The Development of Instructional Model Based on Gardner's Multiple Intelligence Theory to Improve the Mathematics Achievements of Second Grade Primary School Students

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Abstract

This research aimed to 1) study the factors affecting the development of mathematics achievement of second-grade students in Qinhuang Town Primary School, 2) develop an instructional model based on Gardner's Multiple Intelligence Theory, 3) compare the mathematics achievement of second-grade students before and after using an instructional model based on Gardner's Multiple Intelligence Theory. The sample group was 30 second-grade students in Qinhuang Town Primary School. The research Instruments were 1) a questionnaire about the factors affecting elementary school students' mathematics achievement 2) an interview form about the factors affecting elementary school students' mathematics achievement 3) lesson plans 4) a mathematics achievement test 5) students' behavioral observation form 6) interview form about the opinions on teaching and learning. This study was conducted in three steps: a study of the factors affecting the development of second-grade students' mathematics achievement, the development of an instructional model based on Gardner's Multiple Intelligence Theory, and an experimental and improvement process. Data were statistically analyzed, Qualitative data were analyzed through content analysis, and Quantitative data were analyzed through descriptive statistics, frequency, percentage, means, and standard deviation, and the different scores of mathematics achievement before and after using the instructional model were analyzed through t-test for dependent samples.

The results of the study show that:

1) the factors affecting elementary school students' mathematics achievement include four aspects*:* 1) students 2) teachers 3) the learning process and the environment.
2) the instructional model consisted of four components: Principle, Objective, Learning Process, and Result.
3) the implementation of the instructional model based on the multiple intelligences students have after mathematics achievement was significantly higher than that before class with statistical significance at the level .01

Keywords: instructional model, multiple intelligence theory, mathematics achievement, improvement

1. Introduction

1.1 Introduce

Education plays a pivotal role in improving national quality and developing human resources (Hanushek & Woessmann, 2007). To ensure the efficient implementation of education, it is vital to respect the laws of education and the physical and mental development of students (Elias & Weissberg, 1997). Only by exploring and fully developing the potential of learners can we provide rich, high-quality human resources for national development.

Primary education, as the cornerstone of the entire education system, is particularly important for the long-term

development of the country. As a basic subject, mathematics has an irreplaceable contribution in many fields such as economy, society, and humanities. However, the reality is that despite the unquestionable importance of mathematics, individuals refuse to learn it in practice for various reasons. The reasons can be summarized with the following aspects:

(1) Lack of innovation in the instructional model: The teacher's instructional model determines the quality of students' mathematics problem-solving skills (Wasserberg, 2018). At present, in elementary school mathematics teaching, many teachers still stick to the traditional instructional model, overemphasizing the one-way transmission of knowledge, ignoring the learning characteristics and psychological needs of students, and failing to effectively stimulate students' interest in learning. This kind of teaching method, which is oriented to test-taking and emphasizes the transmission of knowledge, lacks sufficient inspiration and exploration (Pang, 2020). This instructional model leads to students' lack of interest and motivation in mathematics, and they only solve problems but cannot apply them practically.

(2) Teachers do not pay attention to the differences of students: In the process of teaching, some teachers may ignore the individual differences and developmental needs of students in terms of multiple intelligences, which leads to ineffective teaching and learning. (Armstrong, 2017). Students have different learning styles, which require educators to be objective and observant. These differences are not only challenges but can be transformed into positive factors that enhance students' cognitive abilities (Subadi & Sulistyanto, 2021).In such an environment, teachers should fully recognize the individual differences of each student and develop their problem-solving abilities accordingly, thus stimulating their genuine enthusiasm for learning mathematics (Jonassen & Grabowski, 2012).

(3) Students' low interest in learning: Classroom learning will determine the quality of students (Griffen, 2001). Since teachers are in direct contact with students in the classroom, they must be able to implement classroom learning that is interesting to students, that allows them to enjoy mathematics, especially mathematics related to arithmetic, and that develops students' problem-solving skills (Shabir, 2015). However, due to the theoretical and abstract nature of mathematics knowledge, it is difficult to arouse students' interest in practical applications. Meanwhile, some teachers lack interest and interactivity in the teaching process, which leads to students' low interest in mathematics.

(4) Inadequate assessment system for teaching results: Some teachers overemphasize students' examination results and take them as the only criterion for measuring students' learning results. However, such an assessment system ignores students' efforts, progress, and ability to understand and apply knowledge in the learning process. The over-emphasis on test scores limits teachers' attention to the multifaceted development of students, including the development of their thinking, creativity, and problem-solving skills (Wang, 2016).

Due to the above reasons, students may find mathematics difficult to understand and apply, thus developing an aversion to learning. This sentiment further affects their interest and motivation in learning, creating a vicious cycle. Students lose interest in mathematics and find it a difficult subject to master, leading to their difficulties in learning and achieving good results in mathematics. This tendency may result in some students not being able to fully realize their unique potentials and talents, thus affecting their all-round development. Such limitations may harm students' long-term development and future career choices, and we therefore need to emphasize and seek ways to address this problem.

1.2 Rationale

After careful observation in the classroom and in-depth communication with students outside the classroom, the researcher found that although some of the students were mediocre in mathematics, they showed high talent and potential in other areas such as arts, crafts, and sports. This phenomenon coincides with the core idea of the Multiple intelligence theory, which states that human intelligence is diversified rather than limited to one aspect and that everyone possesses multiple intelligences to varying degrees.

Although previous research has investigated the impact of multiple intelligence theory on learning, more research is needed to explain the application of multiple intelligence theory in improving primary school students' mathematics achievement, especially in elementary education. Exploring and mobilizing students' multiple intelligences is of great significance to improving students' enthusiasm for learning and promoting students' understanding and memory of mathematical knowledge. Therefore, the researcher is interested in developing an instructional model based on Gardner's multiple intelligences to improve the mathematics performance of second-grade primary school students. To develop an instructional model, we asked the following questions:

1.3 Literature Review

Gardner defined intelligence as the ability of an individual or group to create valuable products or solve problems in a particular cultural context (Ersoy & Uysal, 2018; Gardner, 1983). He asserted that human diversity is reflected in the ability to solve practical problems or obstacles faced, and the ability to innovate effective works based on skill development and new knowledge, which may vary according to cultural contexts. Accordingly, Gardner proposed three principles of Multiple intelligence theory: first, individuals should be encouraged to use their best intelligence in learning; second, teaching activities should be designed to exercise all forms of intelligence; and lastly, the evaluation system of learning should encompass the measurement of multiple intelligences. Gardner defines each person's varying degrees of ability as the "intellectual domain" or "intelligence mode." He named these modes of intelligence as language-linguistic intelligence, logical-mathematics intelligence, visual-spatial intelligence, musical-rhythmic and harmonious intelligence, body-kinesthetic intelligence, interpersonal intelligence, interpersonal intelligence, natural intelligence, and existential intelligence. Professor Gardner believes that everyone has their type of intelligence and that individuals have the potential to be stronger in some types of intelligence and weaker in others. Gardner (2006) argues that individuals are truly human due to the existence of multiple intelligences. Each person has a unique intelligence characteristic with different advantages. While no one type of intelligence is considered superior to others, according to Gardner, all intelligence is what individuals need to participate and act purposefully, and creatively in society (Gardner, 2003). Gardner asserts that individual differences reflect the multiple intelligences of human beings and that the different intellectual potentials of individuals belong to the personal strengths through which a person understands the world (Arnold, 2004).

Howard Gardner's Multiple intelligence theory emphasizes the diversity of eight different intelligences, providing educators with a more scientific and personalized perspective on teaching and learning that guides them to better understand and respond to student differences (Gouws, 2007). Multiple intelligence theory not only affirms the plurality of human intelligence but also advocates the use of multi-modal teaching strategies in educational practice to accommodate students' different types of intelligence and learning styles. By combining multiple teaching styles and approaches, educators can better meet students' learning needs and provide richer and more varied learning experiences. This type of teaching undoubtedly provides more opportunities and possibilities for students' learning and leads to a more comprehensive development of their various intelligences (Haley, 2004). Teaching based on Multiple intelligence theory is expected to allow more students to actively participate in the learning process because it emphasizes and respects the uniqueness and differences of each student, allowing them to learn and express themselves through the areas and ways in which they excel (Van, 2014). This type of teaching focuses on the recognition and development of individual differences, which in turn increases students' motivation and self-confidence, and is also likely to have a positive impact on underachieving students in mathematics as it provides them with more ways to learn and express themselves, which in turn has the potential to improve their mathematics achievement.

The first iteration of The Multiple Intelligence instructional model was structured around Gustafson and Branch's four stages in instructional design (Analysis, Design, Develop, and Evaluate). Steps include 1) analyzing learner behaviors, characteristics, and multiple intelligences to provide design guidance; 2) a design phase in which multiple-intelligence strategies are selected based on known learner characteristics; 3) guiding the designer in developing materials to integrate various intelligent strategies or activities; and 4) using learner behaviors and abilities to provide a multiple-intelligence foundation for assessment objectives (Gustafson, 1991). Lazear proposes a four-step process for organizing an instructional model for mathematics based on Multiple intelligence theory: 1) Awakening Intelligence, in which students are encouraged to use the five basic aspects of intelligence through sensory learning activities; 2) Amplifying Intelligence, in which the teacher guides students to review and grow their knowledge and stimulates their intellectual abilities to create new knowledge; 3) Teaching with/Toward Intelligence, in which students learn to utilize a variety of intelligences, study students' diverse abilities or skills, and organizing practice for intelligent learning activities; 4) Transferring Intelligence, where students apply knowledge to new problems, practice solving problems and completing tasks, and the teacher evaluates and makes recommendations; the work needs to reflect the learner's use of knowledge and intelligence (Lazear, 1999).

Multiple Intelligences Theory is developed based on the traditional multi-factor theory of intelligence, and at the same time draws on the essence of Jean Piaget's theory of cognitive development and goes beyond the information processing theory. Applying this theory to analyze the problems of education in China helps us to form an optimistic view of students, to practice the teaching concept of "teaching according to one's aptitude" and to implement a flexible and diversified view of educational evaluation. The establishment and practice of these concepts are indispensable for promoting China's education reform and improving the comprehensive quality of students.

1.4 Research Questions

1) What are the factors that affect the mathematics achievement of second-grade students in Qinhuang Town Primary School?

2) How to develop an instructional model based on Gardner's Multiple Intelligence Theory?

3) What are the effects of implementing an instructional model based on Gardner's Multiple Intelligence Theory for second-grade students in Qinhuang Town Primary School?

1.5 Objectives

1) To study the factors that affect the mathematics achievement of second-grade students in Qinhuang Town Primary School.

2) To develop an instructional model based on Gardner's Multiple intelligence theory.

3) To compare the mathematics achievements of second-grade primary school students before and after using the instructional model based on Gardner's Multiple intelligence theory.

1.6 Research Hypothesis/Hypotheses

Second-grade primary school students show greater achievement in mathematics after using an instructional model based on Gardner's Multiple Intelligence Theory.

1.7 The Variables

Independent Variable*:* The instructional model is based on Gardner's multiple intelligence theory.

Dependent Variable*:* Mathematics achievements

2. Method

2.1 Population and Sample Group

2.1.1 The Population

80 students in second - grade at Qinhuang Town Primary School

2.1.2 The Sample Group:

Through the cluster random sampling method, 30 second-grade students with mixed ability (strong, medium, and weak) in Qinhuang Town Elementary School, Shanglin County, Nanning City, Guangxi.

2.2 Research – Instruments

1) questionnaire about the factors affecting elementary school students' mathematics achievement

2) interview form about the factors affecting elementary school students' mathematics achievement

3) lesson plans

4) mathematics achievement test

5) students' behavioral observation form

6) interview form about the opinions on teaching and learning

2.3 Research Process

This study was conducted in three steps*:* a study of the factors affecting the development of second-grade students' mathematics achievement, the development of an instructional model based on Gardner's multiple intelligence theory, and an experimental and improvement process.

2.3.1 The Study on the Factors Influencing the Achievement of Second-Grade Students in Mathematics in Qinhuang Town Primary Schools

1) Collect data about the factors affecting the development of second-grade students' mathematics achievement from 5 Academic experts. by using 1) a questionnaire about the factors affecting elementary school students' mathematics achievement and an interview form about the factors affecting elementary school students' mathematics achievement

2) Analyze data about factors affecting the academic achievement of elementary school students in mathematics achievement

2.3.2 The Development of the Instructional Model

1) Studied about the instructional model development process.

2) Determined the instructional model components.

3) Drafted the details of the instructional model: Principle, Objective, Learning Process, and Result.

4) Verified the details of the instructional model by advisers

5) Modify the details of the instructional model according to suggestions

6) Verified the details of the instructional model by the 5 professional scholars and modified the instructional model according to suggestion.

7) Modify the details of the instructional model according to suggestions

2.3.3 The Experimental and Improvement of the Instructional Model

1) The 30 students were tested by the mathematics achievement test

2) The 30 students in the second grade of Qinhuang Town Primary School were taught in 4 units according to the instructional model, 1 lesson/day, 45 minutes of class time, 20 hours in total, and 4 weeks to complete the curriculum.

3) The researcher observed and interviewed 30 students in the second grade of Qinhuang Town Elementary School about the activities gained after learning from the lesson plans according to the instructional model.

4) 1) The 30 students were tested by the mathematics achievement test

5) Analyzed data and improved instructional model according to suggestions.

2.4 Data Analysis

The data are analyzed as follows:

1) Qualitative data are analyzed through content analysis.

2) Quantitative data are analyzed through descriptive statistics, frequency, percentage, means, and standard deviation, and the different scores of mathematics achievement before and after using the instructional model are analyzed through t-tests for dependent samples.

2.5 Results on the Development of Instructional Model Based on Gardner's Multiple Intelligence Theory

The instructional model based on Gardner's multiple intelligence theory is shown as follows:

2.5.1 Principle

Gardner defines each person's varying degrees of ability as the ″intellectual domain″ or ″intelligence mode. ″ He named these modes of intelligence as Linguistic Intelligence, Logical-Mathematical Intelligence, Spatial Intelligence, Musical Intelligence, Bodily-Kinesthetic Intelligence, Interpersonal Intelligence, Intrapersonal Intelligence, and Naturalist Intelligence (Gardner, 1993). Gardner believes that everyone has their type of intelligence and that individuals have the potential to be stronger in some types of intelligence and weaker in others. Gardner expounded the principles of multiple intelligences theory: 1. Individuals should be motivated to use their preferred intelligence in learning. 2. instructional activities should require different forms of intelligence. 3. The assessment of learning should measure many forms of intelligence (Gardner, 2006).

The use of multiple intelligences also allows students to experience more ways to learn and achieve better in mathematics learning (Jackson & Leffingwell, 1999). When students feel that they are achieving, it will in turn increase their self-confidence and interest in learning, creating a virtuous cycle of learning mathematics (Alderman, 2013). This model allows students to experience more ways to learn. Students learn from activities about Linguistic, Logical-mathematical, Spatial, Interpersonal, and Intrapersonal. So, students achieve better in mathematics.

2.5.2 Objective

Students can improve their mathematical achievement, including the ability to remember, understand, apply, analyze, evaluate, and create.

2.5.3 Learning Processes

Step 1: Introduction

The teacher selects some practical examples of real-life situations related to mathematical knowledge and asks

questions to attract students' interest. Students answer questions and connect to the real-life applications of math.

Step 2*:* Learn with intelligence.

1) Teacher displays learning aids questions or activities to stimulate students to learn and practice multiple intelligences in course content.

2) Students learn and practice multiple intelligences in course content.

Step 3*:* Transfer the Learning

1) The teacher guides students to observe, analyze, compare summarize, and describe the characteristics and patterns of mathematical concepts in their own words while encouraging cooperation and communication among students to facilitate the integration and transfer of knowledge.

2) Students participate in learning activities and exploratory experiences, form their cognitive structures, and realize ″intellectual transfer″ through their learning.

Step 4*:* Autonomous use of knowledge

1) Teacher selects real-life relevant examples or problems and teaches students how to apply what they have learned in mathematics to real-world problems.

2) Students connect the knowledge they have learned with real life and complete the learning tasks independently.

Step 5: Conclusion

The teacher reviews the learning objectives and content of the lesson, guides students to reflect on the class, and ensures students' understanding of what they have learned in class.

3. Result

Students improve their mathematical achievement, including the ability to remember, understand, apply, analyze, evaluate, and create.

3.1 Results on the Improvement of Mathematics Achievement of Second-Grade Elementary Students

This section compares students' mathematics scores before and after the experiment through a comparative samples t-test, which provides information on whether the differences are significant before and after using an instructional model based on the theory of multiple intelligences.

Table 2. Comparison of Students' Mathematics Achievement Before and After the Instructional Model Based on Multiple Intelligences Theory

Mathematics Achievement test	Scores	$\bar{x}$	SD.	t	df	p
Pretest	30	16. 37	4.993	16.246**	29	0.00
Posttest	30	22. 20	6.189			

**Statistically significant at the level. 01 ($p < .01$)

From Table 2, it can be found that the difference in students' mathematics achievement before and after the experiment is statistically significant through the paired samples t-test. There is a significant difference in students' mathematical achievement ($t = -16.246$, $p < 0.001$), the implementation of the instructional model based on the multiple intelligences students have after mathematics achievement was significantly higher than that before class with statistical significance at the level.01 Pretest's mean ($\bar{x} = 16.37$) was significantly lower than the Posttest's mean ($\bar{x} = 22.20$), which proves that the instructional model based on the theory of multiple intelligences can enhance students' mathematical achievement.

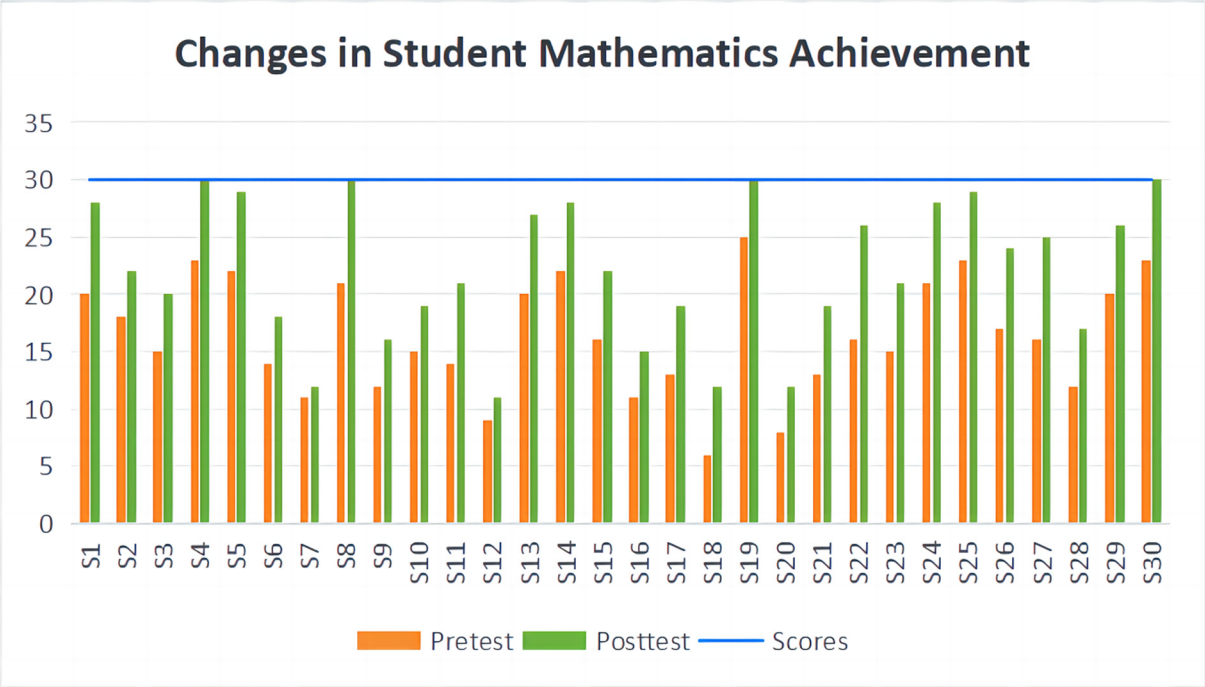

Figure 1. Changes in Student Mathematics Achievement

Figure 1 shows that 30 students improved their mathematics achievement

4. Discussion

The analytical discussion of the study is divided into three parts, which are discussed in turn in this section:

4.1 Discussion on Influences Affecting Elementary School Student's Performance in Mathematics

The findings of this study on the factors affecting elementary school students learning in mathematics showed that the greatest factor affecting elementary school students' performance in mathematics is the learning process, followed by teacher factors and student factors, and the last in the ranking is the environmental factors.

This observation presents similarities with the results of Deng's (2018) study on the academic achievement of junior high school students in China's ethnic minority areas. However, there are some differences when compared to the results of Wang's (2022) data analysis of his study on the academic achievement of fifth-grade elementary school students in the central and eastern provinces of China. The reason for this discrepancy may lie in the outbreak of COVID-19. Before the COVID-19 outbreak, teaching practices were mainly concerned with guiding students to develop good learning strategies and fostering their capacity for self-directed and lifelong learning. At the same time, students were encouraged to actively participate in classroom discussions, cooperative learning, and other diversified learning activities to promote students' academic achievement. These measures provide students with a favorable learning environment and opportunities for interaction and have a positive impact on learning outcomes.

However, during the popularity of COVID-19, online classroom teaching became mainstream, which made the real classroom environment much less interactive and attractive. In this context, online classroom teaching poses a more serious challenge to teachers' professionalism and teaching ability. Teachers need to adapt to the new instructional model, interact with students through the screen, and maintain students' motivation and interest in learning. This is when teachers with rich teaching experience are better able to adapt to the requirements of online classes.

With the effective control of the epidemic, people's lives are gradually returning to their normal state before the epidemic. In this context, the importance of the learning process for improving academic performance has been further enhanced. People have become more aware that when facing the challenges of online teaching, it is particularly important to optimize the learning process and enhance learning strategies, which not only help to improve students' academic performance but also cultivate their independent learning ability and lifelong learning

habits.

Therefore, current educational practices should continue to emphasize the importance of the learning process and actively explore effective teaching methods and strategies in light of the new situation after the pandemic, to ensure that students can obtain quality education and good academic achievements in all environments.

4.2 Discussion on the Development of Instructional Models

In this study, we first systematically sorted out the concepts and theories related to the instructional model, the theory of multiple intelligences, and mathematics achievement. On this basis, it innovatively combines the multiple intelligences theory with the relevant contents of the instructional model and constructs a comprehensive instructional model that addresses the objectives, contents, learning process, and outcomes of the mathematics curriculum for second-grade elementary school students. In addition, the instructional model passed the Index of Objective Coherence (IOC) test. The curriculum consists of four units with a total of 20 credit hours, including reading, writing, comparing, adding, and subtracting numbers up to ten thousand.

In designing mathematics curriculum instruction, mathematics teachers can maximize all the intelligences through teaching and learning, thus helping learners to learn, learn, and learn to do mathematics (Ozdemir et al., 2006). For teaching mathematics, students need to know not only number facts but also good problem-solving skills to accommodate personal strengths and weaknesses. For students to connect their life experiences to mathematics, they need to not only see the skills as relevant to their lives, but also to solve problems in ways that are meaningful to them (Tobias, 1993).

Based on an in-depth study of mathematics teaching materials, this instructional model takes into full consideration the interest characteristics and psychological development of primary school students. Through diversified teaching methods and activities, and the incorporation of life examples and real-life application scenarios, it not only comprehensively stimulates and develops the multiple intelligences of students, but also focuses on solving real-life problems and improving their application and problem-solving abilities. This instructional model aims to promote students' all-around development in the subject of Mathematics, which helps to improve students' learning effectiveness, enhance their interest in Mathematics, and provide them with a solid foundation in Mathematics, which in turn enhances their Mathematical achievements.

4.3 Discussion on the Effectiveness of the Implementation of the Instructional Model

Following the teaching experiment, all 30 students who participated in the teaching experiment improved their scores on the mathematics achievement Test. The results indicated that the instructional model could improve students' mathematics achievement. This is in line with the findings of Ndia (2020). The reason for this is applying the multiple intelligences instructional model in lower primary school students fits the characteristics of lower primary school students, such as being active, curious, and good at figurative thinking. By respecting individual differences, adopting diversified teaching methods, emphasizing teacher-student feedback and communication, and strengthening practical application, the Multiple intelligence theory instructional model has successfully stimulated students' interest in learning and improved their learning outcomes.

In this study, students in the middle and upper levels of achievement made greater progress, which is different from the findings of Geimer et al. (2000). The variation in student progress can be attributed to the distinct foundational requirements inherent in the mathematics and language arts curricula. As a core discipline, mathematics places particular emphasis on the consolidation and practical application of foundational knowledge. Within the framework of the Multiple Intelligences instructional model, mathematics instruction systematically imparts fundamental concepts, principles, and problem-solving methodologies, delving into the intrinsic nature and abstract notions of mathematics. Students at the intermediate level and beyond typically possess a more robust foundational knowledge. Operating within the multiple intelligences instructional model, they exhibit a heightened capacity to assimilate, comprehend, and deepen their understanding of new instructional content, thus facilitating more substantial academic progress.

5. Conclusion

The results of the study are shown as follows:

1) The factors affecting elementary school students' mathematics achievement include four aspects: (1) Students (2) Teachers (3) the learning process and (4) the Environment;

2) The instructional model based on Gardner's Multiple Intelligences Theory consists of four elements: (1) Principle

(2) Objective (3) Learning processes and 4) Result.

3) After the implementation of the instructional model based on Gardner's Multiple Intelligences Theory, the mathematics achievement of the students has been improved.

6. Recommendations

Based on the results of the study, it is recommended that:

1) Learning process factors affecting students' learning achievement, including learning environment, learning methods, teaching interactions, and learning resources, deserve attention and research. These learning process factors directly affect students' learning process and have a significant impact on learning achievement.

2) To improve the mathematics achievement of elementary students in the lower grades, it is more appropriate to use the Multiple Intelligences Theory instructional model.

3) Under the Multiple Intelligences instructional model, students in the middle and upper levels of achievement made greater progress. For low-scoring students with poor fundamentals, teaching should focus on individualization and differentiation. (1) Identifying their weak points in basic knowledge and formulating targeted teaching programs is necessary. (2) Adopt intuitive and visual teaching methods to reduce learning difficulty and enhance interactive teaching to increase student participation. (3) Additional learning support and resources are also necessary to ensure that students receive adequate consolidation and expansion after class. (4) Timely encouragement and feedback can motivate students.

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Data sharing statement

No additional data are available.