ISSN 2522-6398 Vol. 7, Issue 6: 16-27, DOI: 10.25236/FER.2024.070603

Differentiated Instruction Strategies Based on Teaching Difficulty Analysis

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Abstract: *This study explores the effectiveness of differentiated instruction strategies in primary school mathematics, particularly focusing on strategies based on the analysis of teaching difficulties. Employing a case study approach, the research examines the application of these strategies in a sixth-grade mathematics unit on mixed operations with fractions. The study involved two groups: a control group using conventional teaching methods and an experimental group where differentiated instruction strategies were applied. Data were collected through student performance metrics, teacher and student interviews, and a school-wide teacher questionnaire. The findings indicate significant improvements in student learning outcomes in the experimental group, corroborated by statistical analysis, including t-tests. Teacher and student feedback further validate the efficacy of the differentiated instruction approach, highlighting its potential to cater to diverse learning needs and improve academic performance.*

Keywords: *Differentiated Instruction; Teaching Difficulties; Student Performance; Educational Strategies*

1. Introduction

"Differentiated Instruction" is not a concept exclusive to modern times; it finds its roots as early as the Spring and Autumn and Warring States periods in China. The esteemed philosopher and educator Confucius emphasized the need for education to be tailored to the individual, considering each student's unique traits, interests, and abilities. His teachings, recorded in the "Analects," resonate with the notion of "teaching students according to their aptitude" and "universal education," precursors to modern differentiated instruction principles emphasizing personalized and equitable education.

The advent of the Industrial Revolution marked a pivotal shift in educational paradigms. With the rise of mechanized production, the societal demand for workers skilled in specific technical abilities surged, prompting schools to focus on fundamental sciences, mathematics, and technical skills to meet new workforce requirements. Moreover, the necessity for basic literacy and numeracy skills in industrial management led to the widespread implementation of foundational education. Additionally, factory production demanded regular work habits and time management skills, addressed by schools through structured timetables and disciplined learning environments. The initial phase of modern education thus emphasized standardization and uniformity. However, with the continuous evolution of technology and societal needs, the focus has shifted.

According to P21 (Partnership for 21st Century Learning, *Figure 1*), skills such as creativity and innovation, communication, collaboration, information literacy, media literacy, technology literacy, life and career skills, critical thinking, and problem-solving are crucial in today's and the future's societal and work environments. These competencies, seen as essential for 21st-century learners, are vital not only for individual career progression but also for adapting to a rapidly changing global context. These skills and abilities, which traditional standardized education models fail to foster adequately, necessitate a personalized and differentiated teaching environment that cultivates these competencies in children.

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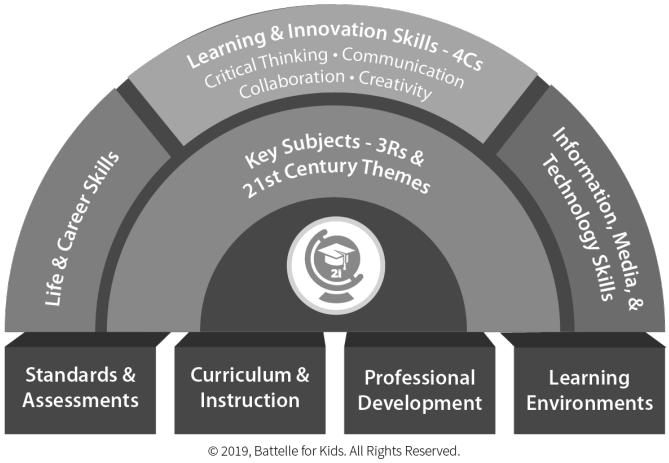

Figure 1: P21 Skills Framework.

2. The Development and Models of Differentiated Instruction

The concept of differentiated instruction in the United States has evolved through five main developmental stages, transitioning from a focus on individual teaching to inclusive education. In the early 20th century, with the widespread implementation of compulsory education, children from various social strata entered schools, increasing expectations for educational quality. Traditional teaching methods, which overlooked the individual differences among students, were then scrutinized. In the 1920s, Washburne introduced the concept of individualized teaching, garnering international attention.

During the Cold War era, the United States emphasized 'gifted education', with Ward first introducing the concept of 'differentiated instruction'. This concept soon became a focal point in educational research, although it was initially targeted mainly at gifted children.

In the 1980s, Gardner of Harvard University, reflecting on the implications of gifted education, proposed the theory of Multiple Intelligences, laying a theoretical foundation for differentiated instruction[1]. By the late 20th and early 21st centuries, as the notion of educational equality gained momentum, there was a growing recognition of the need to meet the individualized learning requirements of all students, in order to adapt to a diverse society. In 1995, Tomlinson of the University of Virginia, in her book "Differentiated Instruction in the Mixed-Ability Classroom", first proposed differentiated instruction applicable to all students, significantly contributing to research in this field. The concept of "differentiated instruction" addressed in this article refers to a personalized teaching approach within a classroom setting[2].

According to Carol Tomlinson, differentiated instruction is an educational method where teachers adjust and design instructional content, processes, environment, and assessment methods based on differences in students' abilities, interests, learning styles, and pace of learning [3]. This method aims to provide a personalized learning experience suitable for each student, ensuring that all students receive the most effective education at their own level and pace.

Differentiated instruction encompasses five main features: recognizing individual differences in students, including their background knowledge, learning abilities, interests, and learning styles[1]; employing flexible teaching strategies to meet diverse learning needs, such as group discussions, individual guidance, and project-based learning [4]; setting personalized learning goals based on students' abilities and needs, which can be uniform for the whole class or tailored for individual students[5]; adjusting course content and materials according to students' comprehension levels and interests[6]; and conducting ongoing assessments and feedback to monitor students' progress and help them understand their learning status, thereby guiding teachers in adjusting their teaching methods[7]. The goal of differentiated instruction is to create an inclusive learning environment where every student can learn according to their abilities and at their own pace[2].

With the increasing research and adoption of differentiated instruction across various states in the USA and other countries, four distinct models of differentiated instruction have emerged in whole-class teaching: Tomlinson's differentiated instruction model, the REACH model, the "To-With-By" three-tier model, and Hall's differentiated instruction model (*Table 1*).

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Table 1: Differentiated Instruction Models.

Differentiated Instruction Model	Description	Key Features
a.REACH	A model developed collaboratively by educators and practitioners, emphasizing responsiveness to the diverse learning needs of students. REACH stands for Readiness, Engagement, Affirmation, Curiosity, and Higher-order thinking.	- Readiness: Tailoring teaching content based on students' prior knowledge and skill level. Engagement: Designing activities to fully engage students. Affirmation: Positively affirming students' identities and backgrounds. Curiosity: Stimulating students' curiosity and desire to explore. Higher-order Thinking: Encouraging analysis, evaluation, and creative thinking.
b.TO-WITH-BY	A layered teaching strategy designed to meet diverse learning needs through staged guidance and activities.	- To: Teachers provide foundational knowledge and skills. With: Teachers offer personalized guidance and support. By: Students engage in autonomous learning under teacher guidance.
c.Tomlinson	A differentiated instruction model proposed by Carol Ann Tomlinson, emphasizing the adjustment of teaching content, process, output, and learning environment based on the diverse needs of students.	- Understanding Students: Assessing students' interests, learning styles, and capability levels.-Differentiating Content: Adjusting teaching materials according to student abilities and interests. Differentiating Process: Employing various teaching strategies. Differentiating Output: Allowing students to demonstrate learning in multiple ways. Utilizing Learning Environment: Adjusting classroom layout and resources.
d.Hall	Hall's differentiated instruction model focuses on understanding students' needs through pre-assessment and accordingly planning and designing instruction.	- Pre-Assessment: Understanding students' prior knowledge, readiness, and interests. Differentiated Planning: Designing teaching based on assessment results. Differentiated Evaluation: Integrating evaluation as a core part of instructional design and implementation.

a. The REACH differentiated instruction model, developed collaboratively by educators and practitioners, responds to the diverse learning needs of students [4]. The key aspects of the REACH model include Readiness, Engagement, Affirmation, Curiosity, and Higher-order thinking. In practice, the Readiness phase involves customizing instructional content based on students' prior knowledge and skill levels, with teachers potentially conducting pre-assessments to determine students' starting levels and accordingly adjusting the teaching difficulty. The Engagement phase focuses on designing activities that fully engage students, possibly including topics meaningful to students or various teaching methods to enhance participation. The Affirmation phase actively affirms students' identities and backgrounds in teaching, respecting their diversity and creating a supportive and encouraging learning environment. The Curiosity phase stimulates students' curiosity and desire to explore, posing intriguing questions and challenges to foster in-depth learning. Lastly, the Higher-order thinking phase encourages students to engage in analysis, evaluation, and creative thinking beyond mere memorization and understanding. The REACH model, through the integration of these five aspects, provides a comprehensive framework to meet the unique needs of different students and promote their overall development [4].

b. Carol Ann Tomlinson's differentiated instruction model (*Figure 2*) is based on a deep understanding and respect for student differences, aiming to meet each student's individual learning needs[6]. In this model, teachers first assess students' interests, learning styles, and ability levels, collecting information through observation, testing, and student feedback. Teachers then adjust instructional materials according to students' abilities and interests, providing texts, tasks, and problems of varying complexity for different student levels. During the teaching process, teachers employ various instructional strategies such as group discussions, role-playing, and project-based learning, providing guidance and support at different levels to match students' learning abilities. Further, Tomlinson's model allows students to demonstrate their understanding and learning in multiple ways, such as oral presentations, writing, or art projects, letting students choose how to complete tasks based on their

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strengths and interests. Classroom layout adjustments facilitate group collaboration or individual learning, and teachers utilize outside-of-classroom resources like libraries and information technology. Teachers regularly assess students and provide timely, specific feedback to help students understand their learning status. Additionally, flexible classroom management and clear classroom rules support diverse teaching activities, with teachers adjusting teaching plans based on student feedback and learning progress. Overall, Tomlinson's differentiated instruction model emphasizes teacher creativity and adaptability, aiming for all students to succeed at their own level while stimulating their interest and potential for learning[6].

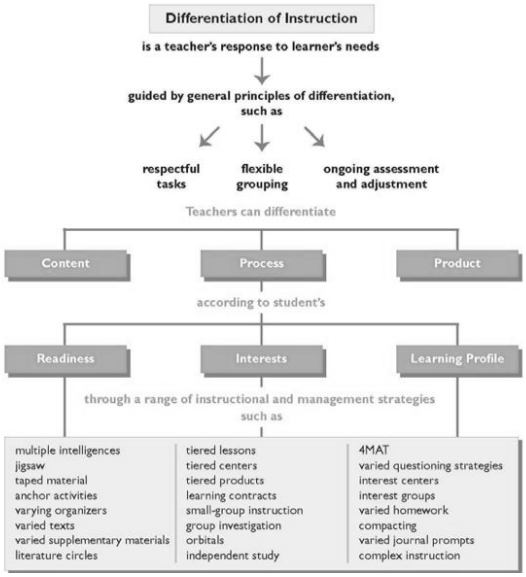

Figure 2: Carol Tomlinson Model.

c. Hall's differentiated instruction model (*Figure 3*) emphasizes pre-assessment to understand students' needs in prior knowledge, learning readiness, learning style, and interests. The core principle of this model is to plan and design differentiated instruction based on these assessment results, enabling teachers to better understand students' starting points and needs before the teaching process begins. A notable feature of Hall's model is the integration of "assessment" throughout the differentiated instruction process, differing from Tomlinson's model. Hall emphasizes that assessment should not only serve as feedback at the end of teaching but also as a starting point and continuous part of instructional design and implementation. Hall's model provides a systematic method to customize and adjust teaching activities to meet students' individualized needs, thereby promoting learning and growth for all students. In summary, Hall's differentiated instruction model, by making assessment a core component of the teaching process, emphasizes considering student differences during the planning and design stages of teaching, aiming for more effective and inclusive educational outcomes [8].

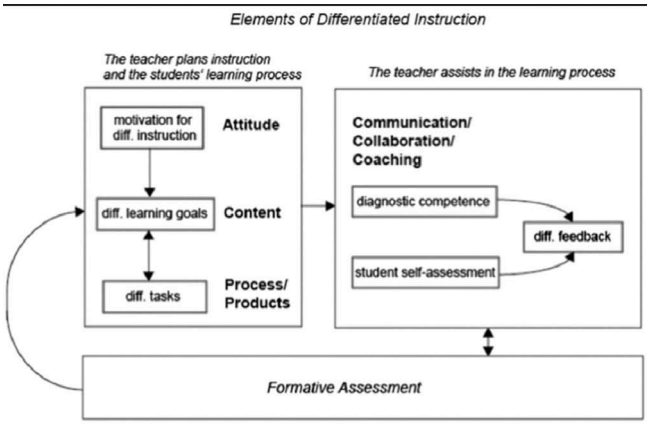

Figure 3: Hall's Model.

d. The "To-With-By" three-tier differentiated instruction model (*Figure 4*) is a layered instructional strategy designed to accommodate students' different learning levels, interests, and styles[9]. This model effectively meets individualized learning needs through a progressive approach across three stages. In

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the "To" phase, teachers play a leading role in the teaching process, providing foundational knowledge and skills that all students need to master. This phase typically includes lectures, demonstrations, or whole-class guided discussions, aiming to establish a common base of understanding for all students. The "With" phase involves teachers and students working together in the learning activities, offering more personalized guidance and support. During this phase, teachers use methods such as group activities, cooperative learning, or small-scale discussions to accommodate students' diverse learning needs and interests. At this point, the teacher's role transitions from a traditional knowledge transmitter to a facilitator and collaborator in student learning. The final "By" phase grants students greater autonomy and responsibility, allowing them to explore and learn in their own ways under the guidance of teachers. Students apply their knowledge and skills through projects, research, and practical activities in this phase. Teachers act as advisors and assessors, providing necessary feedback and guidance to help students self-assess and deepen their understanding. Overall, the "To-With-By" model gradually increases student autonomy and participation, fostering deep learning and personal growth. This adaptive teaching approach not only enhances students' motivation for learning but also aids in developing their independent and critical thinking skills[9].

To	With	By
The foundation	The implementation	The application
Direct instruction	Guided instruction	Self directed-learning
Main lesson	Learning centers	Project-based learning
My project presentations	Student practice	Performance assessments
Teacher-focused	Group-focused	Individual-focused
Introduction of skills	Skill building	Demonstrations of learning
Teach	Practice	Apply
I do	We do	You do

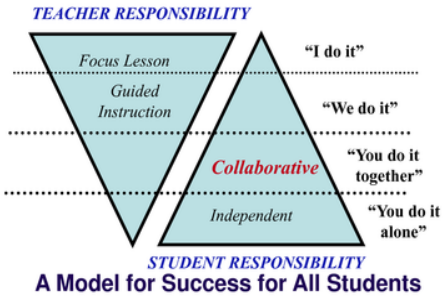

Figure 4: To-with-By Model.

These differentiated instruction models offer a wealth of theoretical foundations and practical examples for frontline teachers, yet they share a common issue: these theoretical models are primarily based on Western educational systems, which may not be directly applicable to the educational environment in inland China, especially considering the differences in classroom and teaching systems. For instance, class sizes in China are typically larger, posing significant challenges to implementing personalized education and differentiated teaching strategies. Additionally, most Chinese primary and secondary school teachers specialize in a single subject rather than teaching multiple subjects, implying that teachers need to deeply understand and apply differentiated teaching strategies within their specific subject area.

Another challenge faced by Chinese teachers is the necessity to complete designated teaching tasks and prepare students for unified examinations within a limited timeframe. Under this teaching model, teachers are required to ensure course progression and examination results while attempting to implement differentiated instruction, undoubtedly increasing their workload. Although differentiated teaching theories have clear advantages in enhancing student learning outcomes, teachers in such educational environments often struggle to find sufficient time and resources to adjust teaching to meet the individual needs of each student.

Therefore, for teachers in China, achieving fully personalized education remains a significant challenge. This not only demands high professional competence and flexibility in teaching from educators but also requires structural and resource adjustments within the education system itself to support the effective application of differentiated teaching strategies in practical teaching. Moreover, further research into differentiated teaching models tailored to the Chinese educational context is necessary, providing more targeted and practical guidance for teachers.

3. Utilizing Teaching Difficulties Analysis for Differentiated Teaching

The definition of instructional difficulties typically refers to parts of the teaching process where students generally encounter challenges or struggle to comprehend. These difficulties may pertain to complex concepts, mastery of skills, application of theories, or cognitive barriers in specific subjects. Identifying these teaching challenges is crucial for effective instruction as they directly impact students' learning outcomes and progress. By recognizing and addressing these difficulties, teachers can more

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effectively design teaching strategies tailored to meet specific student needs, thereby enhancing their understanding and mastery of complex material. Analyzing instructional difficulties is also a key component in implementing differentiated teaching, assisting teachers in customizing appropriate teaching methods and materials for students with varying levels of ability.

Utilizing instructional difficulties analysis to guide the design of differentiated teaching is a comprehensive, multi-step process. It begins with a deep understanding of the specific challenges students face in certain areas or concepts, gained through previous analysis[7]. This understanding is crucial for designing more targeted teaching activities. Following this, teachers group students based on their understanding of specific areas and design specific learning activities for each group to address their individual learning difficulties[6]. Teachers also adjust teaching content and materials based on the different needs of students to ensure adaptability[10].

In implementing differentiated learning activities, teachers design these activities based on students' learning difficulties and ability levels. For instance, for some students, teachers might design more practice-based activities, while for others, more explanation and guidance might be necessary[11]. Providing ongoing feedback and adjusting teaching strategies based on students' performance and progress are crucial. This feedback not only helps students understand their learning progress but also provides teachers with a basis for adjusting their teaching[12].

Finally, teachers regularly reflect on the effectiveness of their teaching practices and make necessary adjustments based on student learning outcomes and feedback. These reflections and adjustments might include changing teaching methods, materials, and activities to better meet student learning needs[13]. Through this comprehensive approach, teachers can more effectively support all students' learning, ensuring that each student can learn at their own level and pace while overcoming learning obstacles to achieve better educational outcomes. Specific differentiated teaching strategies, such as personalized learning plans, tiered instruction, and collaborative group learning, are discussed. These strategies address specific instructional difficulties.

4. Teaching Case Analysis

4.1 Case Background Introduction

In alignment with our differentiated teaching strategy based on the analysis of teaching difficulties, we selected the mathematics subject of the sixth grade in our school for an experimental study. This grade and subject were chosen due to the depth of mathematical content at this stage, which facilitates the identification of key learning challenges. This selection aims to reduce potential difficulties and feelings of frustration in this preliminary trial, thereby ensuring the experiment's feasibility and success. Moreover, this initial attempt will garner valuable experience for implementing similar strategies in other grades and subjects.

4.2 Experimental Design

Control Group: Class 6-1, consisting of 17 students (8 females, 9 males).Experimental Group: Class 6-2, consisting of 17 students (7 females, 10 males). Textbook Used: The compulsory education mathematics textbook published by Beijing Normal University Press. Content for Experimental Teaching: Unit Two of the Sixth Grade First Semester - Mixed Operations with Fractions.

Class 6-1 was chosen as the control group, and Class 6-2 as the experimental group, due to their similar student numbers and gender ratios, and both being taught by the same mathematics teacher. This similarity minimizes variances in the student cohorts, lending greater accuracy and credibility to the experimental data. Currently, Class 6-2 performs slightly lower in terms of grades as it has been shown in *Table 2 and Figure 5*, their previous end term Final exam data and box map, making it a suitable candidate for the experimental group for this unit of study.

Table 2: 2022T2 Final exam data.

2022T2 Last Term Final exam			
Class	Average	Median	Standard Deviation
G6-1-Control Group	88.91	93.50	10.93
G6-2- Experimental Group	80.08	86.75	22.98

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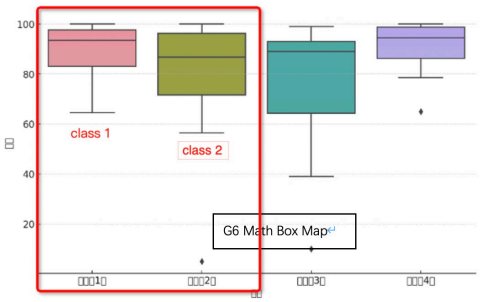

Figure 5: 2022T2 Final Exam Analysis Box map.

4.3. Implementation Process:

The control group (Class 6-1) followed conventional teaching methods without differentiated analysis of teaching difficulties. In contrast, the experimental group (Class 6-2) adopted a differentiated teaching model based on teaching difficulties:

4.3.1 Pre-Lecture Difficulty Analysis

a) Knowledge Difficulty Analysis: Identifying challenging concepts or skills within the course content, such as rules for mixed fraction operations and conceptual understanding.

b) Student Difficulty Analysis: Assessing students' prior knowledge levels and their comprehension of upcoming content. Understanding students' learning obstacles through observation, testing, and interviews, such as attention deficits, slower comprehension, and attitudes toward mathematics.

4.3.2 Targeted Assessment Design and Evidence Collection

Tailoring assessment methods and content based on difficulty analysis. Establishing assessment standards that consider both students' cognitive levels and their progress in overcoming difficulties.

4.3.3 Personalized Question Setting

Setting customized challenges for different students or groups to meet their specific learning needs and capabilities. Ensuring a diversity and appropriateness of questions to promote progress at individual levels.

Grouping Mode

a) Homogeneous Inter-Group, Heterogeneous Intra-Group for New Lessons: Students are grouped with peers of similar ability, with diverse learning needs within each group. This approach enhances the efficiency of collective teaching while addressing internal group differences.

b) Heterogeneous Inter-Group, Homogeneous Intra-Group for Review Lessons: Group members differ in abilities, but each group focuses on specific difficulties for review and practice. This method fosters peer support and concentrates on resolving common challenges.

c) Consolidation Practice: During review lessons, students are given exercises corresponding to their identified difficulties, ensuring that practice problems are targeted to help students overcome specific learning challenges.

[Application Example - Mixed Operations with Fractions, Lesson 1]

The unit is divided into several lessons: Mixed Operations with Fractions (I, II, III), Practice II, Problem Review, Unit Test and Review (3 lessons).

Teaching Difficulty Analysis: The learning objectives of this lesson include four aspects: 1. Learning to visually represent quantitative relationships through drawing, 2. Identifying the unit '1' in problems, 3. Correctly using mixed operation principles, 4. Solving problems involving 'continuous fractions of a number'. The overall difficulty analysis and causation are first addressed, followed by specific analysis based on each lesson's content. This unit mainly encompasses five difficulty areas, with reasons for their complexity outlined in detail. a. Understanding the Concept of Fractions: For many students, fractions as a concept of ratio can be quite abstract. Grasping the significance of the numerator and the denominator and how they reflect the relationship between quantities can pose a challenge. b. Fraction Operation Rules: Operations involving fractions, including addition, subtraction, multiplication, and division, are

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more complex than those with whole numbers. Particularly, adding and subtracting fractions involve finding a common denominator, which requires students to understand and calculate the least common multiple. c. Operations with Different Types of Fractions: The conversion and operations among proper fractions, improper fractions, and mixed numbers necessitate an understanding of the characteristics of these different types of fractions and the ability to flexibly apply operation rules. Mixed Operation Rules: Mixed operations with fractions, which combine addition, subtraction, multiplication, and division, demand an understanding and application of the rules of operation precedence. This could lead to confusion for some students when solving problems. e. Application Problems: Applying fraction operations to real-world situations requires students to not only understand the rules of fraction operations but also to apply them in specific life or mathematical contexts.

The reasons these areas can be challenging include: i. High Level of Abstraction: As a mathematical concept, fractions require a certain level of spatial imagination and logical thinking skills due to their abstract nature. ii. Complexity in Calculations: Operations involving fractions include steps like finding a common denominator and simplifying, which are relatively complex and prone to errors. iii. Interrelation of Concepts: There is a close connection between different types of fractions and their operation rules, necessitating students to integrate multiple concepts. iv. Difficulty in Application: Applying the concept of fractions to practical problems requires students to combine mathematical knowledge with real-life situations, demanding a higher level of understanding and analytical ability.

Based on Difficulty Differentiation Strategy (*Figure 6*): Utilizing three guiding questions, the main difficulty for students is identified as “accurately calculating the continuous fractions of numbers”.

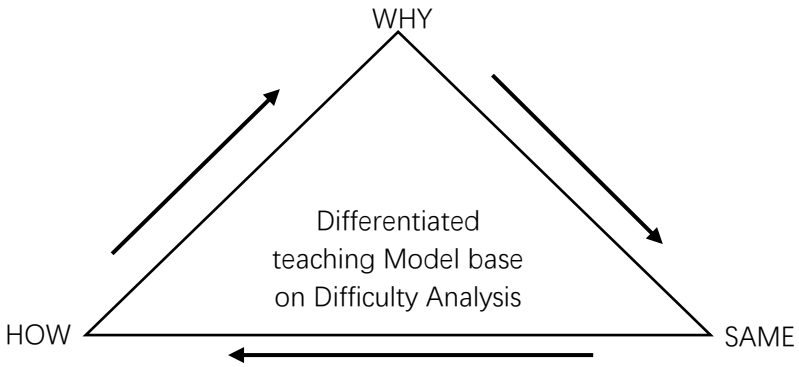

Figure 6: Differentiated teaching model.

Why is this a difficulty (WHY)? The challenge lies in students' ability to accurately interpret and analyze the relationships between quantities in word problems. For instance, a straightforward description like "The weather team has 12 people, and our photography team is 1/3 of that, so how many people are in the model aircraft team?" is generally easier for students. However, if the problem is phrased as "The weather team has 12 people, our photography team is 1/3 of that, and the model aircraft team is 1/5 of the photography team," students often make mistakes due to the complexity of relationships. The abstract nature of these relationships can be confusing for students.

Is this difficulty the same for everyone (SAME)? The answer is no. The same challenge may present different levels of difficulty for different students, necessitating individualized analysis.

How can we help students overcome this difficulty (HOW)? The first step is to guide students through drawing, helping them visually understand the relationships between quantities. During the lecture on new content, students are grouped homogeneously between groups but heterogeneously within groups. After the teacher demonstrates example problems, students work collaboratively to complete additional examples. Those who finish quickly within a group assist others, embodying the role of a 'mini-teacher'. During the extensive practice phase, students are grouped heterogeneously between groups and homogeneously within groups for paper-based exercises. The teacher primarily assists slower students, while quicker learners engage in advanced tasks and access additional resources like micro-courses and exercises on iPads. In the last five minutes, students complete a metacognitive assessment form, reflecting on the difficulties faced and strategies used in the lesson.

For students who do not complete the tasks, the teacher provides additional exercises generated through a question bank focused on the same knowledge points. According to Carroll (*Figure 7*) , if learning rate is considered an indicator of ability, there are no good or bad students, only fast and slow

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learners. She also notes that the time spent on learning is determined by the learner's perseverance and the opportunity for learning[14]. Perseverance refers to the amount of time students are willing to actively engage in learning, while the learning opportunity is the time allocated for student learning. In other words, the time spent depends on students' persistence with the learning task and the time provided for learning. Moreover, she suggests that the required time depends on the student's learning rate for the subject, the quality of instruction, and the student's ability to understand the instruction. Therefore, we believe that in addition to ensuring efficient classroom teaching activities, it is crucial to provide additional time for "slow learners" to study the same content, ensuring they remain at a comparable level.

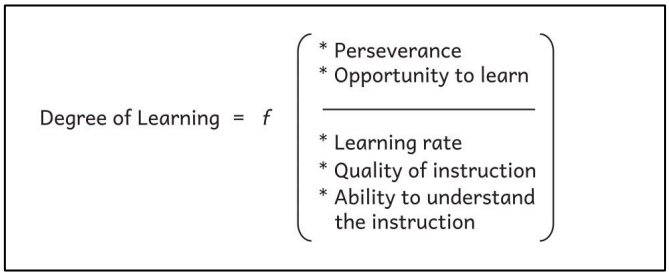

Figure 7: Carroll's Degree of Learning Function, 1963.

4.3.4 Analysis and Results of Experimental Data

In this case study, we primarily collected three types of data: a school-wide teacher questionnaire survey, student achievement data (including last semester's final grades, and pre-test and post-test scores for this semester's second unit) for both the experimental and control groups, teacher interviews from the experimental and control groups, and individual student interviews from the experimental group.

The school-wide teacher questionnaire survey, distributed to 98 teachers with 70 responses received and 65 deemed valid, revealed significant insights. It was found that 100% of the teachers considered the analysis of teaching difficulties as very important and agreed that such analysis aids in effective teaching. However, in the sections regarding professional knowledge and practice of teaching difficulty analysis, most teachers had not received formal training in how to analyze teaching difficulties properly, and many had not seriously considered it. Although all teachers included a section on teaching difficulties in their lesson plans, they typically spent less than 5 minutes on this and often simply copied sentences from the teacher's book or reiterated the teaching points. Therefore, the survey indicated that most teachers had not fully recognized the importance of teaching difficulty analysis nor seriously contemplated its implementation.

We collected and analyzed the grades of both the experimental and control groups from last semester's final, and the pre-test and post-test of the current unit (*Figure 8*). The box plot analysis focused on the average scores, median, and standard deviation of these three tests. The box plot of the last semester's final grades showed that the experimental group's median and quartile ranges were lower than the control group's, with a larger and lower-positioned box, indicating a more significant disparity in the mathematics performance within the experimental group. The pre-test and post-test box plots of the current unit revealed that the experimental group's prior knowledge in fractional mixed operations was significantly weaker than the control group's. However, after employing the differentiated teaching strategy based on teaching difficulty analysis, the experimental group's median score nearly matched the control groups, with a reduction in score dispersion and an overall upward shift in performance.

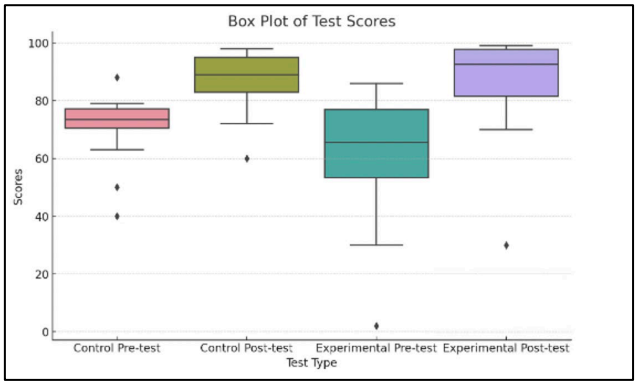

Figure 8: Exam Analysis box map after experiment.

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In assessing the impact of a differentiated teaching model based on the analysis of teaching difficulties on student mathematics performance, we compared pre-test and post-test scores of two sixth-grade classes, one using conventional teaching methods as the control group and the other implementing the differentiated teaching strategy as the experimental group. The paired sample t-test results (*Figure 9*) showed significant improvements in the academic performance of both groups following the intervention, evidenced by their respective t-values and p-values. Specifically, the control group had a t-value of -10.19 and a p-value of 3.89e-08, while the experimental group had a t-value of -12.56 and a p-value of 4.99e-10. These p-values, significantly lower than the standard significance level of 0.05, indicate that the improvements in performance were statistically significant. Particularly in the experimental group, the differentiated teaching strategy proved to be more effective, as evidenced by higher t-values and lower p-values. This data strongly supports the effectiveness of the differentiated teaching strategy based on the analysis of teaching difficulties in enhancing student learning outcomes, especially in mathematics. Thus, we conclude that the differentiated teaching model not only improves student grades but is also more effective in the experimental group, demonstrating its efficacy and practicality in enhancing student learning outcomes.

Group	t-value	p-value
Control Group	-10.19	3.89e-08
Experimental Group	-12.56	4.99e-10

Figure 9: Experiment T- test.

Following the unit's teaching, we interviewed the mathematics teacher who conducted the classes for the experimental group. She expressed satisfaction with the experiment's results, noting a significant change in her teaching perspective and approach. Previously, despite investing considerable effort and time, she felt a sense of defeat due to the overall low effectiveness of her classes and the students' lackluster performance. The new teaching strategy provided a clear direction, especially important for her class with a wide range of student abilities. Before, either the higher-ability students felt unchallenged or the lower-ability students struggled to keep up, leading to low classroom efficiency and hindered progress. The teacher spent a lot of time on one-on-one tutoring outside of class hours, but it was often ineffective, encroaching upon her rest time and making students more resistant to the subject. The new strategy led her to realize the importance of categorizing and understanding student characteristics (*Figure 10*) and to adopt a mindset shift from viewing students as good or bad to fast or slow learners, in line with Carroll's "learning degree function formula." She understood the need to provide additional learning time for slower learners, as learning time depends on a student's perseverance and the opportunities provided.

Type	Class	Students	Students Feature	if will meet problmes in this unit	Solution
Experiment Group	Class 2, Grade 6	2-A	light reading disability	Yes	help reading, depose explanantion into steps
Experiment Group	Class 2, Grade 6	2-B	weak fundamental, slow comprehension	Yes	extral tutorial, face to face correction
Experiment Group	Class 2, Grade 6	2-C		NO	
Experiment Group	Class 2, Grade 6	2-D		NO	
Experiment Group	Class 2, Grade 6	2-E	eak willpower, afraid of practice, Slow comprehensio	Yes	extral tutorial, face to face correction
Experiment Group	Class 2, Grade 6	2-F	light Dyslexia	Yes	help reading, depose explanantion into steps
Experiment Group	Class 2, Grade 6	2-G		NO	
Experiment Group	Class 2, Grade 6	2-H		NO	
Experiment Group	Class 2, Grade 6	2-I		NO	
Experiment Group	Class 2, Grade 6	2-G		NO	
Experiment Group	Class 2, Grade 6	2-K	communication disorder	Yes	extral tutorial, face to face correction
Experiment Group	Class 2, Grade 6	2-L	always say yes, but make mistakes in practices	Yes	More practice, face to face correciton
Experiment Group	Class 2, Grade 6	2-M	always say yes, but make mistakes in practices	Yes	More practice, face to face correciton
Experiment Group	Class 2, Grade 6	2-N		NO	
Experiment Group	Class 2, Grade 6	2-O	weak fundamental, slow comprehension, not good at logic thinking	Yes	slow down explanation, depose explanantion into steps
Experiment Group	Class 2, Grade 6	2-P		NO	
Experiment Group	Class 2, Grade 6	2-Q		NO	

Figure 10: Experiment Group Students' Feature Records.

In interviews with students from the experimental group, we observed the development and changes in their metacognitive abilities. They realized that knowing the goals and challenges at the beginning of a class made them more directed and willing to participate actively, as they were eager to see if they could meet the challenges. The end-of-class reflections helped them understand that overcoming challenges required active effort and allowed them to monitor their progress, the strategies they used, and whether they met the goals. This reflective practice is beneficial for their future growth.

ISSN 2522-6398 Vol. 7, Issue 6: 16-27, DOI: 10.25236/FER.2024.070603

5. Conclusion

The comprehensive analysis presented in this study strongly underscores the efficacy of differentiated teaching strategies, particularly when tailored to address specific teaching difficulties. The integration of these strategies within the educational framework demonstrated a significant impact on student learning outcomes, as evidenced by the marked improvement in student performance. Notably, the application of teaching strategies that were conscientiously aligned with the distinct learning needs and challenges of students, especially in the experimental group, resulted in notable academic advancements. This was clearly reflected in the statistical data, where the t-test results revealed a considerable enhancement in student scores, both in the control and experimental groups, with the latter showing more pronounced improvements.

A critical aspect of this study was the emphasis on continuous research and practice in refining and optimizing differentiated teaching methods. The findings reiterate the importance of ongoing experimentation and adaptation in educational approaches to cater effectively to diverse student needs. This iterative process is pivotal in evolving teaching practices that are not only theoretically sound but also practically viable and responsive to the dynamic nature of classroom environments and student cohorts.

However, the case study also highlighted certain limitations that warrant attention for future research and practice. One significant shortcoming was the relatively limited scope of teacher training and awareness regarding the analysis and application of teaching difficulties. Despite recognizing the importance of addressing teaching difficulties, many teachers lacked the necessary training and understanding to implement these strategies effectively. This gap underscores the need for more comprehensive professional development programs and resources that equip educators with the skills and knowledge to navigate and apply differentiated teaching methodologies effectively.

Moreover, while the study yielded positive results, it is crucial to acknowledge the challenges and increased workload associated with implementing differentiated teaching strategies. Teachers in the study reported a heightened sense of responsibility and effort in planning and executing these strategies. Thus, future research should also focus on developing support systems and practical tools that can alleviate the additional burdens on educators, enabling them to implement differentiated teaching with greater ease and effectiveness.

In conclusion, this case study vividly illustrates the positive impact of differentiated teaching strategies on addressing teaching difficulties and enhancing student learning. It also highlights the need for continuous research, teacher training, and the development of practical support mechanisms to further refine these strategies. Acknowledging and addressing the limitations identified in this study will be crucial in advancing the effectiveness and sustainability of differentiated teaching approaches in diverse educational settings.

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