conferences, professional meetings, and online publications.

Research Questions

This study seeks to improve student numeracy skills by considering student diversity through DI strategies such as assessing prior knowledge, open questions, parallel tasks, and technology integration in secondary mathematics education. It specifically answers the following questions:

1. How do the DI strategies address student diversity to improve student numeracy skills as perceived by the math teachers?
2. How can the students' numeracy skills in terms of scores be described before and after integrating DI strategies?
3. Do the DI strategies effectively improve the numeracy skills of the students?
4. What difficulties do mathematics teachers face when integrating DI strategies to improve the students' numeracy skills?

METHODOLOGY

Research Design

The study's design was practical action research to address student diversity and improve numeracy skills using DI strategies such as assessing prior assessment, open questions, parallel tasks, and technology integration. Because the study looked at a school problem, a practical action research design was the best choice. Teacher practitioners conduct practical action research to study contemporary issues/problems at the school level (Chen & Lin, 2019). A teacher did practical action research to address difficulties in the classroom, school challenges, and practices (Tang, 2022). According to Bondie et al. (2019), most DI studies used a case study approach, with only a few doing action research to evaluate the DI's effectiveness. Therefore, practical action research was the best and most timely approach to solve the students' low numeracy due to student diversity.

Participants of the Study

The participants were twenty mathematics teachers and 5,300 students from grade 7 to grade 11 who attended classes at San Pedro Relocation Center National High School during the school year 2023-2024. Only one school was used as the research locale since the study's nature was action research aims to solve a student's low numeracy in one school. Also, no control group was used for comparison for the test scores. Teachers and students at the institution mentioned above originated from various areas and possessed distinct qualities. The teachers' ages ranged from 26 to 57, with 4 having a master's degree and the rest taking graduate studies. Five male and fifteen female teachers participated fully. Teachers have 4 to 27 years of teaching experience in the said schools and have attended the DI training via school-based LAC.

On the other hand, the students' ages ranged from 12 to 20 years old. The students at this institution have diverse learning interests, styles, and cognitive preferences that contribute to poor numeracy skills. Hence, many students need help with mathematics lessons, necessitating DI strategies to enhance equitable and inclusive mathematics education (Gervasoni et al., 2020). Unfortunately, there have been few studies on secondary students participating in DI (Bondie et al., 2019), particularly in mathematics. So, secondary students were the best participants to investigate the DI's effectiveness.

Instrumentation

The study used self-report survey questionnaires, test materials, and interview guides to collect data. Bondie et al. (2019) contended that previous DI studies needed more methodological rigor to investigate its positive influence on student academic achievement. The researcher believed numerous data collection methods were necessary to refute this claim. Using multiple data collection techniques enabled the researcher to view practices from multiple perspectives, resulting in a more accurate depiction. Multiple data collection methods provided a comprehensive overview of the effectiveness of DI strategies in addressing student diversity and improving students' numeracy.

For student profiling, the McKenzie multiple intelligences inventory (2017), Shumow and Schmidt learning interest inventory (2013), and Reid learning styles inventory (2005) have been adapted with some modifications to suit the present study, like simplicity of

Table 2. Results of experts' content validation

Criteria	Questionnaire	Interview guide	Interpretation
Format & design	2.85	2.94	Suitable
Content	2.96	2.90	Suitable
Clarity	2.90	2.92	Suitable
Usefulness	2.94	2.98	Suitable

statement, adding a Filipino subtitle, and using common words. The profiling results served as bases for crafting DI-based lessons. However, after DI implementation, mathematics teachers were given a survey questionnaire (**Appendix A**) to determine how DI strategies addressed student diversity and improved student numeracy. The teachers' perception of differentiation in mathematics teaching is vital to consider (Hayden et al., 2024). The questionnaire comprised demographic information such as sex, age, maximum educational attainment, years of teaching mathematics, grade level taught, five open-ended questions, and ten Likert scale judgments with six response options. Ten items were included in the questionnaire using the scale from one to six to measure the teacher's perceptions. Four items were taken from Al-Shaboul et al. (2021), three from Handa (2020), and another three from Prast et al. (2018), with modifications like changing the tense of the verb, making the sentence short, and rephrasing the items to make them more applicable to the study. So, the researcher emailed the authors to request permission to use their work.

In addition, a seven-item interview guide about challenges was designed to elicit qualitative feedback from teachers as a supplement to quantitative data reviewed by mathematics education specialists. The questionnaire and interview guide initial draft were then distributed to five expert validators, including the head teacher, three education program supervisors, and a senior education program specialist, for their input on the content and usability. Then, the experts suggested rearranging the items, using common words, and making grammatical corrections. The instruments considered the experts' suggestions in revision. Consequently, content validation was conducted by a committee of subject matter experts who thoroughly reviewed each item (Ismail & Zubairi, 2021).

Table 2 shows the results of experts' validation in terms of the questionnaire's and interview guide's format and design, content, clarity, and usefulness using the scale from one to three, which means 1 for not suitable, 2 for needs revision, and 3 for suitable. Hence, M scores show that both the questionnaire and interview guide were suitable to collect the target data as rated by the experts.

In the third grading period for grade 7 to grade 11, 40 pre- and post-test items were made to evaluate prior and acquired numeracy skills. The test materials were created using the mathematics curriculum guide by the mathematics teachers who attended the DI training. Hence, test materials were validated by the mathematics department's head teacher. After establishing content validation, pilot testing of the questionnaire and test materials was done to determine the internal consistency in one section in the same school with 50 respondents, calculated using Cronbach's alpha and Kuder-Richardson formula 21. The questionnaire obtained a .853 reliability index, while the test material obtained a .876, .887, .896, .852, and .889 from grade 7 to grade 11.

To determine the quality of the test materials, item analysis was conducted on the collected data (Sharma, 2021). The grade 7 pre-test material included twenty easy items with a difficulty index of 0.60-0.79, twelve average items with an index of 0.40-0.59, and eight difficult items with an index of 0.20-0.39. Fifteen excellent items fell between 0.30 and 0.39 in the discrimination index, and twenty-five exceptional items exceeded 0.40. As a result, the distractor efficiency was 100% for thirty-two items and 66.66% for eight. In contrast, the post-test material consists of eighteen easy items with a difficulty index of 0.60 to 0.79, seventeen average items with a difficulty index of 0.40 to 0.59, and five difficult items with a difficulty index of 0.20 to 0.39. However, the discrimination index ranged from 0.30 to 0.39 for thirteen items, while for twenty-seven exceeded 0.40. As a result, the distractor efficiency was 100% for thirty items and 66.66% for ten items.

Meanwhile, the grade 8 pre-test material included twenty-two easy items with a difficulty index of 0.60-0.79, ten average items with an index of 0.40-0.59, and eight difficult items with an index of 0.20-0.39. Fourteen excellent items fell between 0.30 and 0.39 in the discrimination index, and twenty-six exceptional items exceeded 0.40. As a result, the distractor efficiency was 100% for thirty items and 66.66% for ten items. In contrast, the post-test material consists of nineteen easy items with a difficulty index of 0.60 to 0.79, eighteen average items with a difficulty index of 0.40 to 0.59, and three difficult items with a difficulty index of 0.20 to 0.39. However, the discrimination index ranged from 0.30 to 0.39 for fifteen items, while for twenty-five exceeded 0.40. As a result, the distractor efficiency was 100% for thirty-one items and 66.66% for nine items.

On the other hand, the grade 9 pre-test material included twenty easy items with a difficulty index of 0.60-0.79, ten average items with an index of 0.40-0.59, and ten difficult items with an index of 0.20-0.39. Seventeen excellent items fell between 0.30 and 0.39 on the discrimination index, and twenty-three exceptional items exceeded 0.40. As a result, the distractor efficiency was 100% for twenty-five items and 66.66% for fifteen items. In contrast, the post-test material consists of twenty easy items with a difficulty index of 0.60 to 0.79, eleven average items with a difficulty index of 0.40 to 0.59, and nine difficult items with a difficulty index of 0.20 to 0.39. However, the discrimination index ranged from 0.30 to 0.39 for fourteen items, while for twenty-six exceeded 0.40. As a result, the distractor efficiency was 100% for thirty items and 66.66% for ten items.

In addition, the grade 10 pre-test material included sixteen easy items with a difficulty index of 0.60-0.79, fourteen average items with an index of 0.40-0.59, and ten difficult items with an index of 0.20-0.39. Twenty excellent items fell between 0.30 and 0.39 in the discrimination index, and twenty exceptional items exceeded 0.40. As a result, the distractor efficiency was 100% for twenty-six items and 66.66% for fourteen items. In contrast, the post-test material consists of twenty easy items with a difficulty index of 0.60 to 0.79, ten average items with a difficulty index of 0.40 to 0.59, and ten difficult items with a difficulty index of 0.20 to 0.39. However, the discrimination index ranged from 0.30 to 0.39 for eighteen items, while for twenty-two exceeded 0.40. As a result, the distractor efficiency was 100% for twenty-five items and 66.66% for fifteen items.

Lastly, the grade 11 pre-test material included seventeen easy items with a difficulty index of 0.60-0.79, thirteen average items with an index of 0.40-0.59, and ten difficult items with an index of 0.20-0.39. Twenty-three excellent items fell between 0.30 and 0.39 on the discrimination index, and seventeen exceptional items exceeded 0.40. As a result, the distractor efficiency was 100% for twenty-five items and 66.66% for fifteen items. In contrast, the post-test material consists of eighteen easy items with a difficulty index of 0.60 to 0.79, fourteen average items with a difficulty index of 0.40 to 0.59, and eight difficult items with a difficulty index of 0.20 to 0.39. However, the discrimination index ranged from 0.30 to 0.39 for twenty items, while for the remaining twenty exceeded 0.40. As a result, the distractor efficiency was 100% for twenty-four items and 66.66% for sixteen items.

Data Gathering

Permission from the school head was required as part of the process. Then, student profiling and a pre-test dated the second week of January 2024 were administered to determine the students' interests, intelligence, and learning styles, and measure their prior knowledge. The results of the pre-test were retained for future use. DI strategies such as assessing prior knowledge, open questions, parallel tasks, and technological integration were used for three months, from the third week of January 2024 to the third week of April 2024. Therefore, DI classroom implementation was done forty-eight times. Hence, classroom observation and checking of lesson plans were done to ensure the DI implementation weekly. Then, following implementation, students were given a post-test based on the test results to assess their numeracy skills in the fourth week of April 2024. Then, the pre- and post-test scores were compared.

On the other hand, the survey questionnaire was delivered to math teachers in the first week of May 2024 to elicit feedback on how DI strategies address student diversity and contribute to numeracy for their students. However, an interview was undertaken in the second week of May 2024 to obtain qualitative data to ensure accurate responses. Teachers were asked about the challenges experienced because limited qualitative studies have been conducted in the past decades about teachers' experiences in integrating DI (Gibbs, 2023). So, qualitative data were elicited in the study.

For positionality and reflexivity, the researcher had taught mathematics at the same school for nine years. He published several action research articles in various international peer-reviewed journals. To foster objectivity, he withdrew himself and his students from the set of participants. Personal biases were set aside, and bracketing was used to exclude his assumptions that math teachers execute the DI procedures in good faith to prevent data contamination and ensure data integrity. Consequently, he refrained from influencing the participants to partake in the research. Also, he believes that student diversity, when properly addressed, promotes better numeracy.

Ethical Considerations

Research must follow ethical principles (Astaneh & Masoumi, 2018; Stockemer, 2019). The researcher first obtained permission from the school head to adhere to ethical standards and then communicated effectively with mathematics teachers through training, guidance, and mentoring. However, no ethical review board confirmed the ethical compliance of the study. Only the school head who reviewed the research process before the issuance of the permit to conduct. Additionally, prior approval was obtained from the questionnaire's original authors. Also, informed consent was secured before the participants' engagement. Participation was purely voluntary, and participants received no compensation. However, they may terminate their participation at any time.

Likewise, their identities were concealed, and the information garnered from them was kept confidential to prevent potential damage. In addition, the research report and data were stored solely on the researcher's computer, which was deleted two years later. Only professional conferences, faculty meetings, and journal publications served as dissemination channels of the findings.

Data Analysis

Descriptive statistics were computed using Jamovi version 2.4.14 to calculate the M scores, median for ordinal data (Lydersen, 2020), standard deviation (SD), interquartile range, Shapiro-Wilk test, and Levene's test. The study used the paired sample t-test to test whether DI strategies affect numeracy before and after DI integration (Rietveld & van Hout, 2017) and Cohen's d to assess practical significance when data distribution was normal (Goulet-Pelletier & Cousineau, 2018; Lovakov & Agadullina, 2021).

Table 3 shows the results of the normality test and the homogeneity test of variances. The pre- and post-test scores resembled a normal distribution ($p > .05$) using the Shapiro-Wilk test.

It means that the parametric test of difference must be used to test the hypothesis, particularly the paired sample t-test. However, Cohen's d was employed for practical significance (Grech & Calleja, 2018). Similarly, the variances were homogenous ($p > .05$) using Levene's test. At a .05 significance level, the assumption of the paired sample t-test and Cohen's d were satisfied.

Table 3. Homogeneity of variances using Levene's test and normality test Shapiro-Wilk for the test materials

Test	Grade level	Levene's test				Shapiro-Wilk	
		Statistic	df_1	df_2	Sig.	Statistic	Sig.
Pre-test	7	.191	1	18	.667	.912	.068
	8	.148	1	18	.705	.955	.453
	9	2.504	1	23	.127	.947	.201
	10	3.460	1	23	.064	.971	.677
	11	.244	1	23	.626	.924	.348
Post-test	7	.008	1	18	.977	.987	.634
	8	1.392	1	18	.253	.932	.208
	9	.551	1	23	.465	.946	.371
	10	.026	1	23	.872	.982	.558
	11	1.130	1	23	.299	.942	.316

Table 4. Teachers' perception of how DI strategies address student diversity

Statement	MD	IQR	Interpretation
1. Applying differentiation in my mathematics lessons positively affects my students' numeracy.	5	1.25	Strongly agree
2. Differentiated instruction achieved effective learning by addressing student diversity.	5	0.00	Strongly agree
3. Differentiated instruction allows the students to brainstorm ideas and explore possible solutions to mathematical problems.	5	1.25	Strongly agree
4. Differentiated instruction involves the students in learning, considering their varied learning styles, interests, and preferences.	5	2.00	Strongly agree
5. Differentiated instruction produces students' interaction by requiring them to work as a team despite individual differences.	5	1.00	Strongly agree
6. Differentiated instruction makes the math lessons meaningful to diverse students' interests, learning styles, and intelligence.	5	1.25	Strongly agree
7. Differentiated instruction allows the students to understand mathematics concepts and ideas better.	5	1.25	Strongly agree
8. Differentiated instruction allows students to think differently about mathematics problems and promotes inclusive education.	5	1.00	Strongly agree
9. Students can select their preferred tasks and activities through differentiated instruction.	5	1.25	Strongly agree
10. Students can express their creativity in delivering their outputs.	5	1.25	Strongly agree

Note. MD: Median & IQR: Inter-quartile range

On the other hand, thematic analysis was utilized to get correct information from qualitative data. The interview replies were transcribed and read aloud twice by the researcher. Every sentence was allocated with a code to indicate the replies. The coded data were analyzed and organized based on their similarities and differences, which were then organized into more significant concepts called categories, and the categories were organized into themes (Creswell & Plano Clark, 2017). Thematic analysis is a method to convert qualitative data into a pattern of concepts known as themes (Castleberry & Nolen, 2018; Kiger & Varpio, 2020).

Intercoder agreement was used to ensure the reliability of data analysis by asking two research teachers to construct codes, categories, and themes. The two research teachers agreed on the codes by 0.89 using Cohen's kappa, which means nearly perfect agreement. Consequently, transcripts and data analysis were returned to participants to query the completeness and quality of data to establish member checking (Candela, 2019). Participants were asked to check the transcript and themes to examine the qualitative findings represents their insights.

RESULTS

Table 4 depicts teachers' perceptions of how DI addressed student diversity. The teachers believed that DI addressed student diversity by considering the students' learning styles, interests, and preferences in lesson planning and execution. DI allowed the students to brainstorm ideas and explore various solutions to mathematical problems and produced student interaction despite individual differences. Also, students can choose preferred tasks and activities to perform, wherein student creativity can be expressed freely. They were empowered to demonstrate learning. Moreover, DI allowed the students to understand mathematics concepts and ideas better, resulting in better numeracy skills.

Table 5 depicts the descriptive analysis of the pre- and post-test scores. Out of 40 items, pre-test scores got 29 as the highest, while 2 were the lowest. However, the post-test scores range from 2 to 40. Grade 10 had the lowest M score ($M = 10.91$) for the pre-test, while grade 7 got the highest ($M = 14.36$). On the other hand, grade 10 had the lowest M score ($M = 18.20$) for the post-test, while grade 8 got the highest M score ($M = 20.50$). DI enhances the student's academic performance based on the observed improvement in test scores.

Table 6 depicts the repeated measures ANOVA for significant differences. It can be gleaned from **Table 6** that there is a significant difference between the pre- and post-test scores ($F = 366.99$, $p < .001$). However, there is no significant difference among the pre-test scores from grade 7 to 11 ($F = 1.59$, $p = .183$). Similarly, significant differences among the post-test scores did not exist.

Table 5. Descriptive statistics of the pre- and post-test scores

Test	Grade level	Minimum score	Maximum score	M	SD
Pre-test	7	2	29	14.36	3.90
	8	2	28	12.47	3.97
	9	3	25	12.88	3.23
	10	2	25	10.91	3.11
	11	3	31	13.50	3.50
Post-test	7	3	39	19.97	5.80
	8	5	40	20.50	6.63
	9	2	40	19.17	5.81
	10	3	39	18.20	5.21
	11	4	39	19.42	5.05

Table 6. Repeated measures ANOVA for significant differences

Sources	Sum of squares	df	Mean square	F	p	η^2_G
Pre- & post-test	2,514.4	1	2,514.40	366.99	< .001	0.562
Pre- & post-test * grade level	43.5	4	10.87	1.59	.183	0.022
Residual	760.5	111	6.85			

Table 7. Paired sample t-test for significant difference and effect size using Cohen's d

Test	Grade level	Paired differences		t	df	Sig. (2-tailed)	Cohen's d
		M	Standard error mean				
Pre-/post-test	7	5.61	1.068	5.25	19	.000	1.17
	8	8.03	.650	12.35	19	.000	2.76
	9	6.29	.626	10.05	25	.000	1.97
	10	7.30	.609	11.99	24	.000	2.40
	11	5.92	.866	6.83	24	.000	1.37

The paired sample t-test results for significant difference and effect size using Cohen's d are shown in **Table 7**. The p-value (p = .000) shows a statistical difference between the pre- and post-test scores. This means that DI strategies effectively improved the students' numeracy skills based on the observed M scores improvement. Similarly, the effect size greater than 1 signifies the effect of DI strategies in increasing numeracy skills. This implies that DI strategies significantly improved the students' mathematical abilities.

Table 8 depicts the challenges that mathematics teachers who implemented the DI in their classes face. It can be gleaned from **Table 8** that teachers need more pedagogical skills to sustain various integrations of DI strategies in every lesson. They found that integrating DI consumed much of their time in the preparation of lessons, activities, and varied assessment forms. Also, they need help managing classes to cater to the students' different learning needs since the class size ranges from 30 to 45 students per classroom. As supported by Al-Shaboul et al.'s (2021) findings, class size and time limitations are barriers to DI implementation. In addition, the lack of resources contributed to the problems of the teachers.

The participants' words supported the findings above.

> "Preparing differentiated lessons requires time and effort. Creating multiple versions of learning activities to cater to different learning needs."–Participant 2

> "The challenges in implementing DI include time constraints, classroom management, resource limitations, and addressing parental expectations."–Participant 4

> "I encountered problems in the implementation of DI are class management, individualized instruction of a large group can be overwhelming, collaboration, and resources."–Participant 14

DISCUSSION

This study aims to investigate the effectiveness of DI strategies in secondary mathematics education to address student diversity and improve students' numeracy. Student diversity is addressed through teachers' DI strategies, wherein learning interests, readiness, and preferences are prioritized. So, mathematics lessons become more exciting and meaningful in the students' eyes, parallel to Anggoro et al.'s (2024) findings. Considering student differences, DI strategies accommodate student diversity (DepEd Order No. 035 s. 2016, 2016). So, DI solves student diversity to promote inclusive education (Qorib, 2024).

By assessing students' prior knowledge, teachers could determine the students' readiness before teaching the lesson through pre-tests, drills, or reviews. On the other hand, open questions ignite the students' thinking skills and motivate them to think deeply about the mathematical problem. The parallel tasks allow the students to work in groups, brainstorm, and show their acquired competencies fairly. However, integrating technology made lesson delivery convenient, engaging, and attractive for students. Overall, DI strategies in mathematics education address student diversity, which causes students to have better

Table 8. Difficulties faced by the teachers when integrating DI strategies

Themes	Description
Limited pedagogical skills	Teachers lack sufficient training in DI methods.
Time consuming	Planning differentiated lessons requires significant preparation—developing multiple versions of materials, assessments, and activities.
Poor classroom management	Teachers found DI activities led to noise, off-task behavior, and difficulty maintaining control due to the large number of students in a class.
Shortage of resources	Limited materials, technology, and learning aids contribute to the difficulty in DI implementation.

numeracy skills, supporting Chen and Chen's (2018) findings, Özer and Yilmaz's (2018) findings, and Valiandes and Neophytou's (2018) findings.

The effectiveness of DI depends mainly on teachers' application of appropriate strategies (van Geel et al., 2019). Hence, crafting lessons based on the students' interests, intelligence, and preferences, providing options for the students to choose preferred activities, and integrating the available technology make the DI effective in improving students' numeracy. Technology integration is an effective method for DI (Hu, 2024; Pozas et al., 2020). As a result, student numeracy skills improved, as shown in their scores, since student diversity is considered. Nevertheless, grade 10 students have the lowest pre- and post-test scores because the test materials have more difficult items with a high distraction index compared to other grade levels. Also, the test content is more difficult for the grade 10 students.

However, DI integration only sometimes comes smoothly. Challenges arise as usual in integrating DI strategies from the teachers, which are considered to address the challenges in the future. Teachers experienced a shortage of resources, which is similar to the findings of Gibbs (2023) and Saif et al. (2024), limited pedagogical skills, similar to the findings of van Geel et al. (2022), time-consuming, parallel to the findings of Siam and Al-Natour (2016), Lunsford (2017), and Al-Shaboul et al. (2021), and poor classroom management, similar to the findings of Onyishi and Sefotho (2020), however opposing the findings of Merawi (2018) wherein excessive teaching load and insufficient leadership support are the main challenges. However, Onyishi and Sefotho (2020) claim that teachers face difficulties applying DI techniques due to large class sizes, limited resources, a crowded curriculum, and a lack of learning space.

The study believes that the DI integration of mathematics teachers could have been better. Lapses have been observed due to limited resources and time constraints. For instance, using open questions is not regularly done because some mathematical topics are abstract and require only one correct answer. Also, due to limited materials, parallel tasks are done during group activity once or twice a week. However, technology tools like television, calculators, cellphones, and laptops are commonly used since they are available. So, in the next action research cycle, teachers find ways to maximize the integration of DI strategies despite challenges.

The lens of multiple intelligences theory supports the DI concept, which offers students several learning opportunities based on their preferred intelligence, leading to improved learning. If mathematics teachers recognize student diversity, they must carefully arrange every task designed to encourage the use of their diverse intelligence. Meanwhile, the study contributes to the importance of utilizing multiple intelligence theory by providing empirical data that students' intelligence can be used as a basis for lesson planning and execution. On the other hand, students became active knowledge creators if their learning styles and interests were integrated into lesson planning, adding to the constructivist principle that learning occurs when students understand something through independent discovery (Vygotsky, 1978).

The study supported the effectiveness of DI strategies in mathematics education. As a result, teachers may use various DI strategies to meet the unique learning demands of their students while considering their learning preferences, intelligence, and styles. Mathematics teachers must foster inclusive learning spaces that keep the students involved to address student diversity. Hence, DI removes barriers to inclusive and active learning, making mathematics more entertaining, engaging, and relevant (Yavuz, 2020), which leads to better numeracy, supporting the findings of Chavez (2019). However, feedback on the DI strategies impact based on student outputs is required to make the appropriate modifications to enhance the student learning experience and numeracy skills.

The study's limitations are three months of DI implementation in one school, since the nature of the study is action research. Also, no control group is used to compare the test scores of the participants, which makes the findings context-specific and may not be applied to other schools. Therefore, future studies on DI may use different sites and a true experimental design to replicate the present study. Moreover, students' experiences are not considered in the present study, but only the math teachers' experiences. Hence, strongly recommended for future studies to incorporate students' experiences to provide a holistic view of DI's impact on students' learning.

In addition, test scores and math teachers' perceptions and experiences are the sources of data. The study did not include students' outputs, classroom observation data, focus group discussions, and teachers' reflections due to limited time, which may affect the generalizability of the findings, which future studies may address. Moreover, the study was conducted in a natural setting with no randomization or control of variables. In addition, correlations between teachers' demographics and DI perception are beyond the scope of the study, which represents an analytic gap.

CONCLUSIONS AND RECOMMENDATIONS

DI strategies such as assessing prior knowledge, open questions, parallel tasks, and technology integration address student diversity by considering student interests, readiness, and learning preferences. Through these strategies, students brainstorm ideas, explore different perspectives on dealing with mathematical problems, and have options to demonstrate their learning competencies. In terms of numeracy skills, students have low numeracy skills based on the scores from the pre-test. However, numeracy skills improved after integrating DI strategies. So, DI effectively improved the student numeracy skills by addressing student diversity.

Teachers experienced difficulties when integrating DI strategies, such as a shortage of resources, time consumption, poor classroom management, and limited pedagogical skills. Therefore, coaching and mentoring sessions from master teachers, peer assistance with co-teachers, and the provision of technology tools, teaching materials, and online resources are needed. Therefore, it is suggested that school administrators take the necessary actions to consider the challenges to produce better student numeracy skills.

The school administrators may continually support the teachers' DI implementation not only in mathematics subjects but also in other disciplines. Also, they may craft professional development for teachers on how to effectively implement DI strategies despite having limited resources. The DI strategies, such as assessing prior knowledge, open questions, parallel tasks, and technology integration, promise better learning outcomes if properly executed. Therefore, teachers may use these strategies to improve the quality of students' learning experience. Furthermore, peer collaboration may be done to reduce the teachers' planning and preparation time for DI instruction. In addition, feedback from the students may be used by the teacher in modifying DI strategies based on students' interests, readiness, and learning preferences. Hence, students' surveys or focus group discussions may be done by future researchers of DI.

The study is limited to one public school since the study's nature is action research. In addition, no ethical review board was obtained before data collection. So, it is recommended that a parallel study be conducted in other schools, subject to ethical review board approval, to verify the study's findings. Furthermore, a longer implementation of DI strategies in public schools to have more students benefit from DI. Also, teachers who are not teaching mathematics may integrate DI strategies such as assessing prior assessments, open questions, parallel tasks, and technology integration in their teaching. Hence, teachers need to consider student diversity in crafting the lessons to suit student learning needs.

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REFERENCES

Aldossari, A. T. (2018). The challenges of using the differentiated instruction strategy: A case study in the general education stages in Saudi Arabia. *International Education Studies*, 11(4), 74-83. https://doi.org/10.5539/ies.v11n4p74

Al-Shaboul, Y., Al-Azaizeh, M., & Al-Dosari, N. (2021). Differentiated instruction between application and constraints: Teachers' perspective. *European Journal of Educational Research*, 10(1), 127-143. https://doi.org/10.12973/eu-jer.10.1.127

Andika, W. D., Akbar, M., Yufiarti, & Sumarni, S. (2019). Playing board games with mathematical self-concept to support early numeracy skill of 5-6 years old children. *Journal of Physics: Conference Series*, 1166, Article 012019. https://doi.org/10.1088/1742-6596/1166/1/012019

Anggoro, S., Fitriati, A., Thoe, N. K., Talib, C. A., & Mareza, L. (2024). Differentiated instruction based on multiple intelligences as promising joyful and meaningful learning. *International Journal of Evaluation and Research in Education*, 13(2), 1194-1204. https://doi.org/10.11591/ijere.v13i2.24791

Astaneh, B., & Masoumi, S. (2018). From paper to practice: Indexing systems and ethical standards. *Science and Engineering Ethics*, 24, 647-654. https://doi.org/10.1007/s11948-017-9899-x

Awofala, A., & Lawani, A. (2020). Increasing mathematics achievement of senior secondary school students through differentiated instruction. *Journal of Educational Sciences*, 4(1), 1-19. https://doi.org/10.31258/jes.4.1.p.1-19

Balgan, A., Renchin, T., & Ojgoosh, K. (2022). An experiment in applying differentiated instruction in STEAM disciplines. *Eurasian Journal of Educational Research*, 98, 21-37. https://ejer.com.tr/manuscript/index.php/journal/article/view/666/86

Bondie, R., & Dahnke, C., & Zusho, A. (2019). How does changing "one-size-fits-all" to differentiated instruction affect teaching? *Review of Research in Education*, 43, 336-362. https://doi.org/10.3102/0091732X18821130

Candela, A. G. (2019). Exploring the function of member checking. *The Qualitative Report*, 24(3), 619-628. https://doi.org/10.46743/2160-3715/2019.3726

Castleberry, A., & Nolen, A. (2018). Thematic analysis of qualitative research data: Is it as easy as it sounds? *Currents in Pharmacy Teaching and Learning*, 10(6), 807-815. https://doi.org/10.1016/j.cptl.2018.03.019

Chavez, R. A. (2019). Improving the numeracy skills of grade five pupils through differentiated instruction in Duhat Elementary School S. Y. 2017-2018. *Ascendens Asia Journal of Multidisciplinary Research Abstracts*, 3(2L). https://ojs.aaresearchindex.com/index.php/AAJMRA/article/view/11259

Chen, C. S., & Lin, J. W. (2019). A practical action research study of the impact of maker-centered STEM-PjBL on a rural middle school in Taiwan. *International Journal of Science and Mathematics Education*, 17(1), 85-108. https://doi.org/10.1007/s10763-019-09961-8

Chen, J. H., & Chen, Y.-C. (2018). Differentiated instruction in a calculus curriculum for college students in Taiwan. *Journal of Education and Learning*, 7(1), 88-95. https://doi.org/10.5539/jel.v7n1p88

Creswell, J. W., & Plano Clark, V. L. (2017). *Designing and conducting mixed methods research* (3rd ed.). SAGE. https://www.scirp.org/reference/referencespapers?referenceid=2697821

Department of Education. (2023). MATATAG: DepEd's new agenda to resolve basic education woes. *Department of Education*. https://www.deped.gov.ph/2023/01/30/matatag-depeds-new-agenda-to-resolve-basic-education-woes/

DepEd Order No. 021 s. 2019. (2019). Policy guidelines on the K to 12 basic education program. *Department of Education*. https://www.deped.gov.ph/wp-content/uploads/2019/08/DO_s2019_021.pdf

DepEd Order No. 035 s. 2016. (2016). The learning action cell as a K to 12 basic education program school-based continuing professional development strategy for the improvement of teaching and learning. *Department of Education*. https://www.deped.gov.ph/wp-content/uploads/2016/06/DO_s2016_035.pdf

Deunk, M. I., Smale-Jacobse, A. E., de Boer, H., Doolaard, S., & Bosker, R. J. (2018). Effective differentiation practices: A systematic review and meta-analysis of studies on the cognitive effects of differentiation practices in primary education. *Educational Research Review*, 24, 31-54. https://doi.org/10.1016/j.edurev.2018.02.002

Eysink, T. H., Hulsbeek, M., & Gijlers, H. (2017). Supporting primary school teachers in differentiating in the regular classroom. *Teaching and Teacher Education*, 66, 107-116. https://doi.org/10.1016/j.tate.2017.04.002

Gaitas, S., Carêto, C., Peixoto, F., & Castro Silva, J. (2022). Differentiated instruction: 'To be, or not to be, that is the question'. *International Journal of Inclusive Education*, 28(11), 2607-2623. https://doi.org/10.1080/13603116.2022.2119290

Gardner, H., & Hatch, T. (1989). Educational implications of the theory of multiple intelligences. *Educational Researcher*, 18(8), 4-10. http://dx.doi.org/10.2307/1176460

Gervasoni, A., Downton, A., & Roche, A. (2021). Differentiating instruction for students who fail to thrive in mathematics: The impact of a constructivist-based intervention approach. *Mathematics Teacher Education and Development*, 23(3), 207-233. https://files.eric.ed.gov/fulltext/EJ1321054.pdf

Gheyssens, E., Consuegra, E., Vanslambrouck, S., Engels, N., & Struyven, K. (2020). Differentiated instruction in practice: Do teachers walk the talk? *Pedagogische Studien*, 97, 163-186. https://cris.vub.be/ws/portalfiles/portal/109270972/Gheyssens_2021_phd_94_120.pdf

Gibbs, K. (2023). Voices in practice: Challenges to implementing differentiated instruction by teachers and school leaders in an Australian mainstream secondary school. *The Australian Educational Researcher*, 50, 1217-1232. https://doi.org/10.1007/s13384-022-00551-2

Goulet-Pelletier, J-C., & Cousineau, D. (2018). A review of effect sizes and their confidence intervals, part {I}: The Cohen's d family. *The Quantitative Methods for Psychology*, 14, 242-265. https://doi.org/10.20982/tqmp.14.4.p242

Graham, L. J., Bruin, K. De, Lassig, C., & Spandagou, I. (2021). A scoping review of 20 years of research on differentiation: Investigating conceptualisation, characteristics, and methods used. *Review of Education*, 9(1), 161-198. https://doi.org/10.1002/rev3.3238

Grech, V., & Calleja, N. (2018). WASP (write a scientific paper): Parametric vs. non-parametric tests. *Early Human Development*, 123, 48-49. https://doi.org/10.1016/j.earlhumdev.2018.04.014

Handa, M. C. (2020). Examining students' and teachers' perceptions of differentiated practices, student engagement, and teacher qualities. *Journal of Advanced Academics*, 31(4), 530-568. https://doi.org/10.1177/1932202x20931457

Hayden, S. M., Gubbins, E. J., Cody, R. A., & Boldt, G. T. (2024). Teachers' perceptions of differentiation following a math curriculum implementation study. *Journal for the Education of the Gifted*, 47(1), 3-29. https://doi.org/10.1177/01623532231215092

Hu, L. (2024). Utilization of differentiated instruction in K-12 classrooms: A systematic literature review (2000-2022). *Asia Pacific Education Review*, 25, 507-525 https://doi.org/10.1007/s12564-024-09931-y

Iqbal, T., & Muhammad, Y. (2020). Using differentiated instruction in inclusive schools: A qualitative analysis of prospective teachers' self-efficacy. *Journal of Inclusive Education*, 4(1), 229-257. https://ojs.aiou.edu.pk/index.php/jie/article/view/2009

Ismail, F. K. M., & Zubairi, A. M. B. (2022). Item objective congruence analysis for multidimensional items content validation of a reading test in Sri Lankan University. *English Language Teaching*, 15(1), 106-117. https://doi.org/10.5539/elt.v15n1p106

Ismajli, H., & Imami-Morina, I. (2018). Differentiated Instruction: Understanding and applying interactive strategies to meet the needs of all the students. *International Journal of Instruction*, 11(3), 207-218. https://doi.org/10.12973/iji.2018.11315a

Kahmann, R., Droop, M., & Lazonder, A. (2022). Meta-analysis of professional development programs in differentiated instruction. *International Journal of Educational Research*, 116, Article 102072. https://doi.org/10.1016/j.ijer.2022.102072

Kiger, M., & Varpio, L. (2020). Thematic analysis of qualitative data: AMEE guide no. 131. *Medical Teacher*, 42(8), 846-854. https://doi.org/10.1080/0142159X.2020.1755030

Lovakov, A., & Agadullina, E. (2021). Empirically derived guidelines for effect size interpretation in social psychology. *European Journal of Social Psychology*, 51(3), 485-504. https://doi.org/10.1002/ejsp.2752

Lunsford, K. (2017). *Challenges to implementing differentiated instruction in middle school classrooms with mixed skill levels* [PhD thesis, Walden University]. https://scholarworks.waldenu.edu/cgi/viewcontent.cgi?article=6300&context=dissertations

Lydersen, S. (2020). Mean and standard deviation or median and quartiles? *Tidsskriftet*, 140(9). https://doi.org/10.4045/tidsskr.20.0032

Magableh, I. S. I., & Abdullah, A. (2020). On the effectiveness of differentiated instruction in the enhancement of Jordanian students' overall achievement. *International Journal of Instruction*, 13(2), 533-548. https://doi.org/10.29333/iji.2020.13237a

Mainini, M., & Banes, L. (2017). Differentiating instruction to increase conceptual understanding and engagement in mathematics. *Journal of Teacher Action Research*, 4(1), 81-100. https://ln.run/BKBa7

Matsko, K. K., Hammerness, K., & Lee, R. E. (2024). Learning in context and practicing in place: Engaging preservice teachers in urban-focused context specific teacher education. *Urban Education*, 59(4), 1191-1223. https://doi.org/10.1177/00420859211065188

Merawi, T. M. (2018). Primary school teachers ' perceptions of differentiated instruction (DI) in Awi Administrative Zone, Ethiopia. *Bahir Dar Journal of Education*, 18(2), 152-173. https://www.ajol.info/index.php/bdje/article/view/248728/235208

Nepal, S., Walker, S., & Dillon-Wallace, J. (2024). How do Australian pre-service teachers understand differentiated instruction and associated concepts of inclusion and diversity? *International Journal of Inclusive Education*, 28(2), 109-123. https://doi.org/10.1080/13603116.2021.1916111

Onyishi, C., & Sefotho, M. (2020). Teachers' perspectives on the use of differentiated instruction in inclusive classrooms: Implication for teacher education. *International Journal of Higher Education*, 9(6), 136-150. https://doi.org/10.5430/ijhe.v9n6p136

Özer, S., & Yilmaz, E. (2018). The effect of thinking-style-based differentiated instruction on achievement, attitude, and retention. *Kastamonu Education Journal*, 26(1), 11-20. https://doi.org/10.24106/kefdergi.374145

Padmore, E., & Ali, C. (2024). Exploring effective differentiated instruction in the teaching and learning of mathematics. *ASEAN Journal for Science Education*, 3(1), 41-54. https://ejournal.bumipublikasinusantara.id/index.php/ajsed/article/viewFile/320/269

Pozas, M., Letzel, V., & Schneider, C. (2020). Teachers and differentiated instruction: Exploring differentiation practices to address student diversity. *Journal of Research in Special Educational Needs*, 20(3), 217-230. https://doi.org/10.1111/1471-3802.12481

Prast, E. J., Weijer-Bergsma, E. V., Kroesbergen, V., & Van Luit, J. (2018). Differentiated instruction in primary mathematics: Effects of teacher professional development on student achievement. *Learning and Instruction*, 54, 22-34. https://doi.org/10.1016/j.learninstruc.2018.01.009

Qorib, M. (2024). Analysis of differentiated instruction as a learning solution in student diversity in inclusive and moderate education. *Internasional Journal Reglement Society*, 5(1), 43-55. https://jurnal.bundamediagrup.co.id/index.php/ijrs/article/view/452/371

Rahmaniar, R., Surahmat, Z., Sardi, A., & Nurnaifah, I. I. (2024). Challenge and opportunities: A qualitative exploration of junior high school English language educators' perspectives on implementing differentiated instruction. *Journal of English Language Teaching and Literature*, 5(1), 28-40. https://doi.org/10.56185/jelita.v5i1.597

Rietveld, T., & van Hout, R. (2017). The paired t-test and beyond: Recommendations for testing the central tendencies of two paired samples in research on speech, language and hearing pathology. *Journal of Communication Disorders*, 69, 44-57. https://doi.org/10.1016/j.jcomdis.2017.07.002

Rijal, A., Aswarliansyah, & Waluyo, B. (2025). Effectiveness of differentiated learning in mathematics: Insights from elementary school students. *Journal of Education and Learning*, 19(1), 241-248. https://doi.org/10.11591/edulearn.v19i1.21806

Rohendi, D. (2019). Game-based multimedia for horizontal numeracy learning. *International Journal of Emerging Technologies in Learning*, 14(15), 159-170. https://doi.org/10.3991/ijet.v14i15.10679

Saif, S., Safdar, S., Anis, F., & Muhammad, Y. (2024). Embracing diversity: The case for differentiated instruction in Pakistan's inclusive classrooms. *Pakistan Journal of Law, Analysis and Wisdom*, 3(7), 151-163. https://pjlaw.com.pk/index.php/Journal/article/view/v3i7-151-163

Saleem, A., Muhammad, Y., & Qureshi, N. (2021). Strategies and challenges of novice public-school teachers related to classroom management at the elementary level in Lahore. *Pakistan Social Sciences Review*, 5(4), 258-271. https://doi.org/10.35484/pssr.2021(5-IV)20

Saleem, A., Muhammad, Y., & Qureshi, N. (2023). Managing public elementary school classrooms in Lahore: Physical facilities related challenges for novice teachers. *Global Educational Studies Review*, 8(2), 377-387. https://doi.org/10.31703/gesr.2023(VIII-II).34

Samad, F., Salasa, M., & Ramadali, W. O. R. L. O. (2021). Improving numeracy skill through Leng Kali Leng traditional game in learning early math to young learners. *Journal of Physics: Conference Series*, 1832, Article 012031. https://doi.org/10.1088/1742-6596/1832/1/012031

Sapan, M., & Mede, E. (2022). The effects of differentiated instruction (DI) on achievement, motivation, and autonomy among English learners. *Iranian Journal of Language Teaching Research*, 10(1), 127-144. https://doi.org/10.30466/ijltr.2022.121125

Sharma, L. R. (2021). Analysis of difficulty index, discrimination index and distractor efficiency of multiple choice questions of speech sounds of English. International *Research Journal of MMC*, 2(1), 15-28. https://mmchetauda.edu.np/wp-content/uploads/2021/02/Volume-2-issue-1-15-28.pdf

Shukhratovna, M. E. (2024). Enhancing student learning: strategies for accommodating diverse learner needs through differentiated instruction. *Innovative Academy* 3(3), 28-30. https://doi.org/10.5281/zenodo.10907813

Siam, K., & Al-Natour, M. (2016). Teacher's differentiated instruction practices and implementation challenges for learning disabilities in Jordan. *International Education Studies*, 9(12), 167-181. https://doi.org/10.5539/ies.v9n12p167

Smale-Jacobse, A., Meijer, A., Helms-Lorenz, M., & Maulana, R. (2019). Differentiated instruction in secondary education: A systematic review of research evidence. *Frontiers in Psychology*, 10, Article 02366. https://doi.org/10.3389/fpsyg.2019.02366

Smets, W. (2017). High-quality differentiated instruction–A checklist for teacher professional development on handling differences in the general education classroom. *Universal Journal of Educational Research*, 5(11), 2074-2080. https://eric.ed.gov/?id=EJ1159742

Sprott, R. A. (2019). Factors that foster and deter advanced teachers' professional development. *Teaching and Teacher Education*, 77, 321-331. https://doi.org/10.1016/j.tate.2018.11.001

Stockemer, D. (2019). *Quantitative methods for the social sciences a practical introduction with examples in SPSS and Stata*. Springer. https://doi.org/10.1007/978-3-319-99118-4

Tabor, P., Dibley, D., Hackenberg, A., & Norton, A. (2020). *Numeracy for all learners: Teaching mathematics to students with special needs*. SAGE. https://uk.sagepub.com/en-gb/asi/numeracy-for-all-learners/book268322

Tang, J. T. (2022). A practical action research of portfolio assessment on building the learning community for graduate students in Taiwan. *Systemic Practice and Action Research*, 35, 555-578. https://doi.org/10.1007/s11213-021-09583-8

Taylor, M. J., McNicholas, C., Nicolay, C., Darzi, A., Bell, D., & Reed, J. E. (2014). Systematic review of the application of the plan-do-study-act method to improve quality in healthcare. *BMJ Quality & Safety*, 23(4), 290-298. https://doi.org/10.1136/bmjqs-2013-001862

Tomlinson, C. A., & Imbeau, M. (2023). *Leading and managing a differentiated classroom (2nd ed.)*. Association for Supervision and Curriculum Development. https://files.ascd.org/pdfs/publications/books/Leading-and-Managing-A-Differentiated-Classroom-2ed-sample-pages.pdf

Tomlinson, C. A. (2001). *How to differentiate instruction in mixed-ability classrooms*. Association for Supervision and Curriculum Development. https://rutamaestra.santillana.com.co/wp-content/uploads/2020/01/Classrooms-2nd-Edition-By-Carol-Ann-Tomlinson.pdf

Valiandes, S., & Neophytou, L. (2018). Teachers' professional development for differentiated instruction in mixed-ability classrooms: Investigating the impact of a development program on teachers' professional learning and students' achievement. *Teacher Development*, *22*(1), 123-138. https://doi.org/10.1080/13664530.2017.1338196

van Geel, M., Keuning, T., & Safar, I. (2022). How teachers develop skills for implementing differentiated instruction: Helpful and hindering factors. *Teaching and Teacher Education: Leadership and Professional Development*, 1, Article 100007. https://doi.org/10.1016/j.tatelp.2022.100007

van Geel, M., Keuning, T., Frèrejean, J., Van Merriënboer, J., Dolmans, D., & Visscher, A. J. (2019). Capturing the complexity of differentiated instruction. *School Effectiveness and School Improvement*, 30(1), 51-67. https://doi.org/10.1080/09243453.2018.1539013

Vygotsky, L. S. (1978). *Mind in society: The development of higher psychological processes*. Harvard University Press. https://home.fau.edu/musgrove/web/vygotsky1978.pdf

Whitley, J., Gooderham, S., Duquette, C., Orders, S., & Cousins, J. B. (2019). Implementing differentiated instruction: A mixed-methods exploration of teacher beliefs and practices. *Teachers and Teaching: Theory and Practice*, 25(8), 1043-1061. https://doi.org/10.1080/13540602.2019.1699782

Yavuz, A. C. (2020). The effects of differentiated instruction on Turkish students' L2 achievement, and student and teacher perceptions. *Eurasian Journal of Applied Linguistics*, 6(2), 313-335. https://doi.org/10.32601/ejal.776002

APPENDIX A: SURVEY QUESTIONNAIRE

Name: ______________________

Sex: ______________________

Grade level taught: ______________________

Age: ______________________

Highest educational attainment: ______________________

Years of teaching experience: ______________________

Direction: Please answer each item honestly based on your agreement during math class. Your answer will be treated with utmost secrecy. No wrong answer; all answers will be accepted.

Table A1. Survey items

	1	2	3	4	5	6
1. Applying differentiation in my mathematics lessons has a positive effect on my students' numeracy.						
2. Differentiated instruction achieved effective learning by addressing student diversity.						
3. Differentiated instruction allows the students to brainstorm ideas and explore possible solutions to mathematical problems.						
4. Differentiated instruction makes the students feel involved in learning, considering their varied learning styles, interests, and preferences.						
5. Differentiated instruction produces students' interaction by requiring them to work as a team despite individual differences.						
6. Differentiated instruction makes the math lessons meaningful to diverse students' interests, learning styles, and intelligence.						
7. Differentiated instruction allows the students to understand mathematics concepts and ideas better.						
8. Differentiated instruction allows students to think in different ways about mathematics problems and promotes inclusive education.						
9. Students can select their preferred tasks and activities through differentiated instruction.						
10. Students can express their creativity in delivering their outputs.						

Note. 6–Very strongly agree; 5–Strongly agree; 4–Agree; 3–Disagree; 2–Strongly disagree; & 1–Very strongly disagree

Interview Guide Questions

Directions: Please answer the questions below honestly.

1. How do differentiated instruction strategies address student diversity?
2. Does differentiated instruction improve the students' numeracy level? How come?
3. What are the challenges you encounter in implementing differentiated instruction?
4. How do you face the challenges in implementing differentiated instruction?
5. What kind of technical assistance do you need most when integrating DI strategies into your classes?
6. How often do you integrate differentiated instruction in your teaching?
7. How does differentiated instruction address the student diversity in your class?

Thank you for your participation in this fruitful conversation. Rest assured that I will keep everything confidential, and the information you share will be used only in my research. Once again, thank you and God bless!

Validation Checklist

Personal data of the expert

Directions: Please supply the information needed.

Name: ______________________

Sex: ______________________

Years of teaching mathematics: ______________________

School affiliation: ______________________

Educational attainment:

	Course	Year graduated	Institution
Post-graduate	___________	___________	___________
Graduate	___________	___________	___________
Undergraduate	___________	___________	___________

Evaluation

Directions: Kindly check the most appropriate answer to each statement using the code that gives the extent to which you agree or disagree with the statement.

Table A2. Statements

Statements	3	2	1
A. Format and design			
1. The format of the instrument is simple.			
2. The instrument is easy to read.			
3. The font style and size are appropriate.			
4. The layout is proportional.			
5. The instrument conveys a logical sequence.			
B. Content			
1. It contains all the necessary components to be evaluated.			
2. It relates to measurable attributes.			
3. It contains adequate items that genuinely represent the objectives of the study.			
4. It is inclined to the subject of the study.			
5. It measures the variables needed in the study.			
C. Clarity			
1. It is expressed in an understandable language.			
2. It achieves the research goal.			
3. It is unambiguous.			
4. It is expressed most simply.			
5. The directions are clear and easy to follow.			
D. Usefulness			
1. It is a valuable assessment tool.			
2. It is free from bias.			
3. It is easy to administer.			
4. It provides the researcher with a clear set of criteria.			
5. It is appropriate for the study.			

Note. 3–Suitable; 2–Needs revision; & 1–Not suitable

Other comments and suggestions: ____
____
____.

Thank you for sharing your precious time.

Validated by: ____________________________

Signature over printed name of expert