DEVELOPMENT OF LEARNER-CENTERED MATHEMATICS CURRICULUM FOR CULTIVATING MATHEMATICAL PROBLEM-SOLVING SKILLS OF PRIMARY SCHOOL STUDENTS

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การพัฒนาหลักสูตรคณิตศาสตร์แบบผู้เรียนเป็นศูนย์กลางเพื่อพัฒนาทักษะการแก้ปัญหาคณิตศาสตร์ในนักเรียนระดับประถมศึกษา

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BY

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HAS BEEN APPROVED BY THE GRADUATE SCHOOL IN PARTIAL FULFILLMENT OF THE REQUIREMENTS FOR THE DOCTOR OF PHILOSOPHY IN CURRICULUM RESEARCH AND DEVELOPMENT AT SRINAKHARINWIROT UNIVERSITY

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Author	DONGMEI LYU
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The aims of this research area are as follows: (1) to study the current situation of mathematical problem-solving skills among primary school students; (2) to develop a learner-centered mathematics curriculum for cultivating mathematical problem-solving skills among primary school students; (3) to study the effectiveness of the learner-centered mathematics curriculum in cultivating mathematical problem-solving skills in primary school students. The sample consisted of 40 fourth-grade students from Zhoukou City, Henan Province, China. They were selected using a multi-stage sampling method. The experimental design was a one-group pretest-posttest design. The instrument used for collecting data was a mathematical problem-solving skills test paper. This study, guided by the learner-centered educational philosophy, comprehensively utilized cooperative learning, problem-based learning, and gamification to design a range of activities aimed at encouraging active exploration and problem-solving. The learner-centered mathematics curriculum has six components: curriculum principles, curriculum objectives, curriculum content, teaching methods, instructional materials, and learning evaluation. The results of the curriculum implementation showed that the mean scores of students who completed the learner-centered mathematics curriculum on mathematical problem-solving skills were higher than their pre-test scores, and this difference was statistically significant at a level of .05 level.

Keyword : Learner-centered mathematics curriculum, Mathematical problem-solving skills

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After graduation, I will begin a new journey, but no matter where I go, Srinakharinwirot University will always hold a special place in my heart. I will always remember their contributions, and I am committed to giving back to the school through my actions. I sincerely hope that all international students can successfully complete their studies and grow into better individuals. May the school continue to thrive and prosper in the future, and may the teachers enjoy good health and smooth work.

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INTRODUCTION

Research Background

The technological changes of the 21st century have imposed new requirements on human abilities, making traditional school education, which focuses on imparting knowledge and skills, increasingly inadequate to meet societal needs (Zhu, 2016). In the new century, talents must not only possess basic learning abilities but also be able to use the knowledge they have acquired to solve problems independently in a complex social environment. Problem-solving skills are essential for individuals to adapt to the social living environment and to promote social innovation and development (Wang, 2021). Step-by-step problem-solving skills form the foundation for further learning, rapid societal adaptation, and effective personal affairs management (Yang, 2016). The importance of problem-solving skills has become increasingly crucial in this century (Ince, 2018).

In 1982, the British Cockcroft report called on teachers to embed "problem-solving" activities into teaching activities (Gillard, 2007). In 1989, the U.S. government proposed the 21st-century education strategy, focusing on cultivating students' "three foundations and five skills", including creative thinking and problem-solving skills (Zhou & Yu, 2009). In 1999, China's National Skills Revitalization Strategy listed "problem-solving" as one of the eight core competencies (Chen, 1999). In 2002, Japan emphasized in the "Study Guidance Outline" that from elementary school, middle school to high school, attention should be paid to the cultivation of students' problem-solving skills, and teachers must develop students' problem-solving skills purposefully (Li & Ren, 2004). In the new curriculum standard, Germany regards "problem-solving and creativity" as one of the five major goals and points out that the primary task is to arrange problem-solving-oriented teaching (Lyu & Luo, 2018). The global educational sector has shifted its emphasis towards improving students' abilities to situate themselves in the world. It is evident that fostering students' problem-solving skills has become a central concern in the field of education worldwide.

Mathematics is a tool for problem-solving, communication, reasoning about thought patterns, and connecting with other disciplines (NoprianiLubis et al., 2017). Since its inception, mathematics has been used to solve various problems encountered in people's lives, from ancient knots and counting to current savings deposits, artificial intelligence, and beyond. Human civilization is accompanied by mathematics, and every advancement of humanity is closely related to mathematics (Zhang, 2020). Mathematics needs new content and development, often requiring generations of people to continue solving problems. As an indispensable and important part of education, mathematics education must bear the heavy responsibility of cultivating students' problem-solving skills (Jiang, 2021). To foster creativity, logical thinking, critical analysis, and systematic reasoning, students need to acquire a range of problem-solving skills in mathematics (NCTM, 2000). Solving mathematical problems is a goal that must be achieved in learning mathematics (Ibrahim et al., 2021). If students' problem-solving skills are low, the instructional goal of having students acquire problem-solving skills that include understanding problems, designing mathematical models, improving models, and interpreting the resulting solutions will be difficult to achieve (Rahmah et al., 2022). If students are equipped with problem-solving skills, they can solve everyday math problems and will no longer think that math is just a theoretical concept that is useless in daily life (Rahmah et al., 2022). Therefore, it is of great significance to develop and improve students' mathematical problem-solving skills.

China has issued a series of documents emphasizing the importance of cultivating students' awareness of problems and innovation in the new curriculum reform. The Ministry of Education put forward "promote the diversification of training modes, explore ways to discover and train innovative talents, and strive to improve students' innovative spirit of courage to explore and practical ability to solve problems" (Committee of the Communist Party of China, 2010). The new mathematics curriculum reform sets the cultivation of problem-solving skills as one of the curriculum objectives of compulsory education (Ministry of Education of the People's Republic of China, 2012). Developing students' mathematical problem-solving skills aligns with the national math education reform. Nevertheless, the current situation of problem-solving skills among Chinese students is not optimistic. The results of the PISA 2012 test carried out by the Organization for Economic Cooperation and Development (OECD) indicate that students in Shanghai are more proficient in addressing static problems but show significant weakness in handling interactive problems. Students are better at acquiring knowledge but lack the ability to apply it (Caixin, 2014). This indicates that in our country's basic education, particularly in the information environment, the development of students' problem-solving skills lags far behind the acquisition of subject knowledge. Over the course of his many years in the classroom, Song (2018) observed that a considerable number of elementary school students struggle with mathematical problem-solving. Zhang (2020) pointed out that "there are three problems in the mathematical problem-solving skills of primary school students: the cognitive bias of mathematical problem-solving skills, the single way of problem representation, and the relatively weak mathematical problem-solving skills".

As the process of the implementation of the new curriculum reform proceeds, novel developments have been achieved in mathematics education regarding teaching paradigms, pedagogical ideas, and instructional materials. However, because the traditional idea of exam-oriented education is deeply rooted, the effect of the new curriculum reform is not ideal (Shi, 2018a). Many school teachers still utilize the traditional indoctrination teaching method, focusing on explaining mathematical basics and question types, leading to students passively receiving knowledge and a lack of meaningful teacher-student interaction. As the grades increase, mathematics knowledge becomes more and more abstract, and teachers still use traditional teaching methods, which can easily make students feel bored. Consequently, students' learning enthusiasm and proactive attitude gradually diminish, leading to a loss of interest in mathematics (Yang, 2022). Under the current educational reform, educational evaluation has not made a breakthrough. The evaluation's sole focus on test scores ignores students' specific issues and current ability levels, impeding their overall development, individual differences, and qualitative improvement in problem-solving skills (Guo, 2020). During the teaching process, primary school students may grasp fundamental mathematical concepts, yet they seldom independently identify and pose mathematical inquiries when encountering challenging real-life situations (Chen, 2022). These occurrences hinder the development of students' learning capabilities, practical problem-solving skills, exploratory abilities, and capacity for innovation. The focal point of this study lies in integrating "problem-solving" into classroom pedagogy and elevating students' problem-solving skills.

The most effective way to cultivate students' problem-solving skills is to let students "take more responsibility for their work and solve problems by themselves" (Huang & Chen, 2004). In a sense, human learning is a problem-solving process. Only by allowing students to actively discover and identify problems, analyze problems, make plans, choose strategies, and implement plans will effective problem-solving be more conducive (Jiang, 2021). Fully mobilizing the enthusiasm and initiative of students in learning and allowing them to participate in learning is one of the most important factors for their academic success (Christenson et al., 2012). The teaching activities to cultivate problem-solving skills must have the following main characteristics: 1) Activities where the learner is the main focus; 2) A learning mentality of self-responsibility; 3) Opportunities for learners to deal with problems in the field and gain experience from the activities (Huang & Chen, 2004).

Advocates of learner-centered teaching theory believe that people are born with positive motivation (Fang, 1990). Teachers should emphasize the dominant position of students in teaching activities and sincerely believe that students can develop their potential so that they can learn and work happily and creatively. Learner-centered teaching, also known as the learner-centered approach, is a teaching method that creates a customized learning experience by using students' interests and advantages (Smith, 2022). This methodology emphasizes student passions and interests, leveraging cooperative learning to maximize student strengths, thus transitioning them from passive to active learning. Learner-centered learning has several benefits: Fosters better memorization; Enhances participation; Cultivates problem-solving skills; Facilitates personalized learning; Transforms learning into an enjoyable process; Stimulates collaboration and teamwork (Ranido, 2023).

Primary school students have weak autonomous learning ability, making it difficult for them to independently analyze and solve problems, and they are prone to weariness when encountering difficult problems. Cooperative teaching, characterized by strong autonomy, high openness, and strong interest, is very suitable for cooperative learning based on problem exploration in elementary school mathematics classrooms (Chen, 2019). Cooperative learning can enhance students' self-confidence and participation in the learning process (Nebesniak, 2007). Problem-Based Learning is a learner-centered, problem-oriented teaching approach (Wang, 2022). In Problem-Based Learning, students collaborate in groups to tackle complex, real-world problems while being mentored by faculty (Allen et al., 2011). Problem-Based Learning has a positive effect on problem-solving (Valdez & Bungihan, 2019; Wang et al., 2021). The gamification method emphasizes students' whole-class participatory learning and attaches importance to the playfulness and interestingness of classroom teaching (Chen, 2019b). In the teaching process, the gamification method can enable students to learn knowledge in an autonomous and pleasant environment, which is conducive to stimulating students' interest and motivation in learning and cultivating their problem-solving skills (Jiang, 2021). In summary, learner-centered pedagogy promotes active exploration among learners, fostering the advancement of their problem-solving and innovative capabilities. However, further practical application and in-depth research are required to efficiently implement these novel learner-centered teaching strategies and fully engage students' learning enthusiasm.

Primary school is a critical period for children's rapid development of thinking (Pei, 2019). At this stage, students encounter a variety of problems, which provide them with valuable opportunities to practice their problem-solving skills. The key age for the transition of children's thinking from concrete image thinking to abstract logical thinking is the fourth grade of primary school (about 10 to 11 years old) (Wan, 2011). The mathematics curriculum for grades 1–3 in primary school primarily focuses on the initial understanding of numbers and basic arithmetic operations, such as understanding numbers within ten thousand and the four basic arithmetic operations. It also covers recognizing basic shapes and introductory data collection statistics. However, commencing from the fourth grade, the curriculum undergoes significant deepening and expansion, encompassing large numbers above ten thousand, decimals, and more intricate computations. The study of shapes extends to perimeter and area calculations, while data statistics incorporate more complex methodologies like bar charts and line graphs. The complexity of problems escalates, with an emphasis on logical thinking and problem-solving skills. The fourth grade marks a pivotal turning point in primary school mathematics education, with a notable emphasis on enhancing students' problem-solving skills. This not only facilitates a qualitative transformation in students' thinking but also equips them to adeptly handle various challenges in their future lives. Through meticulous guidance and training from educators, we can assist students in establishing independent thinking and problem-solving skills, thereby laying a solid foundation for their long-term development.

Based on the above reasons, this study aims to develop and design a mathematics curriculum with a learner-centered concept, guide teachers to change educational concepts, improve teaching methods, fully mobilize students' enthusiasm and initiative in learning, stimulate their interest in learning, and improve their problem-solving skills. The researcher believes that it is necessary to develop a learner-centered mathematics curriculum to train students' mathematical problem-solving skills.

Research Significance

By referring to relevant literature, this study clarified the connotation of primary school students' mathematical problem-solving skills, understood its current situation, discussed the relevant theories, principles, and strategies for "cultivating mathematical problem-solving skills”, deeply studied the learner-centered teaching concept, developed and implemented a mathematics curriculum based on this research, and aimed to improve traditional educational concepts and teaching methods for teachers. It is highly significant and valuable to guide teachers on cultivating students' problem-solving skills from the perspective of curriculum development.

1) This study not only enriches the theory of problem-solving skills and provides practical materials for measuring these skills but also offers theoretical guidance for changing traditional classroom teaching practices, promoting teaching reform, and improving teachers' teaching abilities.

2) This study provides students with opportunities for active learning through a variety of learning activities, which enhances learners' awareness of participation and subject engagement, and cultivates students' ability to use the knowledge they have learned to solve mathematical problems.

Research Objectives

1) To study the current situation of mathematical problem-solving skills of primary school students.

2) To develop the learner-centered mathematics curriculum for cultivating mathematical problem-solving skills of primary school students.

3) To study the effectiveness of the learner-centered mathematics curriculum for cultivating mathematical problem-solving skills of primary school students.

Research Scope

Population

The research population for this study comprises fourth-grade students in Henan Province. The reasons for selecting Henan Province as the research population are as follows: 1) Henan Province is one of the most populous provinces in China, with a large number of students. According to the Ministry of Education of the People's Republic of China (2023), the number of fourth-grade students in Henan Province is 1,720,712, ranking second in the country. This provides a sufficiently large sample space for the study. 2) Henan Province is actively promoting educational reform aimed at improving students' comprehensive qualities and problem-solving skills. Studying the student population in Henan Province will help to understand the achievements and challenges of the current educational reform.

Sample

The research sample for this study was drawn from a single fourth-grade classroom of 40 students at Zhoukou City's First Primary School in Henan Province, China, during the 2023-2024 academic year. The researcher used a multi-stage sampling technique to select participants. In the first stage, Zhoukou City was selected by a simple random sampling method from 18 prefecture-level cities in Henan Province. In the second stage, the First Primary School of Zhoukou City was selected by a simple random sampling method from 120 primary schools in Zhoukou. In the third stage, a classroom with a total of 40 students (22 boys and 18 girls) was selected by a simple random sampling method from 8 fourth-grade classrooms in the First Primary School.

Variables

Independent Variable: The learner-centered mathematics curriculum for cultivating mathematical problem-solving skills of primary school students.

Dependent Variables: The mathematical problem-solving skills of primary school students.

Definition of Terms

1. Mathematical problem-solving skills in primary school students refer to the abilities that primary school students need in a series of processes such as understanding, analyzing, and solving problems by using the mathematical knowledge and methods they have learned when facing problem situations with no obvious solutions in learning activities or real life. It encompasses the comprehensive mathematical abilities of primary school students. In this study, mathematical problem-solving skills are reflected in four process stages: understanding, analyzing, solving, and reviewing. The students' problem-solving skills are evaluated based on these four elements: understanding, analyzing, solving, and reviewing.

1.1 Understanding means gaining insight into the intrinsic nature of the problem, accurately reflecting the characteristics and objective situation of the problem, and extracting relevant mathematical information from it. Specific performance: Be able to identify the characteristics of the problem, understand the meaning of the text, pictures, tables, and other information presented in the situation; Have the capability to efficiently filter and extract pertinent data from an extensive dataset to facilitate problem-solving; be able to clearly distinguish between known and unknown quantities.

1.2 Analyzing means identifying the internal structure of the problem and establishing the necessary links between the relevant information and the knowledge you have mastered. Specific performance: Be able to judge the quantitative relationships or spatial forms among variables in mathematical problems; be able to present the thinking process in the form of words, symbols, graphs, tables, etc.; be able to organize the known and unknown elements and narrow the gap between them.

1.3 Solving means utilizing suitable mathematical knowledge, methods, and strategies to reach problem solutions. Specific performance: This involves effectively executing mathematical operations and reasoning; transferring mathematical knowledge and applying existing methods and conclusions to novel problems; and demonstrating innovation by attempting to devise alternative solutions.

1.4 Reviewing means after solving problems, the ability to consciously check the correctness of the problem-solving process and results, and reflect on and adjust their problem-solving solutions and ideas. Specific performance: Be able to consciously reflect on whether the process and results are correct and reasonable after solving the problem; be able to understand the solving strategies and methods used during the process; be able to compare different solution processes and identify which method is more efficient.

The mathematical problem-solving skills of primary school students will be evaluated using a mathematical problem-solving skills test paper. The test paper consists of 7 situational items related to real-life situations combined with students' knowledge levels. Each item is answered in four steps, with a full score of 4 for each step. The total score for all items is 112 points (28×4), with 28 points allocated to each of the four stages: understanding, analyzing, solving, and reviewing.

2. Learner-centered mathematics curriculum refers to a curriculum plan

that guides teachers to teach and students to learn with the learner-centered concept. As a guide, teachers choose appropriate teaching strategies, guide students to participate in the curriculum, and promote students to achieve different degrees of development. The curriculum consists of six parts: 1) Curriculum Principles; 2) Curriculum Objectives; 3) Curriculum Content; 4) Teaching Methods; 5) Instructional Materials; 6) Learning Evaluation. The mathematics curriculum covers four areas: Numbers and Algebra; Geometry and Graphics; Statistics and Probability; Synthesis and Practice. It contains 4 units in total: Four Arithmetic Operations; Rectangle and Square; Averages, Bar Charts, and Probability; Nutrition Lunch. This research uses three teaching methods: Cooperative Learning, Problem-Based Learning, and Gamification. This research is always consistent with the concept of "learner-centered", and the authenticity and accuracy of data are guaranteed in the process of measurement and evaluation. In the research process, a variety of evaluation methods such as teacher-student interviews, test scales, student group discussions, self-evaluation, mutual evaluation, and teacher evaluation are used comprehensively.

3. The effectiveness of the learner-centered mathematics curriculum lies in whether the problem-solving skills of students after completing the learner-centered mathematics course have reached the expected learning goals. The method to assess the effectiveness of the mathematics curriculum is by comparing the pre-test and post-test scores of students' mathematical problem-solving skills tests after the completion of the curriculum. The tool for evaluating the effectiveness of the mathematics curriculum is the Mathematics Problem-Solving Skills Test. The criterion for evaluating the effectiveness of the mathematics curriculum is that students who learn through the learner-centered mathematics curriculum should have post-test scores on mathematical problem-solving skills that are higher than pre-test scores, with a statistically significant difference at the 0.05 level.

4. Primary school students refer to the students who studying in grades 4-6.

Research Hypothesis

The mean scores of students who completed the learner-centered mathematics curriculum on the post-test of mathematical problem-solving skills were higher than their pre-test scores, and this difference was statistically significant at the 0.05 level.

Theoretical Framework

A review of relevant literature reveals that problem-solving skills, which are highly valued globally, are also recognized as a curriculum objective in the Chinese Mathematics Curriculum Standards. However, the pervasive traditional teaching philosophy hinders the cultivation of students' practical problem-solving skills, leading to deficiencies in their ability to tackle complex problems. In response, educational reform has focused on making curriculum and instruction more learner-centered, integrating real-life situations into school learning, and prioritizing comprehension and critical thinking over rote memorization. To address these challenges, the researcher has developed learner-centered mathematics curriculum, emphasizing learner-centered approaches to curriculum design, instruction, and assessment. The theoretical framework is illustrated in Figure 1.

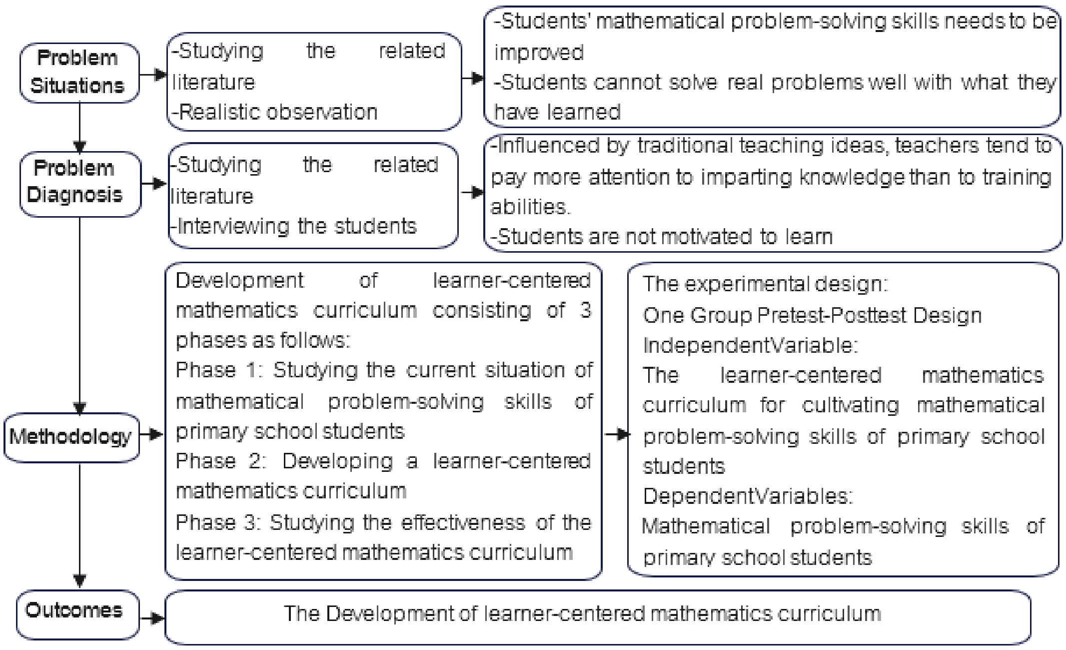


FIGURE 1 The theoretical framework

Conceptual Framework

Effective teaching embodies the harmony between students' learning processes and teachers' instructional methods. In this dynamic, students occupy the central role as the primary learners, engaging actively with the material. Conversely, teachers function as the organizers of the educational environment, offering guidance and working collaboratively with their students. The learning experience for students should be proactive, involving attentive listening, critical and independent thought, practical application, self-directed exploration, and cooperative dialogue. These activities are essential in cultivating a deep understanding of mathematics.

Instructional practices ought to concentrate on heuristic methods that foster critical thinking. Teachers should strive to spark students' interest in learning, gently guiding them to think independently and creatively. Encouraging students to pose challenging inquiries is crucial, as it fosters a culture of curiosity and exploration. Additionally, educators should assist students in identifying and framing problems within real-world contexts. This approach enables learners to employ a range of strategies in analyzing and resolving these issues, thereby enhancing their problem-solving skills and preparing them for the complexities of the real world.

In this study, we fully implement the learner-centered design philosophy in terms of curriculum development, teaching, and assessment. We will employ diverse learner-centered teaching techniques to stimulate students' enthusiasm for problem-solving. In our classrooms, we extensively use three learner-centered teaching methods: cooperative learning, Problem-Based Learning, and gamification. The aim of this research is to develop a mathematics curriculum that is learner-focused and designed to enhance the problem-solving skills of elementary school pupils. During the curriculum development process, we have referenced and adapted both the objectives model and the process model, while incorporating the learner-centered curriculum design philosophy as the guiding principles for preliminary curriculum design. The entire curriculum design process consists of three key steps: Phase 1 : Studying the current state of mathematical problem-solving skills of primary school students; Phase 2 :

Developing the learner-centered mathematics curriculum; Phase 3 : Evaluating the effectiveness of the learner-centered mathematics curriculum. The conceptual framework of this study is shown in Figure 2.

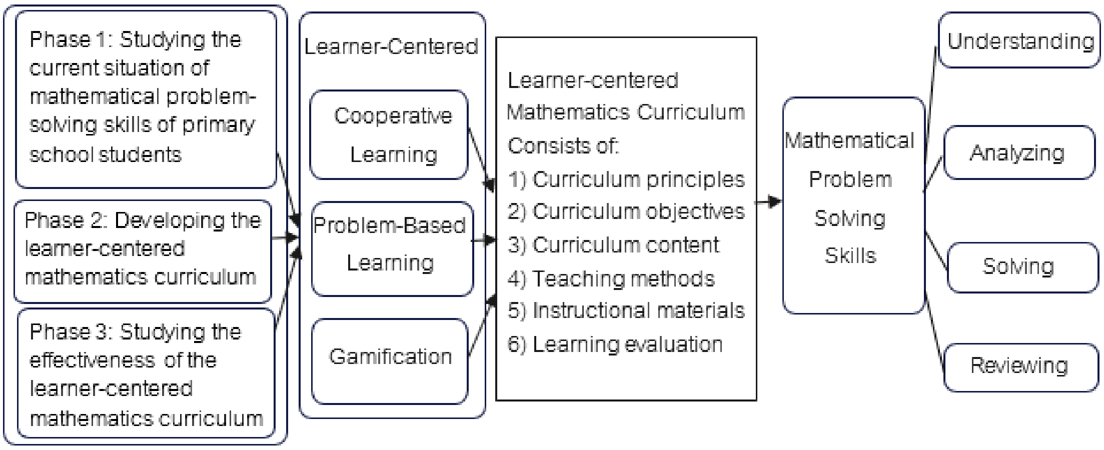


FIGURE 2 The conceptual framework

CHAPTER 2
LITERATURE REVIEW

Based on the research objectives of this study and the scope of the dependent and independent variables, this chapter aims to read, analyze, and organize materials related to primary school students' mathematical problem-solving skills; learner-centered mathematics curriculum; and curriculum development. This will lay a solid theoretical foundation for the writing of this study. The literature review related to this study is divided into the following four sections:

1. Basic education in China

 1.1 A new round of basic education curriculum reform

 1.2 Compulsory Education Mathematics Curriculum Standards

2. Problem-solving skills

 2.1 The meaning of mathematical problems

 2.2 The implications of problem-solving

 2.3 The implications of mathematical problem-solving

 2.4 Mathematical problem-solving process model

 2.5 Factors affecting mathematical problem-solving

 2.6 Evaluation of mathematical problem-solving skills

 2.7 Current Situation of mathematical problem-solving skills

3."Learner-centered" approach: cooperative learning, Problem-Based Learning, and gamification

 3.1 The theoretical basis of "learner-centered"

 3.2 Comparison of "learner-centered" and "teacher-centered" instruction

 3 . 3 Three "learner-centered" teaching methods: cooperative learning, Problem-Based Learning and gamification

 3.4 Application of learner-centered teaching methods

4. "Learner-centered" mathematics curriculum development

 4.1 The meaning of curriculum development

 4.2 Models for curriculum development

4.3 The development of a learner-centered mathematics curriculum

4.4 The learner-centered mathematics curriculum design

1. Basic Education in China

1.1 A new round of basic education curriculum reform

The new round of basic education curriculum reform, known as the "New Curriculum Reform", is the eighth major reform of basic education since the founding of New China. With our country's reform and opening-up policy and socialist modernization entering a new era, the problems and shortcomings of the original basic education curriculum have become increasingly apparent in the face of rapid advancements in science and technology. To meet the new requirements for personnel training in the 21st century, the Central Committee of the Communist Party of China and the State Council (1999) proposed to "deepen education reform and promote quality education in an all-round way". In 2001, the Ministry of Education officially launched the new curriculum reform and issued a series of policy documents, including the "Outline of Basic Education Curriculum Reform (Implementation)". The purpose of this new curriculum reform is to establish a basic education curriculum system that fulfills the requirements of quality education for the 21st century (Wang, 2009). The core concept of the new curriculum reform is "for the great rejuvenation of the Chinese nation and for the development of every student" (Cheng et al., 2017).

The new curriculum reform has made comprehensive and in-depth explorations in various aspects, including curriculum objectives, curriculum structure, curriculum content, curriculum implementation, curriculum evaluation, and curriculum management (Ministry of Education of the People's Republic of China, 2002). Regarding curriculum objectives, the reform emphasizes a shift from the traditional focus on knowledge transmission to the pursuit of comprehensive development in knowledge and skills, processes and methods, emotional attitudes, and values. In terms of curriculum structure, the reform aims to break away from the subject-centered framework and establish a more balanced and reasonable curriculum system that meets the demands of future society for well-rounded talent and aligns with the natural development of students' physical and mental abilities. For curriculum content, the reform advocates abandoning the tendency to rely heavily on textbooks that are too difficult, complex, niche, or outdated. Instead, greater emphasis is placed on connecting with students' real-life experiences and the development of modern technology and society. Attention is also given to considering students' learning interests and prior experiences. In curriculum implementation, the reform encourages active participation, enthusiastic exploration, and diligent practice among students, fostering their abilities in information processing, knowledge acquisition, problem-solving, communication, and collaboration. Concerning curriculum evaluation, the reform adjusts the previous excessive emphasis on selection and screening by giving greater prominence to the positive role of evaluation in promoting individual student development, aiding teachers in self-improvement, and refining teaching practices. Finally, regarding curriculum management, the reform departs from the highly centralized model of the past by implementing a three-tier management system at the national, local, and school levels. This enhances the adaptability and flexibility of the curriculum to different regions, schools, and students.

1.2 Compulsory Education Mathematics Curriculum Standards

The national curriculum standards serve as the foundation for textbook compilation, assessment of teaching effectiveness, and design of examination questions. They also play a crucial role in managing and evaluating the curriculum at the national level. Since the new curriculum reform, China has promulgated three versions of compulsory education mathematics curriculum standards: the Experimental Version, the 2011 Version, and the 2022 Version. The Compulsory Education Mathematics Curriculum Standards (2022 Edition) emphasizes integrity and consistency, highlights core literacy, promotes academic quality, and stresses that the educational value of the mathematics curriculum is the continuation, improvement, and development of the previous compulsory mathematics curriculum standards (Chen et al., 2022).

The overall goal of the Compulsory Education Mathematics Curriculum Standards (2022 Edition) is to enable students to gradually develop the ability to observe the real world from a mathematical perspective, think about the real world using mathematical thinking, and express the real world using mathematical language through their mathematics learning at this stage (Ministry of Education of the People's Republic of China, 2022). Specifically, students should be able to:

1) Master the basic knowledge, basic skills, basic ideas, and basic activity experiences necessary for adapting to future life and further development;

2) In exploring the relationship contained in the real situation, discover and ask questions, and use the knowledge and methods of mathematics and other disciplines to analyze and solve problems;

3) Have curiosity and thirst for knowledge about mathematics, be interested in mathematics, have confidence in learning mathematics well, and have good mathematics learning habits.

To reflect the integrity of the compulsory education mathematics curriculum and coordinate the curriculum content over the nine-year period, while considering students' physiological and psychological development characteristics, the nine-year study period is divided into three learning stages: the first stage (grades 1-3), the second stage (grades 4-6), and the third stage (grades 7-9). This staging approach ensures a comprehensive and systematic approach to teaching and learning mathematics throughout the entire compulsory education period. The mathematics curriculum for compulsory education encompasses four progressively advancing learning modules: Number and Algebra, Graphics and Geometry, Statistics and Probability, and Synthesis and Practice. The primary curriculum content requirements are shown in Table 1 (Ministry of Education of the People's Republic of China, 2012):

TABLE 1 The primary curriculum objectives and content requirements

Modules	Curriculum contents	
	The first stage (grades 1-3)	The second stage (grades 4-6)
Number and algebra	-Understand the meaning of numbers up to ten thousand and be able to perform addition, subtraction, multiplication, and division proficiently. -Have a basic understanding of fractions and decimals, comprehend their meanings, and be able to perform simple addition and subtraction operations with fractions and decimals. -In specific contexts, be able to select appropriate units for simple estimation.	-Understand numbers above ten thousand and comprehend the meanings of fractions, decimals, percentages, and their interrelationships. -Master necessary arithmetic skills, including performing mixed operations of the four basic arithmetic operations, and applying these operations to fractions and decimals. -Understand the meaning and methods of estimation, and be able to make reasonable estimations in specific contexts. -Be able to represent simple quantitative relationships using equations and solve simple equations.
Graphics and geometry	-Recognize common plane figures (such as circles, squares, and rectangles) and solid figures (such as rectangular prisms and cubes). -Understand the basic characteristics of these figures and be able to perform simple classification and combination tasks. -Experience graphic transformation phenomena such as translation, rotation, and axial symmetry, and develop spatial awareness.	-Explore the shape, size, and positional relationships of various figures, and understand the basic characteristics of geometric solids and plane figures. -Experience simple movements of figures (such as translation and rotation), and be able to draw the resulting figure after a simple movement on graph paper. -Master basic methods of measurement, map reading, and drawing, and be able to perform simple calculations of area and volume.

TABLE 1 (CONTINUE)

Modules	Curriculum contents	
	The first stage (grades 1-3)	The second stage (grades 4-6)
Statistics and probability	-Experience simple data collection, organization, and analysis processes, and understand basic data processing methods. -Be able to perform simple statistical analyses and comparisons based on given data.	-Experience the process of data collection, organization, and analysis, and master basic data processing skills. -Understand random events and the concept of equal likelihood, and be able to perform simple probability calculations. -Recognize statistical tables and graphs (such as bar charts and line graphs), and be able to make simple judgments and predictions based on statistical results.
Synthesis and practice	-Through practical activities, experience the role of mathematics in daily life and the process of using learned knowledge and methods to solve simple problems, gaining initial experience in mathematical activities. -Understand the problems to be solved and the methods for solving them during practical activities. Go through practical operations to further understand the content learned.	-Combine real-world situations to experience the process of discovering and posing problems, analyzing and solving them. -Under given objectives, experience the process of proposing design ideas and formulating simple solutions for specific problems. -Through application and reflection, further understand the knowledge and methods used, comprehend the connections between learned knowledge, and gain experience in mathematical activities.

Analysis of the Above Content: Students in grades 1-3 are mainly in the accumulation stage of basic knowledge. In mathematics, they typically learn fundamental concepts such as number recognition, simple addition, subtraction, multiplication, and division operations, as well as the initial understanding of geometric figures. The focus at this stage is to build a solid foundation in mathematics, familiarize students with mathematical language and basic operations, and prepare them for more advanced learning. Entering grades 4-6, the content of mathematics learning becomes more complex. Students begin to explore advanced concepts such as fractions, decimals, and percentages, and are introduced to more complex operations and applied mathematical problems. This stage requires students to not only perform basic mathematical operations but also to develop their ability to apply mathematical knowledge to solve practical problems. This study chooses the fourth grade as the research object for cultivating the problem-solving skills of primary school students. Selecting this grade as the focus of the research aligns with students' cognitive development and the structure of the mathematics curriculum, helping to lay a solid foundation for future mathematical learning. The reasons for this choice are as follows: 1) Intersection of Foundation and Advancement: The fourth grade is a critical period for transitioning from basic to advanced mathematics learning. By this stage, students have mastered fundamental mathematical concepts and methods and are beginning to encounter more complex problems and applications, making it an ideal time to cultivate problem-solving skills. 2) Maturity of Cognitive Abilities: Compared to lower grades, fourth-grade students have significantly improved cognitive abilities. They are better able to understand abstract concepts and engage in logical reasoning, which are essential skills for solving mathematical problems. 3) Suitability of Curriculum Content: The fourth-grade mathematics curriculum introduces more practical problems and application scenarios, offering students ample opportunities for problem-solving practice. The curriculum content is challenging yet manageable, striking a balance that encourages students' thinking without overwhelming them. 4) Preparation for Higher Grades: Focusing on developing mathematical problem-solving skills in the fourth grade can lay a strong foundation for students to tackle more complex mathematical challenges in higher grades. Based on the analysis and organization of existing textbooks for the fourth-grade mathematics curriculum according to curriculum standards, the summary of the learning content requirements for the fourth-grade mathematics curriculum is shown in Table 2:

TABLE 2 Fourth grade students learn content requirements

Modules	Content Requirement
Number and algebra	-In the process of solving simple and practical problems, understand the meaning of the four arithmetic operations and be able to perform mixed arithmetic operations on integers. -In the specific situation, the common quantity relations are understood: total amount = component + component, total price = unit price × unit price, distance = speed × time; the students should be able to use these relationships to solve simple practical problems.
Graphics and geometry	-Understand perimeter and area with examples; explore and master the perimeter and area formulas for rectangles and squares. -Learn about triangles by classifying them based on geometric features and understanding their basic characteristics.
Statistics and probability	-Understand bar charts and use them to represent and analyze data effectively. -Explore the concept of the mean and apply it to solve simple practical problems.
Synthesis and practice	-Gain successful experience in comprehensively applying knowledge and operations from numbers, geometry, statistics, and probability to solve simple practical problems, and begin to build confidence in using mathematics for problem-solving. -Obtain experience and methods for comprehensively applying the knowledge and skills learned to solve simple practical problems.

2. Problem-solving Skills

To understand the current status of cultivating students' problem-solving skills, this study reviews domestic and international research findings. By employing a layer-by-layer analysis method, the study examines research related to students' problem-solving skills, providing a theoretical and practical foundation for developing a curriculum aimed at enhancing students' mathematical problem-solving skills.

2.1 The meaning of mathematical problems

The "Dictionary of Psychology" defines a "problem" as a task situation where there are obstacles between a given state and a target state that need to be overcome (Lin et al., 2003). A problem is the conscious search for an appropriate action to achieve a clearly realized but not immediately attainable end (Polya, 1962). Mathematical problems not only share the common characteristics of general problems but also possess the particularities of mathematics. There is currently no unified regulation on the definition of mathematical problems. The current research results of foreign scholars can be roughly summarized into the following types:

Mathematical problems are a type of problem system. Let's study the system (S, R), where S represents a topic and R represents a set that constitutes an abstract (or concrete) system. We call the set R a topic system (Oganesyan, 1983).

1) A math problem is a situation. The 6th International Conference on Mathematics Education (ICME) in 1988 defined a mathematical problem as an unsolved situation characterized by intellectual challenges to humans, for which no direct methods, procedures, or algorithms exist (Yu et al., 2011).

2) Mathematical problems are a collection. Stollar gave a more abstract definition in Mathematics Pedagogy: “A certain ‘object field’ is described by a mathematical term notation. This object field can be represented by one or several sets. These several sets can be combined into a complete set, and the problems formed with the predicates specified in it are called mathematical problems” (Ma, 2013).

Domestic scholars' definitions of mathematical problems are mostly researched from the aspect that mathematical problems are a kind of situation. For example, Yang (2003) defined mathematical problems as “a situational state that people face in teaching activities and cannot be solved with ready-made teaching experience and methods”. Jin (2005) defined mathematical problems as “new problems and new situations that people face in mathematical activities that cannot be directly solved with existing knowledge and experience and have no ready-made countermeasures".

Through the above analysis, different scholars have not yet reached a unified definition of mathematical problems. At present, it is generally believed that mathematical problems should be considered in conjunction with mathematical situations. In this paper, mathematical problems refer to situations that primary school students encounter during the process of mathematics learning and that need to be analyzed and solved using mathematical knowledge and methods. These situations are based on real-life contexts, lack ready-made mathematical experiences or methods for direct solutions, present challenges, and have the potential to develop students' mathematical thinking.

2.2 The implications of problem-solving

The definition of problem-solving is more precisely defined by psychologists based on the definition of a “problem”. They generally believe that problem-solving is a mental activity that involves a cognitive process. The cognitive component of problem-solving is an essential feature of problem-solving skills (Anderson, 2005). Problem-solving can be divided into conventional and creative types: those that require the development of new steps are called creative problem-solving, while those that use existing steps are called conventional problem-solving (Qi, 2007).

Mayer (2013) considered that “problem-solving refers to cognitive processing directed at achieving a goal when the problem solver does not initially know a solution method”. He outlined three dimensions of problem-solving: primarily, it is a cognitive process since it occurs within the cognitive system of the individual engaged in solving the problem. Secondly, problem-solving is a process because it involves the operation and application of knowledge by the problem solver. Thirdly, problem-solving can be directed because the problem solver is trying to reach a number of goals.

Chinese scholars believe that problem-solving is a mental activity or mental process with thinking as its connotation and problem goals as its orientation. It refers to the situation where people, in social practice and theoretical learning, face new situations and new topics that cannot be directly solved with existing knowledge and experience, and there are no ready-made countermeasures, answers, or solutions, which leads to a psychological activity aimed at dealing with problems (Zheng & Zhang, 2007). Some scholars believe that problem-solving generally refers to the formation of a new answer, which goes beyond the simple application of rules learned in the past to produce a solution. It requires the application of learned concepts, propositions, and rules, and their combination to achieve certain goals (Chen & Liu, 2019).

2.3 The implications of mathematical problem-solving

The connotation of contemporary mathematical problem-solving has transcended the confines of traditional "solving practical problems" and has undergone extension and expansion based on this foundation. Traditional "solving practical problems" emphasizes outcomes, whereas modern mathematical problem-solving places greater emphasis on processes, strategies, and the development of thinking. Scholars in the field of mathematics classify mathematical problem-solving mainly as: a teaching tool, a skill, a creative activity, a psychological process, an active process, an ability, and other types to be parsed. Their starting and ending points are derived from mathematical problems, as elaborated in Table 3 below.

TABLE 3 Implications of mathematical problem-solving

Main Viewpoints	Specific elaboration
A teaching tool (Zheng, 2009)	In mathematics teaching, problems are introduced into the teaching content to stimulate students' enthusiasm for learning mathematics and to review and consolidate the knowledge they have already learned through mathematical problem-solving.
A skill (Zheng, 2009)	Obtain a variety of specific problem-solving skills and methods through mathematical problem-solving.
A creative activity (Zheng, 2009)	Students should use a variety of mathematical knowledge and methods comprehensively and creatively to tackle mathematical problems.

TABLE 3 (CONTINUE)

Main Viewpoints	Specific elaboration
A psychological process (Kong & Ceng, 2009)	The psychological process of applying existing mathematical knowledge to explore solutions to new questions.
An active process (Yu et al., 2011; Yu, 2017)	Mathematical problem-solving is the process of applying previously learned mathematical knowledge to solve a new mathematical problem.
An ability (Cai, 2007)	Students' ability to synthesize and apply their mathematical knowledge to new problem situations.

To sum up, in the field of mathematics research, problem-solving not only focuses on the outcomes but also places greater emphasis on the process of problem-solving, specifically the thinking involved. In this study, mathematical problem-solving is defined as a creative activity where students utilize their own mathematical knowledge and existing experiences to analyze and solve mathematical problems through specific methodologies, always focusing on the problem itself. In classroom teaching, knowledge should be integrated into problems as much as possible, and new problems should be generated during the learning of knowledge to enhance students' problem awareness and cultivate their innovative thinking and problem-solving skills.

2.4 Mathematical problem-solving process mode

Numerous mathematicians and psychologists have conducted in-depth explorations into the field of mathematical problem-solving and developed multiple process models for it. In foreign countries, the following models have had a significant impact:

Polya (2007) proposed the four steps of mathematical problem-solving in the article How to Solve It:

1) Understand the problem, which involves identifying the known and unknown quantities and clarifying the type of question;

2) Formulate a plan, which means finding the relationship between the known and unknown quantities. For unfamiliar question types, consider related problems or more specialized questions to find potential solutions;

3) Implement the plan, which involves carrying out the solution according to the formulated plan;

4) Review, which not only involves checking whether the answer is correct but also trying to solve similar questions, expanding thinking, and summarizing problem-solving methods.

Although Polya's problem-solving process is widely admired, its effectiveness is not always evident in many studies exploring and teaching its four-step approach. For this reason, Schoenfeld pointed out that the success of problem-solving depends not only on Polya's methods but also on the solver's scope of knowledge, self-control, and concepts. Schoenfeld (1985) categorized the mathematical problem-solving process into four distinct stages: 1. Problem analysis and understanding; 2. Design of solutions; 3. Exploration of solutions to difficult problems; 4. Testing of solutions.

Mayer (2013) believed that mathematical problem-solving involves four fundamental stages: transformation, where a mental representation of problem conditions is constructed; integration, in which the relationship between these conditions is mentally represented; planning, to devise a solution; and execution, to carry out the devised plan.

Oganesyan (1983) divided the problem-solving process into four stages: understanding the problem conditions, formulating a problem-solving plan, implementing the problem-solving plan, and researching the obtained solution, and put forward detailed guiding suggestions for the four stages.

Program for International Student Assessment tests (PISA) divides the problem-solving process into six stages: understanding the problem, describing the problem, presenting the problem, solving the problem, reflecting on the solution, and communicating the solution (OECD, 2012).

Chinese scholars have summarized the process model of mathematical problem-solving from different perspectives on the basis of absorbing the research of foreign scholars on the process of mathematical problem-solving, and the specific stages or steps are summarized as follows:

Wang and Wang (1992) summarized problem-solving as four steps from the perspective of the mental operation process on the basis of modern cognitive psychology: problem representation, selection of arithmetic, application of arithmetic, and evaluation of current state.

According to Chen (1995), the thinking process of solving mathematical problems can be simply summarized as the formula of "concrete-abstract-concrete". In the concrete problem-solving process, this formula can be broken down into five parts: information reception, information recognition, information radiation, solution design, and problem-solving.

Yu (2002) further combined the research results of modern cognitive psychology and divided the mathematical problem-solving process into four modules: problem situation, factor analysis, constructing model, and explaining model. The study specifically suggested that psychologists are concerned with the exploration of psychological phenomena and laws of mathematical problems, with less integration of psychological practices with mathematics teaching practices.

Cao et al. (2001) proposed a general process of mathematical problem-solving by analyzing specific mathematical problems: analyzing the problem context and finding mathematical connections; building mathematical models; solving mathematical problems; and testing and generalizing.

Chen and Liu (1997) outlined a four-step problem-solving process: comprehending and defining the problem, searching for solutions, implementing a plan or potential answer, and assessing the outcomes, which are interconnected and sequential, collectively forming the problem-solving framework.

The primary aim of interpreting various problem-solving theories is to enhance comprehension of individuals' problem-solving methodologies and investigate more scientific and efficient techniques, despite the abundance of psychological theories on problem-solving mechanisms. By analyzing the problem-solving models both domestically and internationally, it has been found that these models encompass multiple distinct steps, as detailed in Table 4 below.

TABLE 4 Summary of mathematical problem-solving process mode

Stage or step	1	2	3	4	5	6
Polya (2007)	Understand the problem	Formulate a plan	Implement the plan	Review		
Schoenfeld (1985)	Problem analysis and understanding	Design of solutions	Exploration of solutions to difficult problems	Testing of solutions		
Mayer (2013)	Transformation	Integration	Planning	Execution		
Oganesyan (1983)	Understand the problem conditions	Formulate problem-solving plans	Implement the problem-solving plans	Research the obtained solution		
OECD (2012)	Understand the problem	Describe the problem	Present the problem	Solve the problem	Reflect on the solution	Communicate the solution
Y. Wang and A. Wang (1992)	Problem representation	Selection of arithmetic	Application of arithmetic	Evaluation of current state		
Chen (1995)	Information reception	Information recognition	Information radiation	Solution design	Problem-solving	
Yu (2002)	Understand the situation of problem	Conduct factor analysis	Construct model	Explain model		

TABLE 4 (CONTINUE)

Stage or step	1	2	3	4	5	6
Cao et al. (2001)	Analyze the problem context	Find out mathematical connections	Build mathematical models	Solve mathematical problems	Test and generalization	
Chen and Liu (1997)	Understand and characterize the problem	Seek an answer	Execute a plan or try some solutions	Evaluate the results		

Based on the research results from both domestic and international sources, it can be found that whether the mathematical problem-solving process is divided into four stages, five stages, or six stages, it will go through the following core steps: understanding the problem, analyzing the problem, trying to solve the problem, and testing and reviewing. These core steps can be considered the general process model of mathematical problem-solving.

2.5 Factors affecting mathematical problem-solving

Problem-solving is a complex psychological activity of human beings, and there are various related factors. Scholars explore the factors that affect the solution of mathematical problems from multiple dimensions, such as cognitive psychology, the characteristics of mathematical problems themselves, and teaching practice.

Mayer (2013) proposed three elements for students to solve problems: internal representation of the problem, students' analysis of the problem-solving process, and problem analysis skills. Schoenfeld (1985) identifies four key factors influencing mathematical problem-solving: cognitive resources, referring to the necessary mathematical knowledge base; innovative problem-solving strategies, distinct from conventional methods; effective control, encompassing clear problem-solving objectives, self-regulation, and outcome evaluation; and a strong belief system, reflecting the solver's determination.

There are also scholars who believe that there are multiple factors affecting mathematical problem-solving, such as the school and teachers, students' extracurricular activities, and family background factors (Zheng, 2009). Liu (2013) pointed out that problem awareness and the process of scientific research are the main factors affecting the improvement of students' problem-solving skills after investigating the teaching practices of many American primary and secondary schools. Yu (2002) attributed the factors affecting problem-solving to six aspects: functional fixation, problem representation, response set, knowledge background, intelligence level, and motivation strength. Liu (2015) proposed four factors that affect the development of students' problem-solving skills in an empirical study on the development of problem-solving skills of high school students, including knowledge level, practical experience, school education, and individual characteristics. Wang (2017) sorted out and classified the answers to several types of poorly structured mathematical problems provided by students, analyzed the reasons for the errors, and concluded that the factors affecting the ability to solve mathematical problems are as follows: problem representation, cognitive structure, fixed thinking, metacognition, interest and motivation, personality differences, and interaction between teachers and students. Students' interest in mathematics and sense of self-efficacy are conducive to promoting students' mathematical problem-solving skills, while too much mathematical anxiety is not conducive to improving mathematical problem-solving skills (Xu & Qi, 2018).

Based on the analysis of these factors, the factors affecting the solution of mathematical problems can be roughly divided into student factors, problem factors, and environmental factors. Student factors include knowledge base, problem-solving strategy, metacognition, belief, motivation, functional fixation, thinking set, and self-efficacy; problem factors involve familiarity with the problem, the structure and characteristics of the problem, and the situation and complexity of the problem; environmental factors include social background, cultural traditions, physical environment, and school education. The influencing factors of solving these mathematical problems will provide an effective reference for the following course design.

2.6 Evaluation of mathematical problem-solving skills

2.6.1 The connotation and constituent elements of mathematical problem-solving skills

As a basic ability, problem-solving skills can be regarded as problem-solving skills in the broadest sense. Problem-solving skills are one of the core abilities of students' 21st-century skills, an important part of advanced thinking ability, and a creative and operational way of thinking and intellectual activity (Zhang, 2011). This study is inspired by the expositions of the following scholars or organizations, as shown in Table 5:

TABLE 5 Comparison of different scholars' understanding of problem-solving skills

Scholar or organization	Specific elaboration
Schoenfeld (1985)	Problem-solving skills refers to a person's ability to choose the best solution by considering multiple solution evaluation criteria when solving a problem. Mathematical problem-solving skills include four elements: mathematical knowledge related to problem-solving; skills and techniques used to solve unconventional mathematical problems; control of the problem-solving process; and the problem solver's metacognition and cognition of the problem and environment.
OECD (2012)	Problem-solving skills denotes an individual's capacity to engage in cognitive processing for comprehending and addressing intricate problems lacking immediate solutions. They involve a readiness to tackle such challenges, facilitating the realization of one's fullest potential as a thoughtful and productive member of society.
Fischer et al. (2015)	Problem-solving skills is a person's ability to find a solution to a problem and achieve a goal when there is no obvious solution

TABLE 5 (CONTINUE)

Scholar or organization	Specific elaboration
Xu and Qi (2018)	Mathematical problem-solving skills refers to an individual's ability to understand and solve problems in cognitive situations where immediate solutions are not obvious. They also involve the individual's willingness and motivation to tackle these problems.
Li (2019)	Problem-solving skills is defined from two perspectives: the knowledge application perspective views problem-solving competencies as a cognitive continuum, such as understanding, applying, and mediating knowledge skills; the implementation process perspective views problem-solving competencies as competencies exhibited along a behavioral continuum, including defining, analyzing, designing, implementing, and reflecting.
X. Zhang (2020)	The mathematical problem-solving skills of primary school students is a type of comprehensive ability, which refers to the essential characteristics and key abilities of primary school students to solve mathematical problems in mathematics learning situations, either under the guidance of teachers or independently, by flexibly using the mathematical knowledge and skills they have learned throughout their series of mathematics learning experiences
Pan (2020)	Elementary school mathematical problem-solving skills are embodied in the process of math problem-solving. According to the process of problem-solving in math textbooks, problem-solving skills are divided into three main abilities: reading comprehension ability, analytical solution ability, and reflective review ability.
Zhao (2021)	Mathematical problem-solving skills refer to the ability of primary school students to discover, propose, analyze, and solve mathematical problems by using mathematical knowledge and problem-solving thinking in primary school mathematics education. This ability reflects not only the level of students' mathematical skills but also their capacity to address real-life problems. Mathematical problem-solving skills can be divided into four sub-abilities: problem finding, problem posing, problem analysis, and problem-solving.
Sun (2022)	The mathematical problem-solving skills of primary school students refer to the ability of students to identify and understand problems from a mathematical perspective and to comprehensively apply the knowledge and skills they have learned to solve these problems.

The above scholars have different understandings of problem-solving skills. Different scholars define the concept of problem-solving skills based on their own research. Combined with the above description of the concept of "problem-solving skills" and the target requirements of compulsory education mathematics curriculum standards for "problem-solving”, mathematical problem-solving skills are defined as follows: When primary school students face problem situations with no obvious solution in learning activities or real life, they need to use the mathematical knowledge and methods they have learned to understand the problem, analyze the problem, try to solve the problem, and examine and reflect on the answer. It is the comprehensive mathematical ability of primary school students, reflected in the process of the problem-solving stage.

In this study, mathematical problem-solving skills include four elements: understanding, analyzing, solving, and reviewing. Each element does not exist independently but is interrelated, presupposes, and promotes each other, forming an organic problem-solving cycle. Understanding the problem is the premise of solving the problem, ensuring that we can accurately grasp the content of the problem, the cause, and the problem to be solved. Analyzing the problem is the basis for solving the problem, through detailed analysis, induction, and other operations, to effectively grasp the problem. Problem-solving is the key link in the whole process, where, based on the results of the analysis, mathematical methods are used to solve the problem. Finally, the purpose of reviewing is to test the rationality and correctness of the solution, collect and sort out opinions, update and improve the solution, and summarize the problem-solving experience for future use. By analyzing the contents of primary school mathematics textbooks according to the abilities involved in the process of problem-solving, the researchers clarified the connotation of each element. See Table 6 for details.

TABLE 6 Specific description of each element of mathematical problem-solving skills

Elements and connotation	Specific performance
Understanding means gaining insight into the intrinsic nature of the problem, accurately reflecting the characteristics and objective situation of the problem, and extracting relevant mathematical information from it.	-Be able to identify the characteristics of the problem, know and understand the meaning of the text, picture, table and other information presented in the situation; -Be able to select information that is effective in solving problems from a large number of information; -Be able to clearly divide the extracted information into known and unknown quantities.
Analyzing means identifying the internal structure of the problem and establishing the necessary links between the relevant information and the knowledge you have mastered.	-Be able to judge the quantitative relationships or spatial forms among variables in mathematical problems; -Be able to demonstrate the thinking process in the form of words, symbols, graphs, tables; -Be able to regulate the directions of the known and unknown quantities and narrow the gap between them.
Solving means utilizing suitable mathematical knowledge, methods, and strategies to reach problem solutions.	-Be able to perform mathematical operations and reasoning; -Be able to transfer mathematical knowledge and apply existing methods and conclusions to new problems; -Be innovative and try to come up with different solutions.
Reviewing means after solving problems, the ability to consciously check the correctness of the problem-solving process and results, and reflect on and adjust their problem-solving solutions and ideas.	-Be able to consciously reflect on whether the process and results are correct and reasonable after the problem is solved; -Be able to know what solving strategies and methods were used during the solving process; -Be able to compare different solution processes and know which method is more concise.

2.6.2 Evaluation of mathematical problem-solving skills

Regarding how to evaluate problem-solving skills, Jonassen (2003) proposed assessing students' problem-solving skills from three aspects: problem-solving performance, the content and cognitive skills used in the problem-solving process, and the methods chosen in arguing for problem-solving. Wallace improved on this approach by suggesting that students' problem-solving skills should be assessed across eight areas: collecting or organizing information, identifying problems, forming ideas, formulating plans, executing, evaluating, communicating, and summarizing experiences. The specific indicators for each aspect should be considered in terms of "availability", "feasibility", and "evidence". Huang and Chen (2004) suggest evaluating an individual's problem-solving skills based on three dimensions: attitude towards problems, problem-solving methods and strategies, and the quality of problem resolution, which is assessed comprehensively through 20 abilities across four stages of problem-solving. Waltman (1998) divided the assessment of problem-solving into five dimensions: understanding the problem, planning, implementation, providing answers, and understanding the content, which were graded on a scale from 0 to 5 according to specific principles.

TABLE 7 Waltrman's scoring system for problem-solving

Dimension	Level and score
Understanding the question	Degree of expression of related items: All (5 marks); Most (4 marks); Part (3 marks); Less (2 marks); Minority (1 mark); Does not express any relevant entries (0 marks)
Planning	Planning strategies and procedures: All appropriate (5 marks); Most appropriate (4 marks); Somewhat appropriate (3 marks); Few appropriate (2 marks); Largely inappropriate but appropriate in some factors (1 mark); All inappropriate (0 marks)
Implementation	Strategy or procedure implementation: Correct (5 points); Basically correct (4 points); Partially correct (3 points); Basically incorrect (2 points); Incorrect (1 point); No policies or procedures implemented (0 points)
Answer	Answers: Perfect (5 points); Good (4 points); Reasonable (3 points); Partly reasonable (2 points); Unreasonable (1 point); No answer given (0 points)
Content understanding	Understanding of relevant skills, facts, and concepts: Excellent (5 points); Good (4 points); Adequate (3 points); Limited (2 points); Minimal (1 point); No understanding (0 points).

PISA is an international student assessment program conducted by the Organization for Economic Co-operation and Development (OECD). PISA 2003 classifies problem-solving skills into four levels and describes the specific characteristics of each level, as shown in Table 8 (OECD, 2003).

TABLE 8 Evaluation criteria of problem-solving skills in PISA 2003

Level	Performance description
Level 3: Good thinking and communication problem solver (score greater than 592)	Able to take into account the potential relationships in the problem by accurately analyzing the situation and making better decisions; the ability to consider all the conditions of a problem in order to seek the best solution; and the ability to organize thoughts, express them in writing, monitor, and reflect.
Level 2: Problem solver adept at reasoning and decision making (score 499-592)	Able to apply various reasoning methods to analyze problem situations; able to sort out the information obtained from different channels and make correct reasoning and decisions; and be able to state mathematical problems in correct language.
Level 1: Basic Problem Solver (score 405-499)	Able to deal with relatively simple information problems; Able to understand the problem and find the key information in the question; Able to transfer and process information; It can verify the obvious information in the problem, but it cannot be effectively dealt with when the problem situation is more complex.
Below level 1: Low level problem solver (score less than 405)	For some clear information, the situation of a single problem cannot be understood, and usually, only the most intuitive response to the problem can be made; it is difficult to put the problem in any other form; and it is also very challenging to make decisions and analyze problems.

Researchers in China have argued that PISA's assessment methods can provide insights and lessons for educational assessment in China. Zhang (2020) tested and analyzed the problem-solving skills of a sample of 171 fifth-grade elementary school students based on the PISA assessment framework in three dimensions: decision-making ability, system analysis and design ability, and troubleshooting ability. Drawing on the PISA test, Wu (2022) evaluated students' mathematical problem-solving skills from the overall level, content dimension, contextual dimension, and process dimension, and then analyzed the test data using SPSS software.

Chinese scholars believe that students need to go through the process of problem-solving, so the abilities required in the process become important indicators for the measurement and evaluation of "problem-solving". According to the three stages of "reading and understanding", "analysis and expression", and "review and reflection" in textbook problem-solving examples, this process ability is transformed into 15 second-level ability indicators. Test questions are then prepared based on each ability indicator to evaluate students' mathematical problem-solving skills (Pan, 2020). Guan (2022) designed a 20-item questionnaire based on five dimensions of problem-solving skills (identifying, expressing, analyzing problems, exploring problem-solving strategies, evaluating, and reflecting) and surveyed 160 junior high school students on their problem-solving skills.

To sum up, problem-solving skills depend on how they are analyzed and measured. At present, the evaluation methods for problem-solving skills mainly include paper-based assessments, scales, or questionnaires. This study will adopt a paper-based assessment method to evaluate students' problem-solving skills from four dimensions: understanding, analyzing, solving, and reviewing. This study aims to cultivate students' ability to solve mathematical problems in real life, so the test will attempt to present problem situations in real-life contexts. Unlike a typical "diagnostic test", this study will use an "ability test" approach. The purpose is not to assess students' mastery of mathematical knowledge but to reveal the characteristics of students' problem-solving processes and strategies.

2.7 Current Situation of mathematical problem-solving skills

"Problem-solving" did not receive enough attention in my country initially, and it was not until the 1960s that research on "problem-solving" really began (Yi, 2018). With the introduction of the international trend of thought on "mathematical problem-solving”, the mathematics education community in my country started to regard it as an important component of quality education. Since the 1990s, research on mathematical problem-solving has been increasingly based on the teaching reality in my country, with a greater number of teaching experiments and improved research depth (Yuan, 2015). The 2011 Mathematics Curriculum Standards for Compulsory Education established problem-solving as one of the general goals of the mathematics curriculum. At this stage, China's mathematics textbooks and curriculum are paying more and more attention to the cultivation of mathematical problem-solving skills. A total of 479 relevant pieces of literature on the teaching status of mathematics problem-solving over the past 20 years (2013-2023) were reviewed in CNKI (the largest academic paper database in China). Among these, 380 pieces of literature are focused on the status of primary school mathematics problem-solving instruction, indicating both domestic academic interest in this topic and potential issues with the current teaching situation.

1) Classroom teaching content is divorced from real life

The main purpose of problem-solving teaching is to allow students to connect what they have learned with real life and apply the solutions they have learned to real-life situations (Li, 2022; Yang, 2017). Since problem-solving is an important aspect of mathematics teaching, it needs to be designed in an engaging way to fully interest students. However, judging from the current teaching content of problem-solving in most mathematics classrooms, the material is often monotonous and boring, far from what students actually think, and detached from their real lives (Niu, 2019; Wang, 2018). The teaching methods adopted by teachers are also relatively simple. Many teachers often begin class by using multimedia equipment to show pre-prepared PPT slides, which contain content almost identical to that in textbooks (Li, 2022). In this case, students are not actively engaged in solving mathematical problems, their thinking progresses slowly, and teaching efficiency is low. To speed up the pace of teaching, some teachers ignore students' active participation and directly provide answers when problems arise (Sun, 2018; Wang, 2018). Over time, this approach diminishes students' enjoyment of learning mathematics, limiting their improvement in grades and abilities. Teachers often lack a deep understanding of problem-solving teaching, confusing it with traditional application problems. For example, a common problem involves two trains departing from different points and calculating the distance between the starting and ending points based on the time they meet (Chen, 2018). Such problems, prevalent in past application questions, are often unrealistic, with issues like excessively high speeds or trains meeting on the same track, which is obviously impractical.

2) Classroom teaching mode is too traditional

Although quality-oriented education has been fully implemented in my country today, many primary school teachers still believe that the concept of exam-oriented education is very useful, and that adopting the teaching mode of "teachers telling and students listening" can help students better accept what they are taught (Hu, 2017; Li, 2022). Many teachers still view themselves as the central authority in the classroom, standing at the podium to continuously impart knowledge while students passively listen without participating in classroom interactions (Li, 2022; Y. Sun, 2018). Knowledge is quickly forgotten once it is heard. Without understanding the underlying concepts, students are unable to apply the content to practical problem-solving. Teachers often adhere strictly to their own teaching plans, and when special circumstances arise, they quickly redirect students back to the predetermined teaching track (Liang, 2020). This teaching mode tends to lead students to develop a fixed thinking pattern, which hinders their active problem-solving skills and prevents them from discovering and solving problems on their own. Some teachers do ask students questions during mathematics problem-solving teaching, but the questions are too frequent. When students are unable to answer, teachers often provide the correct answers rather than guiding students through the problem-solving process (L. Sun, 2018). Problem-solving teaching activities can become overly mechanized, focusing too narrowly on specific mathematical knowledge points without integrating previously taught concepts with current material (Y. Yang, 2017). Some teachers require students to memorize formulas and theorems but fail to explain these theoretical concepts in an understandable way (Niyazi, 2015). As a result, the inherent appeal of mathematical knowledge is replaced by monotonous rote memorization, leading to a weak awareness of the application of mathematical knowledge and diminished interest in learning.

3) The idea of solving problems is solidified, and the problem-solving method is single

The teaching goal of mathematical problem-solving is to help students master a variety of problem-solving methods, apply multiple approaches to solve problems, and use these skills in daily life (Niu, 2019; Qiu, 2017). However, examinations remain the primary method of assessing talent. In many current primary school mathematics classrooms, teachers often incorporate recent examination questions into practical teaching and provide students with fixed problem-solving approaches, neglecting the cultivation of students' problem-solving skills in favor of improving test scores (Wang, 2018). Teaching focused solely on achieving high scores ignores the development of students' problem-solving strategies and the diversification of their thinking (Wang, 2019). Many teachers still emphasize methods and results while overlooking the inquiry process of problem-solving, which hinders the improvement of students' problem-solving skills (Chen, 2018). During the actual problem-solving instruction, teachers' limited teaching strategies constrain students' problem-solving approaches, resulting in a relatively narrow scope of ideas (Yang, 2017). Teachers often provide students with problem-solving methods that align closely with textbook knowledge, leading students to memorize these methods mechanically and practice them repeatedly (Li, 2022). As a result, students' thinking becomes rigid, and when faced with new or different problems, their performance tends to suffer.

3. "Learner-centered" Approach: Cooperative Learning, Problem-Based Learning, and Gamification

"Learner-centered" teaching focuses on individual learners, exploring how learning occurs, how to promote learners' enthusiasm, and discovering the most effective teaching methods (Xu, 2018). The "learner-centered" teaching concept requires teachers to shift from traditional teaching methods and genuinely center their approach around the learners in the classroom. McCombs and Whisler (1997) argue that "learner-centered" teaching should emphasize the uniqueness of each learner and address two main aspects of student learning. Weimer (2006) contends that learner-centered classroom teaching should be reformed in five areas: the redistribution of classroom power, the redefinition of the function of teaching content, changes in the role of teachers, changes in students' behavior, and the transformation of assessment processes and purposes. The researcher will elaborate on this concept from the following four aspects:

1. The theoretical basis of "learner-centered".
2. Comparison of "learner-centered" and "teacher-centered" instruction.
3. Three "learner-centered" teaching methods: cooperative learning, Problem-Based Learning and gamification.
4. Application of learner-centered teaching methods

3.1 The theoretical basis of "learner-centered"

Traditional teaching theory centers around three main elements: teachers, textbooks, and classrooms. It emphasizes the cognitive processes of teaching, the leading role of teachers, the foundational principles of teaching, and the acquisition of theoretical knowledge by students (Wang, 2016). In the contemporary era of rapidly evolving information technology, students have access to multiple avenues for acquiring knowledge. Traditional teaching methods have become outdated in addressing individualized student needs, leading to the emergence of a learner-centered approach that aligns with modern educational demands.

Dewey's "child-centered theory" serves as the origin of the "learner-centered" education concept. He believes that the best education comes from "learning from life", "learning from experience", and "learning by doing". According to Dewey, knowledge is acquired in a particular context through independent inquiry or collaborative efforts, such as communication and the use of necessary information, to achieve meaningful learning outcomes. The curriculum must be organized and designed around the needs, interests, and experiences of the child, allowing the child to develop self-initiative and creativity (Dewey, 1994). The teacher's role is not to force learning but to facilitate it, creating an atmosphere of sincerity, care, and understanding to promote learning (Che, 2003; Zhao, 2006). Learners achieve their educational goals through independent study, discussion groups, and teacher assistance, with the ultimate aim of fostering well-rounded individuals (Hua, 2014).

Rogers advanced the "learner-centered" educational theory, advocating that education and teaching should be focused on the learner. This approach emphasizes emotional communication between teachers and students, creating a pleasant learning environment, and ensuring learners' freedom (Fang, 1990). The essence of "learner-centered" education is that "students are the main focus", which is reflected in four aspects: the teacher-student relationship, learning content, learning methods, and learning evaluation (Zhang & Zhang, 2018).

The "learner-centered" education concept provides theoretical guidance for the development of the mathematics curriculum in this study. It emphasizes the importance of addressing students' cognitive and emotional needs, stimulating their interest and motivation, and fostering their independent learning abilities. Our curriculum development and design should therefore be learner-centered, taking into account learners' needs in content selection, organization, arrangement, and presentation, and helping them become the masters of their own learning process.

3.2 Comparison of "learner-centered" and "teacher-centered" instruction

Traditional teaching theory centers around three main elements: teachers, textbooks, and classrooms. It emphasizes the cognitive processes of teaching, the leading role of teachers, the foundational principles of teaching, and the acquisition of theoretical knowledge by students (Wang, 2016). This approach contributed significantly to the rapid development of society at that time. Nowadays, with the rapid advancement and transformation of information technology, students have access to a vast array of information and knowledge through diverse channels. Traditional teaching methods can no longer meet the individualized developmental needs of students, thus necessitating the emergence of learner-centered teaching (Dong & Yan, 2013).

In traditional education, teachers function as preachers, controllers, and authorities (Dong & Yan, 2013). However, in a learner-centered approach, the role of teachers changes significantly. In this model, teachers act as mentors rather than mere imparters of knowledge (Kember & Gow, 1994).

Learner-centered teachers exhibit seven key characteristics: 1) They serve as enablers and mentors; 2) They provide assistance as needed, anytime and anywhere; 3) They embody principles that promote deep understanding; 4) They inspire students to take charge of their own education; 5) They create practical and authentic educational experiences; 6) They utilize technology to customize education for individual students; 7) They are committed to their professional and personal growth (Schneider, 2016).

In the "learner-centered" teaching model, the role of teachers becomes even more crucial as they take on multiple roles: designing and managing classroom activities, promoting and collaborating on students' practical activities, analyzing and addressing learning problems, and growing alongside their students (Du et al., 2019; Jia, 2021). This approach requires teachers to facilitate students' learning and create a supportive learning environment. Teachers must design teaching activities based on students' needs, use diverse methods to help students achieve their learning goals, and encourage independent learning (Xiao, 2020a).

In a teacher-centered classroom, students are accustomed to teachers leading and controlling the learning process and often take the teacher's authority for granted. In a learner-centered approach, students transition from passive, dependent learners to active, autonomous learners (Lai, 2018). The learner's role in this model includes the following aspects (Xiao, 2017): 1) Active learner: The learner should engage actively rather than passively. 2) Self-regulated learner: The learner should be self-directed, capable of self-regulation and self-monitoring. 3) Mutual aid learner: The learner should also participate in teaching, sharing newly acquired knowledge with others to deepen their own understanding and benefit both parties.

Teacher-centered teaching often emphasizes academic achievement and focuses excessively on score-based assessments, generally using terminal evaluations as the main assessment method (Wang, 2005). This type of evaluation relies on test scores as the sole measure of learning outcomes, often neglecting individual differences, learning processes, and the development of non-intellectual factors. In contrast, a learner-centered approach requires rethinking assessment methods. This involves downplaying the significance of grades, focusing on self and peer evaluations, and incorporating learners into the assessment process (Weimer, 2006). Establishing diverse evaluation subjects and enabling learners to conduct self-diagnosis and self-assessment based on classroom and extracurricular learning conditions can create a growth-oriented evaluation platform. This approach fosters students' enterprising spirit, emphasizes process evaluation, implements tiered assessments, and builds an online evaluation system (Li, 2017; Zhan & Ding, 2020).

Mtitu (2014) also describes the main differences between teacher-centered and learner-centered teaching in his paper, as shown in Table 9:

TABLE 9 The distinction between learner-focused and teacher-focused teaching methodologies.

Component	Learner-centered	Teacher-centered
Pedagogical reasoning and decision-making	Students take center stage and participate actively in the planning of classroom instruction.	Teachers lead course materials and plan lessons independently.
Identification of instructional needs	Teachers and students collaborate to determine instructional requirements based on the subject matter, learners' circumstances and prior knowledge, available resources, employment prospects, and the educational ideology of their country.	Teachers incorporate pre-established instructional requirements, identified by curriculum designers and teachers, into their classroom practice.

TABLE 9 (CONTINUE)

Component	Learner-centered	Teacher-centered
Motivation	The emphasis lies in nurturing learners' inquisitiveness and innovativeness, as well as the amalgamation of their preexisting understanding of the subject.	The lesson objectives are focused on the teacher, and external rewards and punishments are used.
Teaching and learning process	Teaching in a live classroom setting primarily involves engaging students through structured and interactive activities, such as small group deliberations, think-pair-share drills, assignments, and field trips.	In the classroom, the teacher takes a dominant role while students sit quietly and passively listen to lectures, taking notes. There is minimal interaction between students and teachers.
Teacher and students relationships	In an environment of equality and harmony, teachers and learners engage in mutual learning, blurring their traditional roles. Teachers become facilitators, co-constructors, and learning companions rather than merely imparting knowledge.	The instructor holds significant authority, serving as both the primary provider of knowledge and the director of classroom instruction.
Classroom atmosphere Understanding	Characterized by warmth, trust, democracy, informality, supportiveness, and collaboration, this approach has strong potential for in-depth and long-term exploration of social studies phenomena.	Environments characterized by tension, apprehension, low trust, authority-driven approaches, and rigidity exhibit a high likelihood of superficial comprehension and transient conceptualization of studied phenomena.

After reviewing the aforementioned literature, the researcher summarized the distinctions between learner-centered and teacher-centered teaching approaches in Table 10.

TABLE 10 Contrast between teacher-centered and learner-centered teaching approaches

Component	Learner-centered	Teacher-centered
Teaching focus	Students are the focal point of learning, while teachers serve as facilitators, encouraging active participation, exploration, and the discovery of knowledge.	Teachers are the transmitters and authorities of knowledge; they dominate classroom activities and decide the content and progress of teaching.
Teaching method	Teaching places more emphasis on students' practice and experience. Teachers design various activities for students to engage in, such as group discussions, practical operations, and role-playing.	The traditional lecturing method is often used, in which teachers impart knowledge through explanation, demonstration, and lectures.
Evaluation method	More comprehensive and diverse assessments include not only test scores but also student engagement, cooperation, innovation, and other factors.	Evaluations are usually based on test scores, with teachers using tests to evaluate how well students learn.
Learning environment	The learning environment takes place in a traditional classroom setting, with a clear division of roles between teacher and student.	More flexible and open, and can be conducted in various places such as classrooms, laboratories, libraries, and the Internet.
Learning motivation	Learning motivation comes more from their curiosity for knowledge and love for learning.	Learning motivation mainly comes from the respect for teachers and the pursuit of achievement.

3.3 Three "learner-centered" teaching methods: cooperative learning, Problem-Based learning and gamification

Teaching methods refer to the operating norms and steps of teaching and learning that are directed towards specific courses and teaching objectives, constrained by specific course content, and followed by teachers and students (Zhang, 2014). They constitute a standard system that guides and regulates the teaching process. The teacher-centered classroom teaching method has five significant characteristics (Liao, 2022): 1) Teachers use traditional teaching methods such as explanations and blackboard writing to impart knowledge, and students passively accept this knowledge; 2) Teachers are the active educators; 3) Students are passive recipients of external stimuli; 4) Teaching materials are the content that teachers impart to students; 5) Teaching media are the methods and tools that teachers use to convey knowledge to students. Traditional teaching, based on flawed assumptions about human nature, uses indoctrination, rendering students passive and stripping them of independent viewpoints and adaptability (Du, 2020).

When the classroom is learner-centered, the choice of teaching methods focuses on highlighting the dominant role of learners, guiding them to think, analyze, and explore, and encouraging questions to deepen their thinking (Lai, 2018). Therefore, the principle of teaching method selection is to stimulate interest, promote learning, cultivate learners' awareness of active learning, and gradually develop their self-management abilities. The success of curriculum reform depends to a large extent on the reform of classroom teaching (Jia, 2021). Learner-centered classroom teaching implements strategies based on students' individualized learning styles.

There are various learner-centered approaches, and the TeachThought website provides 28 learner-centered teaching methods (TeachThought Staff, 2020). The physical and mental development of primary school students is still maturing; they are susceptible to external influences and enjoy interacting with peers. Cooperative learning provides a positive peer interaction environment, allowing students to learn from and help each other in groups, thus fulfilling their social needs. At the same time, primary school students are full of curiosity about new things. Through group discussions and collaborative problem-solving in cooperative learning, their thirst for knowledge and exploratory spirit can be stimulated. In cooperative learning, primary school students can also pool their ideas and jointly search for solutions to problems. Collaborative efforts can often lead to discovering the crux of the problem more quickly and improving problem-solving efficiency. Problem-Based Learning stimulates students' exploratory desires and learning interests by presenting challenging problems. At the same time, when facing real and complex problems, primary school students need to learn to analyze issues, make hypotheses, and verify solutions. This approach helps them form a deep understanding and long-term memory of knowledge while improving their problem-solving skills. Primary school students naturally enjoy games, and game-based teaching methods make learning interesting and engaging by integrating game elements. This approach stimulates primary school students' learning motivation and enthusiasm. Gamification methods usually include immediate feedback and reward mechanisms. This immediate positive reinforcement can satisfy the need for a sense of achievement among primary school students and enhance their learning motivation. At the same time, immediate feedback helps them adjust their learning strategies and methods in a timely manner. In summary, considering the physical and mental development characteristics, cognitive processes, and interest needs of primary school students, this study selects cooperative learning, Problem-Based Learning, and gamification methods to improve students' learning outcomes and enthusiasm, effectively enhance their mathematical problem-solving skills, and promote their overall development.

3.3.1 Cooperative learning

3.3.1.1 What is cooperative learning?

Cooperative learning is a learner-centered pedagogy. As the esteemed university teaching scholar McKeachie (2021) articulated, "The best answer to the question, ‘What is the most effective method of teaching?’ is that it depends on the goal, the student, the content, and the teacher. However, the next best answer is, ‘Students teaching other students.’"

The teaching concept of cooperative learning gradually emerged in the United States in the 1830s, and research on cooperative learning began to appear in China in the 1980s and 1990s (Zhao, 2020). From the perspective of the definition of cooperative learning, different researchers have various definitions, and their understandings include the following:

Cooperative learning involves small groups of students collaborating to enhance their individual and collective learning outcomes (Johnson & Johnson, 2008). PateŞan et al. (2016) contend that cooperative learning, where students work together in small groups on structured activities, constitutes a distinct form of collaborative learning. Learning groups promote learning through interaction and evaluate group performance holistically to achieve learning goals (Wang, 2005). Cooperative learning is distinguished from individual independent learning by its emphasis on social interaction and cooperation (Gao & Zhao, 2022). This definition highlights the social and cooperative aspects of learning as opposed to individual and independent learning.

From this perspective, it can be seen that cooperative learning is a pedagogical approach that relies on student interaction and cooperation, while also requiring teacher guidance and supervision. In the classroom, cooperative learning cannot be entirely separate from the teacher's role in providing oversight and support. Therefore, in this study, cooperative learning is understood as a teaching method in which students work in learning groups under the guidance of teachers to achieve common goals through mutual interaction and promote their development.

3.3.1.2 Components of cooperative learning

Cooperative learning, as outlined by Birt (2023), consists of five fundamental components: 1) Positive Interdependence: Teachers create an environment that fosters mutual reliance among students, encouraging responsibility for both personal and group success; 2) Direct Interaction Among Students: Students engage in discussions, maintain eye contact, and offer mutual support; 3) Individual and Collective Responsibility: Each student takes on a specific role within group tasks to contribute to the achievement of team goals; 4) Development of Social and Behavioral Skills: This includes the enhancement of interpersonal communication and collaboration skills; 5) Group Reflection: Students evaluate the team's performance based on members' collaborative abilities at the conclusion of the project.

3.3.1.3 Strategies for effective cooperative learning

Cooperative learning is both a teaching theory and strategy endorsed by the new curriculum reform and a novel learning approach advocated by contemporary educational initiatives. It has garnered significant attention and interest in recent years (Liu, 2020). Effective cooperative learning is essential for fostering students' independent learning abilities, problem-solving skills, and cooperative communication competencies. To achieve these outcomes, teachers must meticulously organize cooperative learning groups, carefully design learning tasks, create a relaxed and exploratory learning environment, stimulate students' positive thinking, and facilitate the dynamic evolution of classroom interactions (Ou & Liao, 2018).

Through teaching practice research, the following considerations are essential for the effective implementation of cooperative learning (Zhang, 2015):

1) Reasonable Grouping and Clear Division of Labor: The grouping of cooperative learning groups is generally based on the principle of "homogeneity between groups and heterogeneity within groups". A typical group size is 4 -6 people. After grouping, teachers should clarify the responsibilities of group members;

2) Teaching Skills and Cultivating Awareness: To be truly effective in group cooperative learning, teachers must focus on cultivating students' skills in listening, discussion, expression, questioning, and integration, as well as fostering an understanding of cooperation and participation, and developing their cooperative abilities;

3) Seize the Opportunity and Create an Atmosphere: When organizing classroom group cooperative learning, you should seize appropriate opportunities to ensure that the group cooperative learning is effective, and simultaneously create a positive atmosphere to enhance the cohesion of the cooperative group;

4) Effective Evaluation and Motivation: An effective evaluation mechanism can encourage students' enthusiasm for cooperative exploration, serve as a driving force for group cooperation, achieve the purpose of promoting learning through

evaluation, and focus on the methods, timeliness, and practicality of the evaluation.

The cooperative learning strategies that can effectively promote the development of students' abilities are as follows (Ou & Liao, 2018): 1) Leading—bringing students into problematic situations that create practical contexts; 2) Opening—cultivating students' qualities in an open teaching environment; 3) Questioning—encouraging in-depth thinking through the questioning of mathematical problems; 4) Refining—allowing students to develop mathematical abilities through the refinement and sublimation of knowledge; 5) Evaluation—providing motivation for students' cooperative learning.

3.3.1.4 The importance of cooperative learning

Cooperative learning refers to the process in which students cooperate with others to complete a learning task or solve a problem. It is an important method of learning because it can benefit students in many ways. The results of teaching practice based on cooperative learning are as follows (Sun, 2012): 1) Cooperative learning improves students' interest in learning; 2) Cooperative learning increases students' participation in the learning process; 3) Cooperative learning enhances students' ability to analyze and solve problems; 4) Cooperative learning promotes the mutual progress of both teachers and students in practice. The benefits of student cooperation are immediately evident: 1) Cooperation fosters mutual understanding and affection among students; 2) It significantly enhances critical thinking skills; 3) Oral communication abilities are improved; 4) Peer recognition boosts self-esteem (PateŞan et al., 2016).

In conclusion, cooperative learning is crucial for students' learning and future development. First, cooperative learning can improve students' learning outcomes. By collaborating with others, students share information and exchange ideas, which helps them gain a deeper understanding of the material and fosters active learning and the development of thinking skills. Second, cooperative learning enhances students' social and communication skills. In a cooperative learning environment, students must communicate with others, listen to different opinions, and work together to solve problems, which improves their teamwork skills, boosts their confidence, and fosters a spirit of cooperation. Finally, cooperative learning prepares students for future social interactions. In the real world, most tasks require teamwork, and through cooperative learning, students can develop essential teamwork skills and prepare for future collaborative endeavors.

3.3.2 Problem-Based Learning (PBL)

3.3.2.1 What is Problem-Based Learning?

Problem-Based Learning “is well suited to helping students become active learners because it situates learning in real-world problems and makes students responsible for their learning (Hmelo-Silver, 2004)”. In Problem-Based Learning, students learn by solving problems and reflecting on their experiences (Barrows & Tamblyn, 1980). Problem-Based Learning has a positive impact on students' problem-solving skills (Valdez & Bungihan, 2019; Wang et al., 2021). The proponents of Problem-Based Learning, Barrows and Tamblyn (1980), initially regarded it as a learning process in which learners spontaneously collect relevant materials or information to solve problems and acquire knowledge during problem exploration. With the development of Problem-Based Learning, its theoretical system has continually improved, and scholars have developed different understandings of its definition.

Some scholars understand Problem-Based Learning from the perspective of teachers and regard it as a teaching strategy, teaching method, or teaching model. For example, Mayo et al. (1993) believe that in the implementation of Problem-Based Learning, teachers need to provide learners with problem-related resources and certain guidance, so they regard it as a teaching strategy. Problem-Based Learning represents a learner-centered instructional methodology that enables learners to undertake research, integrate theory with practice, and utilize their knowledge and skills to devise practical solutions for specific problems (Savery, 2006). It is a teaching model in which students actively solve problems through consulting materials, experimental exploration, cooperative learning, and other methods (Wu, 2017).

Some scholars understand Problem-Based Learning from the perspective of learners and regard it as a learning environment, learning method, or learning mode. For example, Woods (1994) describes Problem-Based Learning as a problem-driven learning environment where learning begins with problems, and learners discuss these problems to find solutions and reflect on their value. Walton views Problem-Based Learning as a method where learners, faced with a real problem situation, work together through resource sharing, division of labor, and cooperation to solve common tasks or challenges (Wu, 2012). Problem-Based Learning is also described as a learning model aimed at cultivating learners' autonomous learning abilities and problem-solving skills, where learners acquire knowledge, experience, and skills by solving real complex problems (Xu & Huang, 2019).

Although there is no unified definition of Problem-Based Learning, most researchers agree that it is a process focusing on students, with teachers playing a supplementary role, aimed at cultivating students' problem-solving skills. This suggests that students, teachers, and problems are the fundamental elements of Problem-Based Learning. Based on the understanding of many scholars, researchers believe that Problem-Based Learning is both a learning process and a teaching method. For students, Problem-Based Learning is a process where they learn through collaborative methods such as resource sharing and group discussions to solve common problems, thereby gaining knowledge and mastering skills. For teachers, Problem-Based Learning is a learner-centered, teacher-assisted teaching method that involves placing students in real problem situations, providing appropriate guidance, and enabling them to complete learning tasks through cooperative learning.

3.3.2.2 Characteristics of Problem-Based Learning

Problem-Based Learning, with its focus on students and problems, diverges significantly from conventional teaching methods, as it organizes student groups into learning units and positions teachers as facilitators and guides (Zhang, 2005).

Barrows outlines the core tenets of Problem-Based Learning: 1) Learners should bear the responsibility for their own educational journey; 2) The simulations employed in Problem-Based Learning ought to be unstructured, facilitating unrestricted exploration; 3) Educational content should amalgamate insights from various fields; 4) Collaborative efforts are indispensable; 5) Insights gained through self-directed learning must be reintegrated into problem-solving with renewed analysis; 6) A conclusive evaluation discussing the knowledge acquired and the underlying principles is imperative; 7) Both self and peer evaluations are necessary upon the completion of each problem and curricular module; 8) The activities in Problem-Based Learning must align with real-world applications; 9) Assessments should gauge learners' progression towards Problem-Based Learning objectives; 10) Problem-Based Learning should constitute the educational backbone, rather than being a mere didactic component (Savery, 2006).

3.3.2.3 Effective techniques for Problem-Based Learning

Briggs (2015) proposed effective techniques for Problem-Based Learning based on some strategies mentioned in the Stanford University Teaching Newsletter:

1) Clearly Define Your Purpose for Doing Problem-Based Learning: Before the first Problem-Based Learning meeting, the teacher should define the purpose clearly, understand the procedures you will use, and set your expectations;

2) Hold Brainstorming Sessions: One of the core difficulties of Problem-Based Learning is problem design, and brainstorming sessions can be used to determine the core problems of the course;

3) Develop Ill-structured Problems: The educator designs ill-structured or open-ended problems featuring multiple potential solutions, encouraging learners to explore various methodologies before selecting a particular answer;

4) Refrain from Providing Information: Regardless of the topic chosen, before providing any formal instruction on the subject, the instructor poses questions to the student body. This approach aids in contextualizing the inquiries and recognizing potential problem areas;

5) Ensure Adequate Time for Collaborative Work: Teachers should

guarantee the participation of all students in the problem-solving process during every lesson;

6) Emphasize Depth over Breadth: Depending on the complexity of the problem, students are given two to six weeks to solve a problem;

7) Conduct Regular Assessments: Interrupt group work when necessary to rectify misconceptions or ensure parity among groups;

8) Hold Class Discussions: Whether at the close of a Problem-Based Learning session or at the onset of the next lesson, provide an allocated period for collective deliberation on pertinent matters;

9) Enable Peer Feedback Facilitation: Peer-provided feedback constitutes a significant aspect of Problem-Based Learning assessment;

10) Ensure Authentic Evaluation: Problem-Based Learning assessments must exhibit authenticity and be designed in such a way that learners can effectively showcase their comprehension of the problem and their proposed solutions within a relevant and meaningful contextual framework.

3.3.2.4 The importance of Problem-Based Learning

Primary school mathematics learning is not a process of passive absorption by students, but a process of reconstruction based on existing knowledge and experience. The main body of primary school mathematics teaching is primary school students. Their curiosity is particularly strong, and their emotions are easily influenced by the outside world, which fosters a mindset of exploration. Guiding students to listen carefully, think positively, discover problems, analyze problems, and solve problems through inquiry is the primary way to learn mathematics. Problem-Based Learning can place students in real situations, allowing them to observe and address real-life problems, and overcome the passive, closed, and one-way learning methods of traditional teaching. Through the process of solving problems, students can realize the meaning and value of "Problem-Based Learning". This approach benefits both students and teachers.

Problem-Based Learning offers numerous educational advantages. It not only promotes students' long-term knowledge retention but also encourages their continued engagement. Through Problem-Based Learning, students develop transferable skills, including teamwork, interpersonal communication, and high-level thinking skills. This approach encourages students to focus on understanding and applying knowledge rather than simply memorizing it. Problem-Based Learning also enhances students' motivation to seek solutions to problems more actively and connect learning to the real world. Additionally, it provides students with a wealth of collaboration, practical, and networking opportunities that help develop their social skills. In general, Problem-Based Learning helps students identify problems and develop their ability to actively seek solutions (TeacherPediaNG, 2021).

3.3.3 Gamification

3.3.3.1 What is gamification?

For gamification, the core concepts that need to be focused on are fun and reward mechanisms (Li, 2013). The term “gamification” was only widely used around 2011 (Liu & Zhu, 2015). Deterding (2011) defined gamification as "the application of game design elements to non-game situations”. Gamification integrates games into classroom activities to enhance teaching quality and optimize learning outcomes. According to the age characteristics and cognitive levels of students at different stages, and relying on current teaching content, new teaching methods such as competitions and scenario simulations are adopted as breakthrough strategies (Chen, 2017).

Gamification is the integration of games and learning. This approach is not merely for fun but aims to enable students to learn new knowledge in a pleasant state of mind and body while playing games (Liu, 2019). Gamification is a brand-new teaching method that allows students to understand mathematical concepts through games and uses gameplay to stimulate their thinking (Zhou, 2023). With students as the focal point, Gamification leverages the engaging qualities of games to invigorate the classroom environment and extend students' attention spans, thereby achieving effective teaching outcomes (Zhong, 2023). There are two main approaches to designing Gamification activities (Shang & Jiang, 2018): 1) Using games as an auxiliary tool in the teaching process, applying them to specific teaching segments; 2) Incorporating game elements such as points, tasks, badges, and leaderboards into teaching activities, and even designing the entire classroom experience as a large-scale game.

In this study, gamification refers to a teaching method that integrates learning with games, including both the direct application of electronic games and traditional classroom game activities. Specifically, by selecting appropriate games or designing and organizing game-based activities, game elements are introduced into teaching, and games, concepts, and mechanisms permeate all aspects of the educational process. This approach turns the process of gaming into a problem-solving activity, allowing learners to build knowledge and skills in a relaxed and enjoyable teaching environment, ultimately enhancing their problem-solving skills.

3.3.3.2 Problems that should be paid attention to in gamification

1) Appropriate Game Difficulty and Clear Explanation of Game Rules

When designing teaching games, teachers should take the principle of being close to the zone of proximal development of students. If the game is too simple, it will not be able to mobilize the enthusiasm of students for learning. If the game is too difficult, it will cause too much psychological pressure for students, and they will lose the confidence to challenge the game, so that they will not be able to achieve the goal of teaching effect. When designing the game, the teacher should combine the students' learning situation, specific teaching content and other factors to make a reasonable design. The cultivation of the awareness of rules is very important to the moral growth of students in the primary school stage. Without the constraints of rules, they will not be able to improve their self-control, which is dangerous for the growth of students. When teaching games, teachers should explain the rules of the game to students in advance, and describe the requirements of the game in simple and clear words, so that every student can understand the rules of the game as much as possible.

2) Conducting Reasonable Evaluations and Setting Appropriate

Rewards and Punishments

When conducting gamified teaching, teachers should inform students in advance about what they can and cannot do, the rewards they will receive for good performance, and the punishments for rule violations. This helps regulate student behavior during the game. Rewards should include verbal encouragement such as, “Your idea is great, keep up the good work!” or “Your progress is amazing; we applaud you!” Additionally, small prizes like stickers or cute stationery can be used. For punishments, keeping safety in mind, students can be asked to add plants and flowers to the classroom, engage in physical activities, or perform classroom cleaning tasks to develop their awareness of labor. The design of both rewards and punishments should be reasonable and balanced, avoiding extremes that are too severe or too lenient.

3.3.3.3 The importance of gamification activities

Gamification activities are conducive to cultivating students' thinking abilities. In the information age, proficiency in information technology tools and effective problem-solving thinking skills are crucial (Bai & Gu, 2019). Researchers have suggested that game-based teaching methods in thinking activities can encourage learners to think boldly and imagine freely in a relaxed environment, helping them to unlock their potential and develop their thinking skills (Zhang & Wang, 2018). For example, Xu et al. (2018) found that Gamification fosters higher-order thinking abilities, while Zhuang et al. (2015) argued that applying game mechanisms of competition and cooperation in problem-solving activities not only helps achieve teaching goals but also enhances knowledge mastery and develops higher-order skills in students.

Gamification activities also enhance students' learning interest and motivation. By integrating game elements and mechanisms, gamification makes learning more engaging and motivates learners to participate actively (Zhu et al., 2017). It can improve learning efficiency and motivation, particularly by encouraging deeper processing of learning content (Erhel & Jamet, 2013). Gamification naturally increases students' motivation, interest, and self-expression during the learning process, leading to better problem-solving skills and knowledge acquisition.

Furthermore, gamification activities foster students' sense of cooperation and competition. Integrating gamification elements into teaching activities creates a relaxed learning environment and promotes teamwork and competition (Cheng, 2022). The process of gamified learning involves problem-solving, independent inquiry, and collaborative exploration (Song, 2022). By presenting game tasks in problem-solving scenarios, gamification transforms the learning process into a problem-solving journey, allowing students to discover, analyze, solve problems, and verify results while completing tasks.

3.4 Application of learner-centered teaching approach

In this study, three primary learner-centered methodologies are employed: cooperative learning, Problem-Based Learning, and Gamification. This summary will explain the application of each teaching method in this study.

3.4.1 The application of cooperative learning in this study

In teaching, cooperative learning is seen as an innovative and efficient teaching method that can significantly enhance students' mathematical problem-solving skills. In this study, the cooperative learning method is used to enhance students' subjective consciousness and participation, cultivate students' teamwork spirit and assistance ability, and promote students' critical thinking and problem-solving skills. The following will elaborate on the specific application of cooperative learning in primary school mathematics teaching from these four aspects.

1) Cooperative learning promotes a deeper understanding of the problem

In the understanding problem stage, teachers need to create a suitable situation so that students can clarify the conditions and objectives of the problem. In this process, cooperative learning can promote student interaction and communication and help students understand problems from different perspectives. Specifically, teachers can implement this through the following points:

1. Grouping and Clarifying Roles

Form reasonable groups based on factors such as students' mathematical abilities and cognitive styles, and assign a leader to each group who will be responsible for organizing and coordinating group activities.

2. Asking a Question and Leading a Discussion

The teacher asks a question and guides the group through a discussion. During the discussion, students need to clarify the known and unknown conditions of the problem, as well as the goal of solving the problem.

3. Sharing and Integrating Views

Students are encouraged to share their own views and understanding within the group, and through interaction and discussion, integrate the opinions of the group members to form a common understanding of the issue.

2) Systematic analysis of cooperative learning reinforcement

During the problem analysis phase, students must perform a thorough examination and exploration of the issue, discovering strategies and techniques for its resolution. Cooperative learning can help students broaden their thinking and find more ways to solve problems. To be specific, teachers can take the following measures:

1. Guide the Group to Discuss Problem-Solving Strategies: Encourage group members to explore possible problem-solving strategies and methods, and find effective solutions through mutual communication and inspiration.

2. Provide Appropriate Support: Teachers can offer support tailored to students' needs, such as providing tips, examples, and other resources, to help students overcome thinking barriers and identify the key points for solving the problem.

3. Advocate Diversified Thinking: Encourage students to view problems from different perspectives, propose a variety of problem-solving methods, and broaden their approaches to problem-solving.

3) Cooperative learning promotes effective problem-solving

In the problem-solving phase: Students need to apply the knowledge and skills they have learned to solve problems. Cooperative learning can help students work together to complete problem-solving tasks. Specifically, teachers can take the following steps:

1. Division of labor: Based on the strengths and advantages of team members, divide the tasks and collaborate to accomplish the problem-solving task. This approach leverages each student's strengths and enhances the efficiency and quality of problem resolution.

2. Check and correct each other: Encourage team members to review and correct each other's problem-solving processes and results to ensure the correctness and completeness of the solution. This practice helps develop students' critical thinking and self-monitoring skills.

3. Share problem-solving experience: Encourage students to share their problem-solving experiences and ideas within the group to promote learning and communication. This sharing broadens students' problem-solving ideas and methods, and improves their mathematical problem-solving skills.

4) Deep reflection on cooperative learning guiding problems

After solving the problem, students need to reflect on and summarize their problem-solving methods and experiences. Cooperative learning can promote interaction and communication among students, helping them to reflect on and refine their problem-solving approaches. Specifically, teachers can take the following steps:

1. Lead the group to discuss the problem-solving process: Encourage group members to discuss the strengths and weaknesses of the problem-solving process, as well as areas for improvement. This helps to develop students' self-awareness and critical thinking skills.

2. Provide feedbacks and suggestions: Teachers can offer specific feedback and suggestions based on students' problem-solving processes and results to help them identify problems and deficiencies and develop improvement plans.

3. Expand questions and applications: Teachers can expand relevant questions and application scenarios based on students' learning situations to guide further exploration and practice. This helps to consolidate students' mathematical problem-solving skills and improve their mathematical literacy and innovation.

Through the application of the above four aspects, cooperative learning can effectively improve primary school students' mathematical problem-solving skills. In the teaching process, teachers should focus on cultivating students' subjectivity, cooperative spirit, and innovative abilities, as well as on developing their thinking and enhancing their mathematical literacy throughout the stages of understanding, analyzing, solving, and reflecting on problems. The application of strategies such as rational grouping, clear task objectives, providing resources and tools, advocating active participation and interaction, emphasizing process evaluation and feedback, and expanding the depth and breadth of problem-solving can help students gradually improve their mathematical problem-solving skills and achieve comprehensive development.

3.4.2 The application of Problem-Based Learning in this study

Problem-Based Learning, which has extensive applications in mathematics education, aims to foster the advancement of students' mathematical learning and problem-solving skills by guiding them through the resolution of authentic and significant problems. In this research, it is employed to enhance the mathematical problem-solving skills of primary school pupils through several designated measures:

1) Problem-based instructional design

Teachers should be driven by problems and design questions with challenging and practical significance. These questions should be closely related to students' real lives or mathematical applications and should stimulate students' interest and inquiry. The problems should have a certain level of complexity and openness, requiring students to use mathematical knowledge and skills to think deeply and analyze.

2) Creation of real situation

In order to enable students to better understand and apply mathematical knowledge, teachers can create real-life problem situations. This can be achieved by introducing real-life cases, simulating scenarios, role-playing, and other similar methods. Creating real-life situations helps students connect mathematical knowledge with practical problems and improves their mathematical problem-solving skills.

3) Combination of independent inquiry and cooperative communication

Problem-Based Learning emphasizes students' independent inquiry and cooperative communication. Teachers should encourage students to think independently and explore different problem-solving methods and strategies. At the same time, teachers should organize group discussions, collaborative problem-solving activities, and other similar activities to promote students' interaction and communication. This combination of independent inquiry with cooperation and communication helps students learn from each other and collectively improve their problem-solving skills.

4) Provide appropriate support and guidance

During the implementation of Problem-Based Learning, teachers need to provide appropriate support and guidance. This includes equipping students with the necessary mathematical knowledge, skills, and methods to help them build mathematical models and develop problem-solving strategies. Teachers can provide support through asking questions, demonstrating techniques, and leading discussions. Additionally, teachers can utilize digital tools and resources, such as computer software and online platforms, to assist students with data analysis and visualization tasks.

5) Process of evaluation and reflection

Evaluation and reflection are crucial components in the implementation of Problem-Based Learning. Teachers should employ a variety of evaluation methods, such as observation, work displays, and oral reports, to assess students' problem-solving processes and outcomes. The evaluation should focus on students' performance, problem-solving strategies, and methods, as well as the development of their problem-solving skills and mathematical literacy. At the same time, teachers should guide students in reflecting on and reviewing their problem-solving processes and methods, summarizing experiences and lessons learned to facilitate continuous improvement in future learning and problem-solving endeavors.

By applying these specific measures—problem-driven instructional design, the creation of real-life situations, a combination of independent inquiry and collaborative communication, the provision of appropriate support and guidance, and a process of evaluation and reflection—Problem-Based Learning can effectively enhance the mathematical problem-solving skills of primary school students in mathematics instruction. Continuously optimizing these measures and addressing students' learning needs and characteristics will better cultivate their mathematical literacy and problem-solving skills, laying a solid foundation for their holistic development.

3.4.3 The application of gamification in the teaching process

This study mainly proposes three application forms for integrating game-based teaching into primary school mathematics instruction. The first form is using games as a guiding tool to review existing knowledge and introduce new content. The second form involves incorporating games into the teaching process to consolidate knowledge. The third form is employing games for evaluating teaching effectiveness;

1) Guiding role

Reviewing traditional knowledge through games to lead to new content. In traditional teaching processes, teachers often review the previous lesson's material through questions before introducing new content. This approach can result in a disjointed connection between knowledge points, which may confuse primary school students due to their relatively simple cognitive development. To address this issue, teachers can introduce small, simple educational games at the beginning of the lesson to provide students with a preliminary understanding of the background knowledge. For example, teachers might present an educational game that requires solving a specific problem related to the new content of the lesson, thereby stimulating students' interest and engagement in learning. This approach primarily utilizes electronic courseware or flash games as the main application method for integrating review and introduction of new material.

2) Used in the teaching process to consolidate knowledge

Traditional teaching processes in mathematics are often perceived as monotonous, leading to a lack of student engagement and difficulty in maintaining concentration. To address this issue, teachers can incorporate games into the classroom to deepen students' understanding of mathematical concepts through interactive exercises. Gamification creates an enriched learning environment by revitalizing the classroom atmosphere and significantly increasing students' interest in learning. This is primarily achieved through the use of teacher-designed games or online educational games.

3) Used for teaching effect evaluation

Educational games are an innovative educational tool that not only enhances the enjoyment of learning but also serves as a means of evaluating teaching effectiveness during and after the instructional process, which has contributed to their growing popularity. During the teaching process, teachers can observe students' performance while playing games to gauge their grasp of new knowledge and adjust instructional methods based on their observations. After the lesson, teachers can assess students' understanding of the material through game scores and use this information to evaluate and summarize students' learning outcomes. Educational games, therefore, represent a highly effective method for both engaging students and assessing their learning progress, ultimately helping teachers to improve their teaching practices.

4) Use real-time feedback and rewards

In gamification, instant feedback is crucial. Teachers can use software or applications to display students' scores, rankings, and progress in real-time. This immediate feedback allows students to understand their performance promptly, enabling them to adjust strategies and improve methods. Establishing reward mechanisms, such as points, badges, and leaderboards, can further motivate students. When students reach certain goals or achieve excellent results, providing appropriate rewards not only recognizes their efforts but also encourages them to continue striving for success.

4. "Learner-centered" Mathematics Curriculum Development

4.1 The meaning of curriculum development

Curriculum, in a broad sense, encompasses the totality of all subjects or student activities led by teachers, while in a narrow sense, it specifically denotes a single subject (Dong, 1985). Wu (1986) believes that "curriculum refers to a purposeful and planned teaching process of a certain subject". Liao (1991) states, "Curriculum is composed of certain educational goals, basic cultural achievements, and learning activities to guide schools". Li (1995) asserted that curriculum is "a plan to guide students to obtain all educational experiences".

The Concise International Encyclopedia of Education summarizes nine classic "curriculum definitions" as shown in Table 11 below (Jiang, 1991):

TABLE 11 Curriculum definition

No.	Curriculum Definition
1	The school organizes potential experiences into a curriculum.
2	The full journey of the student's experience under the guidance of the school.
3	A set of teaching contents and implementation plans provided by the school for students
4	The curriculum is designed to explore ways in which teachers, students, disciplines, and environments can influence the content of the discipline.
5	The curriculum is the life of the school.
6	A course is a learning program.
7	Courses are the result of learning.
8	The curriculum is basically composed of five areas of study: mother tongue, mathematics, natural sciences, history, and foreign languages. The curriculum is equated with the curriculum as a whole, and the definition is equated with the division.
9	The curriculum is considered a viable mode of thinking about human experience.

Through the above analysis, it is evident that there are various definitions of curriculum, with many experts and scholars offering their own perspectives. In this study, the researcher characterizes the curriculum as an educational program designed to offer learners a more efficient approach to acquiring education, and the learners actively participated in the curriculum with the aim of achieving the predetermined learning outcomes.

The term 'curriculum development' has been interpreted in various ways. For example, Lewy (1991) defines it as "the preparation of an operational plan for putting an existing syllabus into practice”. Barrow and Milburn (1990) believe that curriculum development is the practical process of reshaping or designing a curriculum. Alvior (2014) defines curriculum development as a systematic, intentional, and gradual process designed to foster positive changes in the educational system. In this study, curriculum development encompasses all activities and processes, including determining curriculum objectives, selecting and organizing curriculum content, designing implementation, establishing curriculum principles and designing curriculum evaluation based on relevant ideas and theories.

4.2 Models for Curriculum Development

In the field of curriculum development, educators have designed many curriculum development models. In this study, the researcher is committed to applying the objectives model and the process model to the development and implementation of the curriculum. This approach aims to make the curriculum more relevant to real life and ultimately enhance students' ability to solve practical problems.

4.2.1 Objectives model of curriculum development

4.2.1.1 The main point of objectives model:

The objectives model takes the goal as the starting point and destination of curriculum development. It selects course content based on the establishment of course objectives and their realization, implements course design, and finally evaluates the quality of the course according to whether the objectives are achieved or not. In the book "Basic Principles of Curriculum and Instruction”, published in 1949, Tyler systematically expounded on the procedures, methods, and steps of curriculum development, known as the "Tyler Principles". Tyler believes that in the course preparation process, the organizer must answer four questions, as shown in Table 12 below (Tyler, 1994):

TABLE 12 Four questions for Tyler curriculum development:

Question number	Four questions
1	What are the educational objectives that schools should strive to achieve?
2	Which educational experiences can potentially be offered to effectively achieve these educational objectives?
3	How can we efficiently structure these educational experiences?
4	How can we determine whether these purposes are being attained?

In brief, these four questions correspond to the four phases of curriculum development: determining objectives, choosing experiences, structuring experiences, and assessing objectives. Among these, determining the objectives is the most important part. It can be seen that the objectives model takes the determination of behavioral objectives as the starting point and basis for curriculum development.

As a student of Tyler, Taba provided a more comprehensive and precise elaboration on Tyler's model, thereby extending its scope to some degree. The Taba objectives model emphasizes that the goals and objectives of the course should be determined first, and then the course should be evaluated based on these precisely stated goals. Taba followed Tyler's linear curriculum design paradigm and extended Tyler's four-step curriculum design framework into a comprehensive seven-step model. After conducting a thorough examination of societal contexts, scholarly resources, learners' educational journeys, and the intrinsics of knowledge, she outlined the principles and methodologies for constructing curricula, further elaborating on the nuanced components and structures inherent in curriculum design. The detailed steps are illustrated in the accompanying Table 13 (Taba, 1962).

TABLE 13 Taba's curriculum design model

STEP NUMBER	STEP NAME	CONTENT
1	Diagnosis of learners needs	Course developers identify the needs of students and understand their shortcomings, deficiencies, and background differences.
2	Formulation of objectives	Based on the assessment of students' needs, establish the educational objectives to be accomplished.
3	Selection of the content	The content and theme of the course are selected based on the established objectives, considering the effectiveness and importance of various alternative contents, methods, and means.
4	Organization of the content	Arrange and organize the courses and learning subjects according to the learners' maturity and current level, ensuring an appropriate sequence of topics.
5	Selection of learning experiences	Based on the subject matter, theme, and its sequence, select the suitable mode of learning or development, including listening, experimentation, observation, and discussion.
6	Structuring of learning experiences	Structure, sequence, and deploy the pre-selected learning experiences and materials.
7	Identify the evaluation targets and establish the methodologies and instruments for assessment	Develop suitable evaluation methods and instruments to assess learners' academic accomplishments and ascertain the extent of goal attainment.

4.2.1.2 Evaluation of the objectives model

The objectives model takes the course objectives as the starting point, and course development proceeds along the path of objectives - content -

organization - evaluation, ensuring a systematic approach that facilitates implementation and comprehension by teachers. This model is characterized by clear processes, defined steps, and relative ease of implementation for teachers. These characteristics affirm the objectives model's significant role in the history of curriculum development.

The main advantages of this model include clear and concise objectives, facilitating ease of implementation for teachers, straightforward course evaluation methods, and the convenience of linear course development. However, the model's high degree of control by educators highlights its limitations. Firstly, the teacher-designed objectives and led teaching processes often sideline children's initiative and creativity. Secondly, the emphasis on observable behaviors in the behavioral objectives model tends to overlook unobservable psychological qualities such as emotions, attitudes, and values. Thirdly, decomposing and refining curriculum objectives into clear targets can potentially fragment children's learning experiences, contradicting the holistic development principle of providing comprehensive experiences.

4.2.2 Process model of curriculum development

4.2.2.1 The main point of process model:

The process model, recognized as an important curriculum development model following the objectives model, was proposed by British curriculum theorist Stenhouse in response to perceived limitations of the instrumentalism in the objectives model. Stenhouse emphasized intrinsic educational values and practical experiences. A notable feature of the process model is its open design approach. Unlike the objectives model, which bases curriculum development on predetermined behavioral goals, the process model prioritizes overarching norms throughout the teaching development process, aligning them with broader educational purposes. Therefore, the main procedures of the process model include setting general goals, implementing creative teaching activities, conducting discussions, and evaluating the outcomes of teaching activities.

Stenhouse did not completely oppose objectives; rather, he saw the formulation of general objectives as the starting point of the process model. However, the objectives in his model differ fundamentally from those in the objectives model; they are broader and more general in nature. The process model selects course content based on the intrinsic value of knowledge and activities. Stenhouse referenced Raths' criteria for identifying activities of intrinsic value to guide this selection process. For the curriculum design approach of the process model, Stenhouse adopted Bruner's "spiral" curriculum model, which emphasizes the systematic organization of knowledge to benefit students. Teaching methods advocated in the process model include discovery-based learning and collaborative problem-solving discussions. The course process involves teachers and students jointly discussing proposed problems, enhancing thinking skills, and developing cognitive structures through problem-solving. Regarding evaluation methods, Stenhouse viewed the curriculum as an open system. He advocated for teachers to act as diagnosticians rather than mere graders, promoting open and diagnostic evaluation practices (Stenhouse, 1989).

4.2.2.2 Evaluation of the process model

Recognizing the shortcomings of the objectives model, the process model emphasizes the intrinsic value of education and knowledge, respects the unique contexts of educational processes, and advocates for the teacher as a researcher. These principles prioritize the cultivation of children's subjective spirit and creative thinking. This developmental approach grants teachers greater autonomy and flexibility, enabling them to design distinctive courses tailored to students' interests and specific circumstances.

However, Stenhouse's portrayal of the process model falls short of his critique of the objectives model. Curriculum development under the process model often lacks systematic organization, planning, and practicality. Moreover, the extensive freedoms granted to teachers can be idealistic. In practice, teachers frequently encounter challenges in developing truly exceptional courses or find themselves constrained by various factors.

4.3 The development of a Learner-centered mathematics curriculum

Traditional curriculum development methods typically exclude student involvement, following a fixed sequence of teaching and assessment. The content, objectives, and methods of the curriculum are primarily determined by educational experts or institutions. This approach often adopts a "one-size-fits-all" approach and neglects individual student differences and learning needs. In contrast, learner-centered curriculum development prioritizes students' active participation and collaboration, basing curriculum design on students' background knowledge, personal experiences, and learning needs (Xiao, 2011). Teachers and students engage in curriculum planning, implementation, and evaluation through ongoing dialogue and consultation. This approach emphasizes the learning process and students' needs, aiming to cultivate autonomous learning abilities, critical thinking, and problem-solving skills.

This study is guided by learner-centered educational theory in developing and designing a mathematics curriculum. The development model draws on the experiences of the objectives model and process model.

Firstly, the objectives model is considered valuable for developing this course due to its advantages such as a linear course development process, operational feasibility, and straightforward evaluation. Initially, adopting a linear development model with a clear implementation process is recommended for the course's initial implementation. Based on previous findings, problem-solving skill development is identified as the core goal of the course. To achieve this goal, clear lesson objectives should be defined before implementing each session. Mastery of core subject knowledge remains crucial for teachers, distinguishing it from previous courses. The course organization's activity and operational aspects, as well as the multidimensionality and dynamic nature of course evaluation, require attention and modification during the target model's application in course development.

Secondly, the process model's significant contribution to this course development lies in its standard for selecting course content. The process model's 12 principles for content selection are valuable considerations for teachers in practice. These principles emphasize allowing students to independently choose learning content, selecting personal and societal issues as research topics, providing tangible teaching aids, employing cooperative inquiry learning methods, facilitating question-based inquiry scenarios, and engaging teachers and students in collaborative inquiry processes, culminating in summary reports and shared insights.

The curriculum development process in this study is divided into three phases: Phase 1 involves studying primary school students' current mathematical problem-solving skills. Phase 2 focuses on developing a learner-centered mathematics curriculum. Phase 3 evaluates the effectiveness of the learner-centered mathematics curriculum.

4.4 The learner-centered mathematics curriculum design

Curriculum design is a specific organizational method adopted by curriculum developers, primarily involving curriculum objectives and the selection and organization of curriculum content (Xiao, 2020b). It encompasses the design of teaching objectives, teaching content, teaching methods, learning environments, and learning assessment (Zhang, 2012), guided by three fundamental principles: integrating targeted knowledge, focusing on student experiences, and dynamic curriculum design (J. Zhang, 2005). Under the "learner-centered" concept, curriculum design adheres to principles such as constructive alignment, backward design, and authentic assessment, typically comprising four steps: setting learner goals, designing teaching assessments, planning teaching activities, and reflecting on teaching practices (Wang et al., 2023). During the "learner-centered" curriculum design process, teachers should empathize with learners' needs, select appropriate textbooks, utilize process outline methods and project-based assignments effectively, and engage in collaborative curriculum design discussions with learners (Liu, 2009).

The curriculum design in this study progresses through the following steps:

1) Understand the characteristics and needs of learners

Firstly, it is essential to assess elementary school students' mathematics foundation, learning styles, interests, and learning difficulties. This involves gathering relevant data through communication with students, parents, and teachers, providing a foundational basis for curriculum design. Concurrently, understanding the cognitive development stage of primary school students is crucial to ensure that the curriculum content's difficulty is appropriate and aligns with their cognitive abilities.

2) Set curriculum objectives

Establish clear curriculum objectives based on learners' characteristics and needs. These objectives should concentrate on enhancing students' mathematical problem-solving skills, including abilities such as problem analysis, hypothesis formulation, solution identification, and answer verification. Simultaneously, ensure that these objectives are specific, measurable, and attainable, providing students with a clear understanding of their expected outcomes by the course's conclusion.

3) Select and organize content

When selecting and organizing curriculum content, educators should adhere to students' cognitive development stages and their learning interests. Choosing real-life problems or projects can effectively integrate mathematical concepts and skills. For instance, educators can design problems related to shopping, travel, graphics, and other practical scenarios. These questions and tasks should be challenging and intriguing to stimulate students' interest and motivation in learning. Additionally, educators must ensure the coherence and hierarchical structure of the content. This approach helps students establish a comprehensive mathematical knowledge system through gradual and in-depth learning processes.

4) Adopt a variety of teaching methods and activities

To accommodate diverse learning styles and needs among students, it is crucial to employ a variety of teaching methods and activities. When designing teaching methods, educators should prioritize active inquiry and cooperative learning among students. Innovative approaches like Problem-Based Learning and project-based learning can guide students in comprehensively understanding mathematical concepts and applying their knowledge through practical engagement, discussions, and reflections. Furthermore, educators can integrate digital tools and gamified teaching methods to enhance student interest and engagement. This approach enables students to learn mathematics and solve problems in a more enjoyable and interactive manner.

5) Provide timely feedback and evaluation

During curriculum implementation, educators should employ a variety of evaluation methods to assess students' learning progress and identify any challenges they may encounter. These evaluation methods may include observation, presentations of work, oral reports, and more. Through ongoing evaluation, educators can promptly identify issues and provide targeted feedback and guidance to help students enhance their learning strategies and improve their academic outcomes.

Additionally, educators should be attentive to changes in students' learning emotions and attitudes. It is important to encourage students to actively participate in mathematics learning activities and foster enjoyment in the learning process. This approach helps students develop a positive attitude towards mathematics and promotes their engagement and achievement in the subject.

6) Pay attention to the cultivation of students' emotional attitudes and values

In designing a learner-centered mathematics curriculum, it is crucial to prioritize the development of students' emotional attitudes and values. Educators should actively encourage, support, and guide students to cultivate positive attitudes and self-confidence in mathematics learning. Additionally, emphasizing the practical applications of mathematics in real life is essential to fostering students' mathematical literacy and problem-solving skills. It is equally important to address students' emotional education and value development, ensuring that they derive enjoyment and a sense of fulfillment from their mathematics learning experience.

In summary, the design of a learner-centered mathematics curriculum aimed at cultivating primary school students' problem-solving skills requires consideration of learners' characteristics and needs, the establishment of clear curriculum objectives, careful selection and organization of content, adoption of diverse teaching methods and activities, provision of timely feedback and assessment, and emphasis on the development of students' emotional attitudes and values. These efforts will help stimulate students' learning interest and motivation, enable them to actively construct their own knowledge systems, and enhance their proficiency in mathematical literacy and problem-solving skills.

CHAPTER 3
METHODOLOGY

The research methodology used in the study consisted of three phases as follows:

Phase 1: Studying the current situation of mathematical problem-solving skills of primary school students

1.1 Related literature studies

1.2 Preliminary research

Phase 2: Developing the learner-centered mathematics curriculum

2.1 Designing a learner-centered mathematics curriculum

2.2 Curriculum evaluation by experts

2.3 Undertaking a pilot study.

Phase 3: Studying the effectiveness of the learner-centered mathematics curriculum

3.1 Curriculum implementation

3.1.1 Experimental design

3.1.2 Variable

3.1.3 Population and sample

3.1.4 Ethical considerations in research

3.1.5 Research instruments

3.1.6 Curriculum implementation

3.1.7 Data collection

3.1.8 Data analysis

3.2 Curriculum Evaluation and Revision

The research methodology of this study is shown in the figure 3 below:

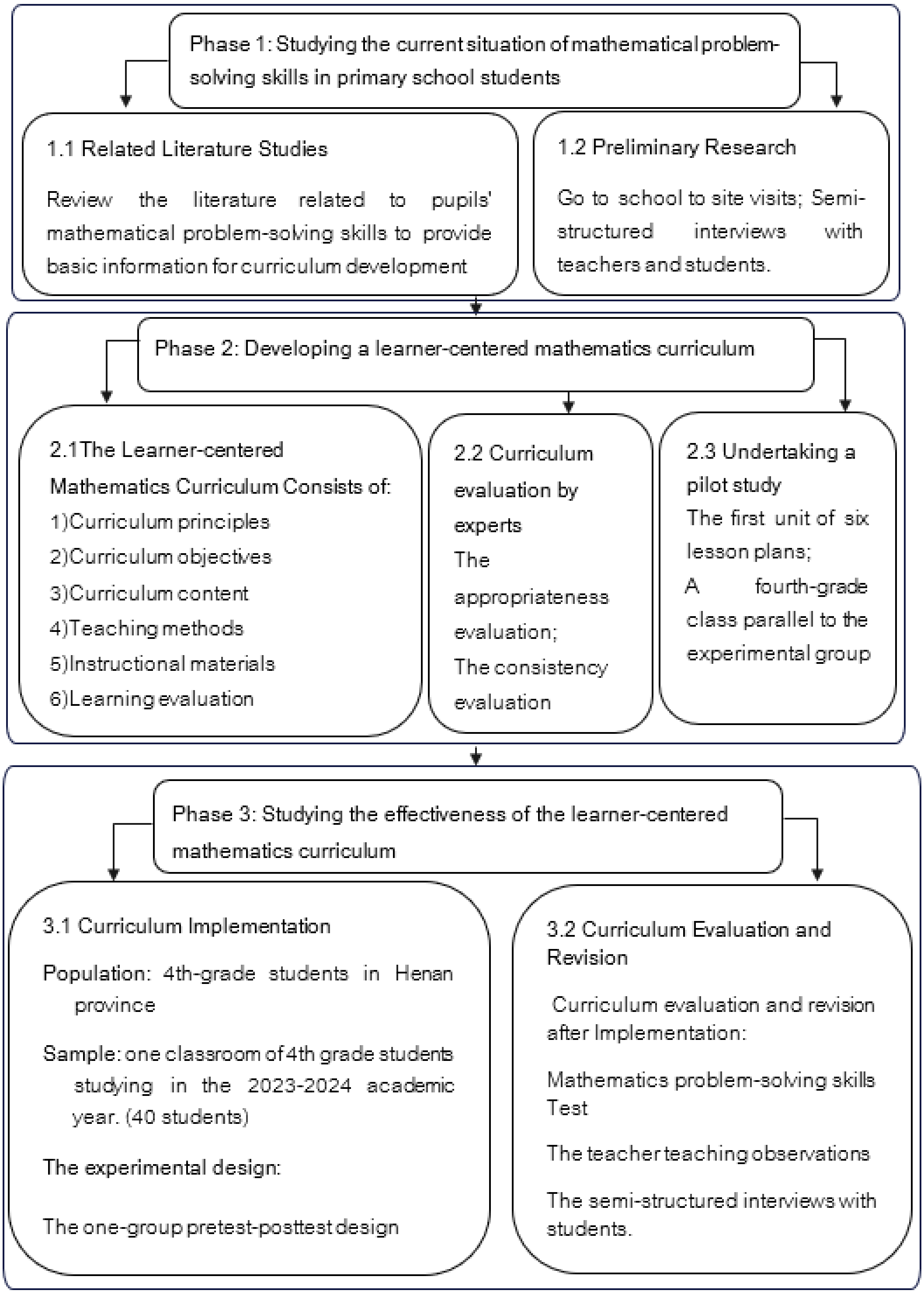


FIGURE 3 Research methodology structure framework

Phase 1: Studying the Current Situation of Mathematical Problem-solving Skills of Primary School Students

During this phase, through conducting a literature review, visiting schools, and engaging in semi-structured interviews with teachers and students, we aim to comprehend the current status of primary school students' mathematical problem-solving skills, thereby providing essential data for the advancement of this curriculum.

This phase is divided into two main steps:

1.1 Related literature studies

2.2 Preliminary research

1.1 Related literature studies

The objective of this step is to ascertain the current circumstances and prevalent issues regarding primary school students' mathematical problem-solving skills through literature review. This will provide essential data for the development and design of a learner-centered mathematics curriculum. The detailed procedures are outlined below:

1) Study and examine documents related to national educational guidelines and policies to understand background information pertinent to this study and grasp the significance of cultivating problem-solving skills among primary school students. This background knowledge will inform subsequent curriculum design and ensure alignment with national educational objectives.

2) Review and analyze concepts, theories, research findings, and online resources related to elementary school students' mathematical problem-solving skills. Define the meaning and components of students' problem-solving skills, explore evaluation methods, assess the current status and existing challenges in primary school students' problem-solving skills, and investigate strategies for enhancing these skills.

3) Analyze literature on curriculum development to provide theoretical guidance for learner-centered curriculum design. This exploration will facilitate the design and development of curricula that meet the needs of primary school students and promote the development of problem-solving skills. It ensures that teaching activities are tailored to the characteristics and requirements of learners.

1.2 Preliminary research

The purpose of this step is to understand teachers' perspectives on mathematical problem-solving skills, investigate challenges in primary school mathematics teaching, and identify students' needs. This aims to provide empirical support for developing a learner-centered curriculum focused on cultivating students' mathematical problem-solving skills. This phase involves conducting school visits to observe classroom teaching and interact with teachers and students. To gain a comprehensive understanding of mathematics problem-solving instruction, classes across different grades are randomly selected for observation. Additionally, targeted semi-structured interviews are conducted with mathematics teachers representing various grades, teaching experiences, and proficiency levels. Moreover, purposive sampling is used to interview nine fifth-grade students with diverse learning styles, abilities, and backgrounds from eight different classrooms. These interviews aim to assess students' understanding of mathematical problem-solving skills, explore their attitudes towards learning, identify their interests, and uncover learning challenges. This process helps reveal genuine student needs in developing effective strategies for solving mathematical problems.

The research tools used for data collection include the classroom observation record form and the semi-structured interview form with teachers and students. The production process is outlined as follows:

1) The classroom observation record form

The process of constructing the classroom observation record form is divided into five steps, as follows:

Step 1: Explore and study professional methods for constructing classroom observation records by consulting relevant literature.

Step 2: Clarify and refine the indicators of teachers' teaching behaviors and the points for observing students' learning behaviors in class.

Step 3: Invite professional instructors to review the appropriateness and accuracy of the established observation indicators.

Step 4: Make necessary adjustments and optimizations to the classroom observation record based on the professional feedback from the instructors.

Step 5: Finally, create a scientifically sound and practical classroom observation record sheet, which is used to systematically record and analyze the actual performance of teachers and students in class (See Appendix A).

2) The semi-structured interview form with teachers and students.

The process of constructing the semi-structured interview form is divided into five steps, as follows:

Step 1: Master the professional construction method of the semi-structured interview form through in-depth study of literature related to its construction.

Step 2: Carefully prepare the semi-structured interview questions, categorized into questions for teachers and questions for students:

1) Teachers are interviewed on five aspects: understanding of mathematical problem-solving skills, teaching content, teaching methods, teaching evaluation, and curriculum suggestions.

2) Students' interview questions cover five aspects: understanding of mathematical problem-solving skills, learning activities, learning styles, learning evaluation, and curriculum needs.

Step 3: Submit the carefully crafted interview questions to instructors for thorough review of appropriateness and accuracy.

Step 4: Based on valuable feedback from the instructors, carefully revise the semi-structured interview questions.

Step 5: Finally, integrate and compile a systematic semi-structured interview form to conduct in-depth interviews with teachers and students (See Appendix A).

Data Collection and Data Analysis

Using self-designed interview forms, the researcher conducted one-on-one semi-structured interviews with six teachers and nine fifth-grade students. Following the interviews, the researcher meticulously analyzed and summarized the collected interview data using the content analysis method.

Phase 2: Developing the Learner-centered Mathematics Curriculum

In this phase, we utilized the information gathered in the initial stage to develop a learner-centered mathematics curriculum focused on enhancing primary school students' mathematical problem-solving skills. To ensure the effectiveness of the curriculum design, we engaged five experts from relevant fields to conduct a thorough assessment of the appropriateness and coherence of the course content. Based on their feedback, targeted adjustments were made to the curriculum. Subsequently, we conducted a pilot study of the revised curriculum to evaluate the teaching quality, implementation feasibility, and accuracy of language used in handouts and learning materials.

This phase is divided into three main steps:

2.1 Designing a learner-centered mathematics curriculum

2.2 Curriculum evaluation by experts

2.3 Conducting the pilot study

2.1 Designing a learner-centered mathematics curriculum

Based on the results of the first phase of research, we designed a learner-centered curriculum aimed at developing mathematical problem-solving skills of primary school students. The curriculum framework encompasses six key elements: curriculum principles, curriculum objectives, curriculum content, teaching methods, teaching materials, and learning evaluation. The process of creating the curriculum draft in this study included seven primary steps:

2.1.1 Assess the needs of learners

To assess learners' needs, conducting a comprehensive analysis of students' backgrounds, interests, and learning preferences is crucial. This assessment ensures that the curriculum design, including its objectives, content, teaching methods, and assessment strategies, is tailored to the unique characteristics and requirements of the student population. By understanding the actual situation of the students, educators can create a curriculum that not only meets their academic needs but also fosters engagement and excitement for learning.

2.1.2 Follow the learner-centered curriculum principles

The curriculum adheres to the guidelines set forth in the Outline of the National Medium- and Long-Term Education Reform and Development Program (2010-2020) and the Mathematics Curriculum Standards for Compulsory Education (2022 edition). It advocates a learner-centered approach, aiming to provide every student with a quality mathematics education. This approach recognizes and supports different students' diverse developmental trajectories in mathematics.

2.1.3 Develop scientific and reasonable curriculum objectives

Curriculum objectives provide teachers with clear teaching direction and goals, aiding them in organizing teaching content and planning activities effectively during lessons. They ensure the coherence and efficacy of teaching. Simultaneously, curriculum objectives help students by delineating the knowledge and skills they need to acquire, clarifying their learning direction, and fostering interest and motivation in their studies. This approach enables students to comprehensively and systematically acquire relevant knowledge and skills. Therefore, it is essential to formulate scientific and reasonable curriculum objectives. Following the new curriculum reform principles and the mathematics curriculum standards for primary and secondary schools, this course designs reasonable, balanced, and practical teaching objectives for each unit.

2.1.4 Create interesting and easy to understand course content

When developing the content for this curriculum, a thorough analysis of existing textbooks and syllabi is conducted to ensure alignment with syllabus requirements. The selection process prioritizes the most crucial and fundamental content, ensuring students focus on these key areas during their studies. Respectful of the cognitive development abilities of fourth-grade students, the curriculum aims to stimulate their interest in learning by incorporating real-life scenarios and presenting content that is engaging, easily understandable, vivid, and rich.

2.1.5 Choose the right teaching method

The teaching design in this study strictly adheres to the core concept of "learner-centered", placing students at the center and selecting appropriate teaching methods based on their actual needs and abilities, aligned with teaching principles and objectives. Guided by this concept, teachers comprehensively consider students' characteristics, learning goals, and educational requirements, employing a variety of flexible teaching methods aimed at enhancing students' learning interest and improving outcomes. This research incorporates three innovative teaching methods: cooperative learning, Problem-Based Learning, and gamification.

In Problem-Based Learning, the researcher craft realistic and complex mathematical problems presented through vivid scenarios such as situational simulations and case analyses at the outset of the course. This approach stimulates students' independent thinking and encourages them to explore solutions to problems bravely. Teachers provide timely guidance and support throughout this process, acting as facilitators as students delve into the realm of knowledge.

Cooperative learning emphasizes collaboration and communication among students. Working in groups, students collectively tackle problems, engage in lively discussions, and share insights and solutions. By presenting their findings to the class, each group fosters cohesion and provides peers with learning opportunities, creating a collaborative environment that enables students to enhance their problem-solving skills through mutual learning.

Gamification principles are integrated to make learning math enjoyable. We've developed a series of engaging and challenging mathematical games designed to stimulate students' curiosity and inquiry. Through active participation and friendly competition in these games, students showcase their abilities, while teachers provide timely evaluation and feedback to reinforce their learning achievements.

2.1.6 Design learning activities and teaching materials

Learning activities should be tailored to fit the course curriculum and the goals of each learning module, taking into account the interests and abilities of the learners. Activities should be both enjoyable and beneficial, such as participating in collaborative activities, group projects, and gamification activities. Lesson plans encompass detailed planning of the entire teaching process, including teaching objectives, content, methods, procedures, classroom interactions, exercises, and evaluation methods. These plans ensure that each session is well-organized and effectively supports the learning goals and needs of the students. The study's learning unit, comprising 15 lesson plans, is presented in Table 14.

TABLE 14 15 lesson plans

Lesson Plan	Content	Class periods
1	The meaning of addition and subtraction and the relationship between the parts	1
2	The meaning of multiplication and division and the relationship between each part	1
3	24-point calculation technique	1
4	Relationship among unit price, quantity and total price	1
5	Promotion activity	2
6	Chartering problem	1
7	The circumference of a rectangle and a square	2
8	Cognitive area	1
9	Area of rectangle and square	2
10	Practical application	1
11	Average	1
12	Compound bar chart	1
13	Possibility	1
14	Household budget	1
15	Nutrition lunch	2

The lesson plan includes 8 parts: Topic of content, learning content, learning objectives, teaching methods, teaching process, homework assignment, learning evaluation, and teaching materials. The learner-centered mathematics curriculum teaching schedule and lesson plans are shown in Appendix C.

2.1.7 Determining the learning evaluation

Learning evaluation is an indispensable and important link in the teaching process. It entails examining and determining students' understanding level, knowledge mastery, and learning outcomes during their learning journey. Based on the results of learning evaluation, teachers can grasp students' learning situations, identify their learning patterns, refine teaching plans, adjust teaching content, and assist students in achieving learning objectives more effectively. This study adopts a learner-centered assessment approach, emphasizing both learners' subjective experiences and objective performance, as well as their developmental progress throughout the learning process. It focuses on learners' motivation, learning strategies, abilities, outcomes, and their active participation in learning activities.

In this research, various real-time evaluation methods are employed in the classroom, including questioning, observations, timely feedback, classroom participation, group work, group discussions, student presentations, and self-assessment. Post-class homework assignments are tailored to accommodate students' differences, employing differentiated tasks of varying difficulty levels to ensure each student's maximum development. Recognition and encouragement are given based on students' completion of tasks appropriate to their level. Multiple evaluations of homework promote the habit of error correction and allow more students to experience the joy of success. By combining subjective and objective evaluation methods, multi-level evaluation ensures sustainable student development in a nurturing environment conducive to building good habits of awareness, cooperation, and efficiency, thus promoting students' overall well-being.

Following the course, curriculum implementation is evaluated with researchers acting as observers, recording student performance and conducting semi-structured interviews to assess student outcomes. Evaluation tools include teacher teaching record forms, classroom management optimization logs (assisting in recording student classroom behavior), and semi-structured student interview forms.

In addition to informal classroom assessments for ongoing teaching and learning insights, teachers should incorporate formal, purposeful, and scientific evaluation activities to gather essential information. Therefore, at the conclusion of the course, each student undergoes a mathematical problem-solving skills test to assess their learning effectiveness formally. This evaluation exercise aims to provide objective and comparable data to enhance teachers' understanding of student learning outcomes. These evaluation results furnish crucial information for adjusting teaching strategies, optimizing student learning outcomes, and guiding further improvements in teaching practices.

Research tools for data collection include the mathematics problem-solving skills test, the teacher teaching record form, the student semi-structured interview form, and the classroom performance statistics tool. The production process is as follows:

1) Creating the mathematics problem-solving skills test

The mathematical problem-solving skills test aims to assess students' ability to apply mathematical knowledge and methods to solve practical problems, focusing on their problem-solving process rather than just the outcomes. The process of creating a math problem-solving test involves 8 steps, as follows:

Step 1: By consulting literature closely related to mathematical problem-solving skills tests and their scoring criteria, thoroughly explore the design methods and implementation details.

Step 2: Analyze the learning objectives and curriculum contents to define the content to be evaluated.

Step 3: Developing a mathematics problem-solving skills assessment. Composing preliminary versions of the problem-solving assessment and its scoring rubric. Under the review of the instructor, the test items are verified in a full range, including the analysis of the fit of the test content and the scoring criteria, the assessment of the accuracy and precision of the test, and the review of the expression of the test is clear and unambiguous, so as to ensure the suitability and professionalism of the entire test. The mathematical problem-solving skills test adopts the four stages of problem-solving constructed in the literature, and each item is completed in four stages. The details are as follows:

1) Understand the problem (for example, what data will you use for this question? What are the known and unknown quantities in this question, and how do you understand the problem?).

2) Analyze the problem (write down the quantitative relationship to be used in the topic, write down your problem-solving ideas, such as what to do first and then what to do, write down what strategies need to be used such as drawing, list, replacement, assumption, etc.).

3) Solve the problem (the detailed process of solving this problem, write as many solutions as possible).

4) Review after solving the problem(after solving this problem, what do you think? For example, have you seen this problem before, whether you have checked the calculation, whether there are other solutions, problem-solving feelings, etc.).

The scoring criteria for each item in four stages are shown in Table 15 below:

TABLE 15 The scoring criteria for each item

Scores	Understanding	Analyzing	Solving	Reviewing
4 points	Completely understand the meaning of the problem and be able to identify all the key information and find out all the implied conditions in the problem.	Able to find out all the quantitative and spatial relationships needed to solve problems, and able to present the thinking process with the help of words, symbols, graphics, tables and other ways to clearly express their ideas.	Able to translate analysis results into concrete steps, write different solutions, and come up with the right answer.	Be able to check and reflect consciously, check the results correctly, say the method in the process of solving the problem, and be able to compare the advantages and disadvantages of each scheme.

TABLE 15 (CONTINUE)

Scores	Understanding	Analyzing	Solving	Reviewing
3 points	Understand most of the problem, find out most of the key information, find out most of the implicit conditions in the problem.	Able to find out most of the quantitative and spatial relationships needed to solve problems, and able to present the thinking process with the help of words, symbols, graphs, tables and other ways, but with a small number of mistakes, to express their ideas more clearly.	Be able to translate analysis results into concrete steps, write a solution, and get the right answer.	Be able to check and reflect consciously, check the results correctly, say the method in the process of solving problems.
2 points	Understand part of the meaning of the topic, able to find out some of the key information, find the implicit condition of part of the problem.	Able to find out some of the quantitative and spatial relationships needed to solve problems, and to present the thinking process with the help of words, symbols, graphics, tables, etc. but some errors, and to express their own ideas, but not clearly.	Able to translate analysis results into concrete steps, write a solution, but the calculation results are wrong.	Be able to check and reflect consciously and check the results correctly.
1 point	Understand the meaning of few parts of the problem, be able to identify few key information and identify few implied conditions in the problem.	Able to find out the quantitative and spatial relations of a small part needed to solve the problem, and present the thinking process with the help of words, symbols, graphs, tables, etc. but there are most of the mistakes, and can express his own thinking, but the thinking is chaotic.	Able to translate analysis results into concrete steps to write a solution, but the solution is incomplete.	Capable of self-examination and reflection, but the examination results are not correct.

TABLE 15 (CONTINUE)

Scores	Understanding	Analyzing	Solving	Reviewing
0 point	Completely unable to understand or answer the problem.	Unable to write useful information. Unable to write out the idea of the problem or no answer.	Unable to write down the process or no answer.	No reflection.

According to the class schedule of this course, the test consists of 7 items, of which 3 items belong to number and algebra problems, 2 items are geometry and graphics problems, 1 item is statistics and probability, and 1 item is synthesis and practice problems. In combination with the scoring criteria, the answers to each stage of each item were scored. The highest score for each stage of each course is 4 points, and the lowest score is 0 points. The full score of each stage is 28 points (4×7), and the total score of the paper is 112 points (28×4). Refer to Appendix A for the math problem solving test paper and the grading criteria.

Step 4: Modify the test items and evaluation form based on the instructor's advice. Seek evaluation from five relevant experts to assess the validity and consistency of the test items and evaluation form, and to determine the overall quality of the assessment using the Index of Item Objective Consistency (IOC) (Refer to Appendix A).

Step 5: Analyze the Index of Item Objective Consistency (IOC) for the assessment items. The formula to compute the IOC index is presented as follows:

$$IOC = (\sum R)/N$$

Where IOC: Objective Consistency means Index of Item

$\sum R$: means Summation of experts opinion marks

N: means A number of experts

When the Index of Item Objective Consistency (IOC) for each item in the assessment exceeds 0.5, it signifies that the item is suitable for inclusion in the assessment. The Mathematical Problem-Solving Skills Test Item Consistency Evaluation

Form is shown in Appendix A. Experts assess an IOC value between 0.8 and 1.0 (see Appendix B), indicating that the consistency of each item meets the requirements.

Step 6: Assessment of item difficulty (p) and item discriminability (r), along with reliability, was conducted by the Mathematics Problem-Solving Skills Assessment to 40 fifth-grade students from Zhoukou City First Primary School who had already studied the relevant content.

Step 7: Each item was analyzed for its difficulty (p), discriminability (r), and reliability. Difficulty (p) is calculated using the formula p = A/N, where p represents difficulty, A denotes the mean score of the item, and N indicates the total number of scores for the item. Discriminability (r) is computed with the formula r = 2(A - B)/N, where r represents discriminability, A is the mean score of the item's high group (top 27%), B is the mean score of the item's low group (bottom 27%), and N is the total score of the item. The reliability coefficient of the assessment is determined by calculating the Cronbach's Alpha coefficient.

Step 8: After conducting data analysis, we have selected items for the problem-solving skills test. The difficulty (p) of these items ranges from 0.20 to 0.80, ensuring that each item maintains a discriminability (r) of at least 0.20. The test results confirm that all selected items meet the designated difficulty range, with each item achieving a discriminability score exceeding 0.20. Moreover, the overall reliability of the test items has attained 0.72. For detailed information on item difficulty (p), item discriminability (r), and reliability (See Appendix B).

2) The teacher teaching record form

The teacher teaching record form is utilized by either the teacher or the researcher. Following each teaching unit, the form documents students' performance, including their learning attitude, class participation, cooperation, and completion of homework, followed by a post-teaching reflection. The production process of the teacher teaching record form unfolds as follows:

Step 1: The initial step involves comprehensive literature research related to the development of a teacher's instructional record form, establishing a robust theoretical basis for the subsequent design of the form.

Step 2: Following the literature review, the form is created, comprising two main sections. The first section records students' performance across four dimensions: learning attitude, class participation, cooperation, and completion of homework. The second section facilitates post-teaching reflection.

Step 3: After the initial form design, five experienced experts are invited to evaluate the appropriateness of the questions and the clarity of wording in the form.

Step 4: Based on feedback and suggestions from the experts, necessary modifications and improvements are made to ensure the form's accuracy and effectiveness in collecting required data during the curriculum implementation phase. The teacher teaching record form is provided in Appendix A.

3) Student semi-structured interview form

Step 1: Conduct a thorough literature review on semi-structured interviews with students, focusing on techniques for structuring such interviews.

Step 2: Based on the insights gained from the literature review, develop interview questions. These questions primarily address four core aspects: course content, teaching methods, learning experiences, and learning evaluation. The aim is to craft questions that are both comprehensive and specific to elicit genuine thoughts and feelings from the students.

Step 3: Upon completing the interview question design, submit the interview form to an instructor for review. The instructor evaluates the questions for appropriateness and accuracy, providing valuable comments and suggestions.

Step 4: Modify and improve the semi-structured interview form based on the feedback received from the instructor.

The semi-structured interview form is located in Appendix A.

4) Classroom performance statistics tool: Class optimization master App

Class Optimization Master APP is an intelligent class management tool specially created by Seewo for teachers. Through the application integration of intelligent technologies such as AI and teaching management, it enables three core scenarios: classroom management, home-school communication, and class administration for Chinese teachers. This aids in managing teaching, activating classroom learning atmospheres, reducing communication costs between home and school, and improving shift handling efficiency.

The Class Optimization Master APP assigns a unique cartoon character to each student, which can be upgraded based on points through addition or subtraction and random selection. Gamification elements such as rules, interfaces, and sound effects stimulate students' competitiveness and creativity. Data is automatically recorded, archived, and calculated, and can be easily shared with parents.

The software enhances classroom management by addressing issues such as dull classes and low student interest and motivation, employing incentive evaluation mechanisms to foster engaging and gamified educational experiences.

The specific functions are as follows: 1. User-defined evaluations: Teachers can customize comments to motivate and standardize student behaviors with multiple reward and punishment mechanisms. 2. Classroom tools: Electronic attendance, random selection, and group teaching features ensure efficient and enjoyable classrooms. 3. Weekly Honor List: Replaces traditional methods like red flowers and score books with updated weekly evaluation lists to encourage continuous student growth. In this study, the researcher utilized the Class Optimization Master app to accomplish the following functions:

1. Record detailed behavior of all students in the class.

2. Establish individual student files.

3. Randomly group students.

4. Implement multiple reward and punishment mechanisms to motivate and regulate classroom behavior.

5. Utilize the software for teaching assistance.

2.2 Curriculum evaluation by experts

Five experts have evaluated the developed mathematics curriculum, conducting a thorough review of each component to ensure appropriateness and consistency. Based on their expert opinions, modifications will be made to the mathematics curriculum to ensure effective implementation.

Firstly, the appropriateness of various components of the developed mathematics curriculum, such as curriculum principles, objectives, content, learning activities, materials, and evaluation, was assessed.

Secondly, the inherent consistency between these components was evaluated, including alignment between curriculum principles and objectives, objectives and content, content and learning activities, as well as the congruency of learning materials, resources, time allocation, and evaluation with the objectives.

Recommendations from the team of five experts, which includes specialists in measurement and evaluation, curriculum development, and instructional content relevant to specific subjects (refer to Appendix A), were used to revise the mathematics curriculum.

The research utilized the Mathematics Curriculum Quality Assessment Form as the data collection tool, consisting of four parts: 1) Experts' demographic information; 2) Evaluation of the appropriateness of curriculum components; 3) Evaluation of consistency among curriculum components; and 4) Experts' feedback and recommendations. The final version of the assessment tool is provided in Appendix A.

Data collection and analysis were conducted to evaluate the mathematics curriculum based on expert evaluations, ensuring the appropriateness and consistency necessary for effective curriculum implementation.

The appropriateness level score for each item in the mathematics curriculum ranges from low to high on a scale of 5 as shown in Table 16 (Best, 1981)

TABLE 16 Appropriateness level scores for each item in the mathematics curriculum

Scale value (points)	The appropriateness level
5	Very high level
4	High level
3	Low level
2	Very low level
1	Moderate level

In the evaluation process, appropriateness data was collected using the evaluation form. The average scores were calculated for analysis, and corresponding appropriateness levels were determined, as detailed in Table 17.

TABLE 17 The interpretation of appropriateness level in the mathematics curriculum

Mean scores	Interpretation
4. 51 – 5. 00	Very high level
3. 51 – 4. 50	High level
2. 51 – 3. 50	Moderate level
1. 51 – 2. 50	Low level
1. 00 – 1. 50	Very low level

If the mean scores of the appropriateness evaluated by a group of experts were higher than 3.51, it indicates that the components of the mathematics curriculum met a high standard of appropriateness.

The researcher analyzed the consistency of the mathematics curriculum by calculating the Index of Item Objective Consistency (IOC). Table 18 provides details of the consistency level scores corresponding to each item within the mathematics curriculum.

TABLE 18 Consistency level scores for each item in the mathematics curriculum

Scale value (points)	The consistency level
+1	Consistent
0	Not sure
-1	Inconsistent

The analysis shows that the consistency index value falls between 0.60 and 1.00 (which is higher than 0.5), indicating strong consistency among all components of the mathematics curriculum.

2.3 Undertaking a pilot study

Before the official implementation of the curriculum, a pilot study is conducted to assess the feasibility and quality of the designed mathematics course. This pilot study also aims to identify potential issues and challenges that may arise during usage, providing valuable feedback for further refinement and optimization of the curriculum.

The pilot study targets 40 students from a different class in the fourth grade of Zhoukou First Primary School, separate from the initial sample group. The research tool consists of the first unit of six lesson plans developed by the researcher, implemented over two class periods per week for a total duration of three weeks.

Phase 3: Studying the effectiveness of the learner-centered mathematics curriculum

The revised mathematics curriculum is initially implemented to assess its practical feasibility. During this implementation, students' problem-solving skills in mathematics are evaluated both before and after the curriculum is introduced. Additionally, the outcomes of the teaching process and interviews with students are documented to assess the effectiveness of the revised curriculum. Based on the collected feedback, adjustments and optimizations are made to further refine the curriculum.

This phase is divided into two main steps:

3.1 Curriculum Implementation

3.2 Curriculum Evaluation and Revision

3.1 Curriculum Implementation

3.1.1 Experimental design

This study utilized the one-group pretest-posttest design (Campbell & Stanley, 1963) to examine the effectiveness of implementing the revised mathematics curriculum, as outlined in Table19:

TABLE 19 The one group pretest-posttest design

Group	Pretest	Treatment	Posttest
Experimental	O_1	X	O_2

O1 was measurement of the mathematical problem-solving skills before an instruction or implement the mathematics curriculum

X was Instruction through learner-centered mathematics curriculum

O2 was measurement of the mathematical problem-solving skills after an instruction or implement the mathematics curriculum

3.1.2 Determine population and sample

The target population for this study comprised fourth-grade students in Henan Province. According to the Ministry of Education of the People's Republic of China (2023), the number of fourth-grade students in Henan Province is 1,720,712, ranking second in the country. Henan Province was characterized by a large population and a weak educational foundation (Zhang, 2022). Despite efforts to deepen educational and teaching reforms and enhance the quality of compulsory education, education in Henan still faced challenges, including disparities with national standards and regional imbalances.

The Henan Provincial Party Committee proposed increasing funding to support teacher development, educational reform, school infrastructure improvements, teaching and research innovations, and overall education quality enhancements. While educational concepts among teachers and principals in Henan were evolving, challenges remained. The practices of 'teaching to the test' and 'evaluating based on exam results' persisted, and there was a prevalence of rote learning. A survey indicated that while more teachers were embracing new curriculum concepts and materials, some still prioritized knowledge over comprehensive skill development. Additionally, 83.01% of teachers reported that student test scores were the primary measure of teacher evaluation. Students noted that teachers spent considerable time lecturing or answering questions themselves, and 56.92% of primary school teachers frequently assigned repetitive homework to correct initial mistakes.

Due to limited enrollment quotas amid high demand, schools, society, and parents overly emphasized students' test scores at the expense of broader skill development, a particularly acute issue in Henan Province, which served as the focus of our research.

The study sample comprised a class of fourth-grade students (40 students) during the 2023-2024 school year at the First Primary School in Zhoukou City, Henan Province, China. The researcher employed a multi-stage sampling method to select participants. In the first stage, Zhoukou City was chosen through simple random sampling from 18 prefecture-level cities in Henan Province. In the second stage, the First Primary School in Zhoukou City was selected through simple random sampling from 120 primary schools in Zhoukou. In the third stage, a classroom consisting of 40 students (22 boys and 18 girls) was selected from eight fourth-grade classrooms at the First Primary School through simple random sampling.

3.1.3 Ethical considerations in research

The following section outlines the steps taken by the researcher to adhere to the ethical standards required for conducting the study.

1) The researcher completed a full-day online training on "Ethical

Principles of Research Involving Human Subjects", conducted by the Strategic Wisdom and Research Institute of Srinakharinwirot University on May 25, 2023. The researcher successfully passed the Ethics Committee Test and received a certificate on the same day, valid until May 25, 2026, allowing for the conduct of human subject research (see Appendix B).

2) Upon approval of the research proposal by the research panel, the researcher submitted it to the Institutional Review Board (IRB) / Ethics Committee of Human Research at Srinakharinwirot University for ethical approval, ensuring adherence to research guidelines (see Appendix B).

3) Prior to commencing data collection, all participants were informed of their voluntary participation. During recruitment of the final 40 participants, each participant was reminded of their voluntary participation and right to withdraw at any time without providing a reason. After confirming their decision to participate, all 40 participants read and signed both the consent form and the participant information sheet. During the introductory session, the researcher verbally confirmed each participant's willingness to participate and reiterated their right to withdraw from the study at any time without consequences.

4) In reporting the research findings, participant confidentiality was maintained by presenting only aggregated data that excluded personally identifiable information, ensuring anonymity. All raw data collected for the study will be securely stored and handled confidentially in accordance with ethical guidelines.

3.1.4 Research instruments

The research instruments were the tools used to collect data for this study. The following were the research tools utilized in this study:

1. The classroom observation record form
2. Semi-structured interview form with teachers and students
3. The teacher teaching record form
4. Student semi-structured interview form
5. The learner-centered mathematics curriculum

6. The lesson plans and instructional materials

7. The mathematical problem-solving skills test

8. Classroom performance statistics tool: Class management optimization App.

3.1.5 Curriculum implementation

The mathematics curriculum developed by the researcher was implemented at Zhoukou First Primary School, Henan Province, with the approval of the school principal before implementation. A classroom of 40 students was randomly selected from eight Grade 4 classrooms to participate in the curriculum implementation. The researcher followed the teaching plan outlined in Table 20.

TABLE 20 The schedule for the curriculum implementation

<table>
<tr><th>Weeks</th><th>Class Periods</th><th>Lesson Plans</th></tr>
<tr><td>1</td><td>2</td><td>Introduction and Pretest (The mathematics problem-solving skills test)</td></tr>
<tr><td rowspan="2">2</td><td>1</td><td>1.1 The meaning of addition and subtraction and the relationship between the parts</td></tr>
<tr><td>1</td><td>1.2 The meaning of multiplication and division and the relationship between each part</td></tr>
<tr><td rowspan="2">3</td><td>1</td><td>1.3 24-point calculation technique</td></tr>
<tr><td>1</td><td>1.4 Relationship among unit price, quantity and total price</td></tr>
<tr><td>4</td><td>2</td><td>1.5 Promotion activity</td></tr>
<tr><td rowspan="2">5</td><td>1</td><td>1.6 Chartering problem</td></tr>
<tr><td rowspan="2">2</td><td rowspan="2">2.1 The circumference of a rectangle and a square</td></tr>
<tr><td rowspan="2">6</td></tr>
<tr><td>1</td><td>2.2 Cognitive area</td></tr>
<tr><td>7</td><td>2</td><td>2.3 Area of rectangle and square</td></tr>
<tr><td rowspan="2">8</td><td>1</td><td>2.4 Floor tile problem</td></tr>
<tr><td>1</td><td>3.1 Average</td></tr>
<tr><td rowspan="2">9</td><td>1</td><td>3.2 Compound bar chart</td></tr>
<tr><td>1</td><td>3.3 Possibility</td></tr>
<tr><td>10</td><td>1</td><td>3.4 Household budget</td></tr>
</table>

11	2	4 Nutrition lunch-rational combination
	2	Posttest (The mathematics problem-solving skills test)
Total	23	

Note: 40 minutes per class period

3.1.6 Data collection

The data collection processes are as follows:

1) The sample was administered a pretest to measure mathematical problem-solving skills using a constructed instrument, specifically a mathematical problem-solving skills test.

2) The samples were taught through learner-centered mathematics curriculum.

3) The sample was taught through 15 Lesson plans and the allocation time for instruction was 11 weeks, two class periods a week (A total of 23 class periods, 40 minutes each).

In the course of curriculum implementation, the researcher will carefully observe and record the teaching process, learning process, classroom atmosphere and students' behavior in class to collect data related to curriculum use. After completing each lesson plan, the researcher summarized and reflected on the effectiveness of teaching and the issues encountered during instruction. Adjustments to teaching strategies were made promptly, and continuous improvements to the lesson plans were implemented to enhance teaching effectiveness, ensuring smooth course delivery and providing an optimal learning experience for students.

After the curriculum implementation, the sample received a posttest using the same constructed instrument—a mathematical problem-solving skills test—as used in the pretest. Subsequently, semi-structured interviews were conducted with the students to explore their perceptions of the course. The framework structure of curriculum implementation is shown in Figure 4:

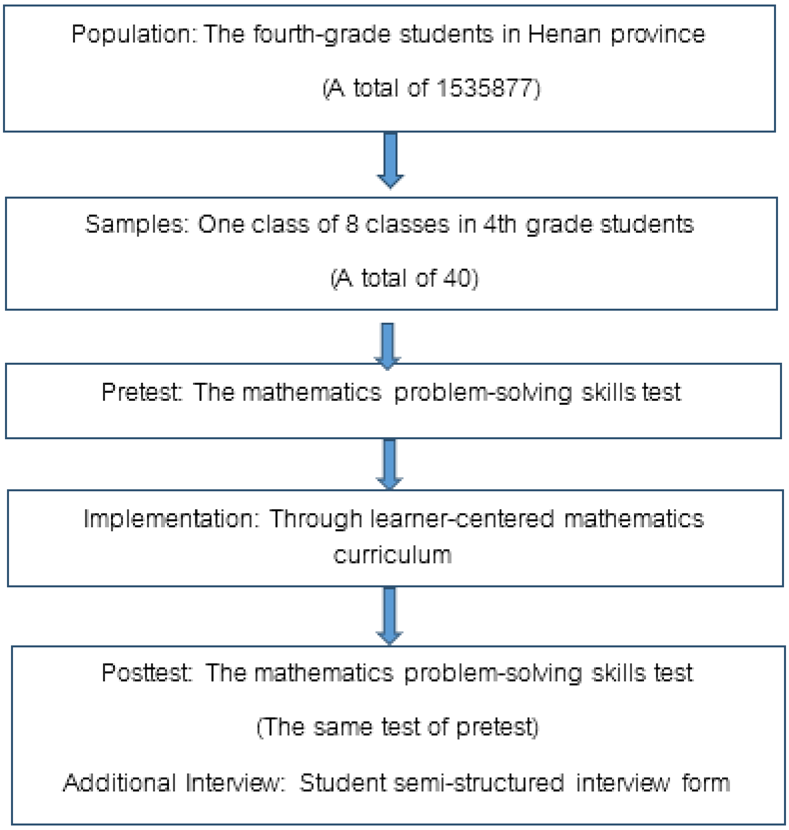


FIGURE 4 The framework structure of curriculum implementation

3.1.7 Data analysis

Firstly, students' pre- and post-test scores in mathematical problem-solving skills were quantitatively analyzed using SPSS software. Descriptive statistics and T-tests were employed to compare the differences in pre- and post-test scores. Secondly, qualitative analysis was conducted on the pre-test papers of mathematical problem-solving skills based on students' responses. This analysis aimed to understand the students' level of problem-solving skills, identify issues and deficiencies in their mathematical abilities, and provide a foundation for curriculum design. After the course, semi-structured interviews were conducted with students to gather their feedback on the course. The results of the course implementation were analyzed using the content analysis method, integrating teachers' teaching records.

3.2 Curriculum Evaluation and Revision

The research hypotheses were tested to evaluate the effectiveness of the math program based on the following criteria: The mean scores of students who completed the learner-centered mathematics curriculum on the post-test of mathematical problem-solving skills were expected to be higher than their pre-test scores, with this difference being statistically significant at the 0.05 level.

Following implementation, the curriculum was revised again based on the results of teacher observations and semi-structured interviews with students.

CHAPTER 4
RESULTS

According to the curriculum development process, this chapter presents the data analysis results of each stage of the curriculum in three phases:

Phase 1 : Results of studying the current situation of mathematical problem-solving skills of primary school students.

Phase 2: Results of developing the learner-centered mathematics curriculum.

Phase 3 : Results of studying the effectiveness of the learner-centered mathematics curriculum.

Phase 1: The Results of Studying the Current Situation of Mathematical Problem-solving Skills of Primary School Students

1.1 Results of relevant literature research

Through literature review, data on mathematical problem-solving skills of primary school students were collected. These results were then applied to the development and design of a learner-centered mathematics curriculum. Specific findings are as follows:

1.1.1 The significance and importance of cultivating pupils' problem-solving skills

The rapid advancement of communication technology in the 21st century has profoundly transformed daily work and lifestyles. This shift necessitates individuals to possess a diverse set of skills aligned with contemporary social contexts, including critical thinking, life skills, innovation, and problem-solving skills. However, amidst the rapid pace of technological development, the limitations and deficiencies of traditional basic education curricula have become increasingly apparent. In order to meet the new requirements of talent training in the new century, the state has promulgated a series of educational reforms and policy guidelines, for example, The Decision of The State Council on the Reform and Development of Basic Education, the Core Literacy of Chinese Students' Development, the Outline of the National Medium and Long Term

Education Reform and Development Plan (2010-2020), and the Mathematics Curriculum Standards for Compulsory Education (2022 edition), etc. These initiatives emphasize a new curriculum philosophy centered on learners, aiming to foster well-rounded development and the application of knowledge to solve practical problems among students. This educational approach prioritizes not only subject knowledge but also critical thinking, innovation, and problem-solving skills. By implementing these policies and programs, the goal is to cultivate students who are better equipped for the demands of modern society. They will possess robust subject knowledge alongside flexible thinking and problem-solving skills, contributing significantly to China's educational advancement, scientific and technological development, and social progress.

1.1.2 The study and analysis of mathematical problem-solving skills are summarized as follows:

1.1.2.1 Definition of mathematical problem-solving skills

Mathematical problem-solving skills refer to the ability that primary school students need to understand, analyze, and solve problems using the mathematical knowledge and methods they have learned, particularly in situations where solutions are not immediately apparent during learning activities or in real-life scenarios. It encompasses the overall mathematical competence of primary school students. In this study, mathematical problem-solving skills are categorized into four stages: understanding, analyzing, solving, and reviewing. Students' problem-solving skills were evaluated based on these four elements.

1.1.2.2 Current situation of mathematical problem-solving skills

The current status of mathematical problem-solving skills is summarized, and the results are as follows:

1) Insufficient foundational knowledge

Many primary school students lack a solid foundation in mathematics, which hinders their ability to apply knowledge flexibly when solving problems.

2) Lack of independent thinking ability

Some primary school students overly rely on parental and teacher assistance, lacking the ability to think independently and solve problems on their own.

3) Lack of innovative consciousness

In problem-solving processes, many primary school students lack innovative awareness and tend to rely on fixed models and methods rather than exploring new solutions.

4)Deficiency in practical operational skills

The cultivation of mathematical problem-solving skills requires a lot of practical operation, but at present, many primary school students lack the opportunity to practice, resulting in weak problem-solving skills.

Consulting relevant literature, analyze the issues existing in the development of primary school students' mathematical problem-solving skills, and summarize the results as follows:

1) Pedagogical approaches are excessively traditional

Currently, many teachers in primary school mathematics education continue to rely on traditional teaching methods such as explanation and demonstration. This approach often limits students' ability to think critically and solve problems independently.

2)Ignoring the individual differences among students

In the teaching process, some teachers neglect the individual differences among students and fail to tailor instruction according to their aptitudes. This oversight can hinder the effective improvement of problem-solving skills in certain students.

3) Single evaluation system

The current evaluation system in primary school mathematics primarily relies on test scores, which often leads students to excessively prioritize scores over the development of problem-solving skills.

1.1.2.3 Methods and strategies for fostering mathematical problem-solving skills of primary school students

Through in-depth research and analysis of relevant literature, we find that it is necessary for teachers and students to work together to cultivate the mathematical problem-solving skills of primary school students. Teachers need to change traditional teaching ideas and adopt more flexible and effective teaching strategies. Students need to take an active part in learning and exert their subjective initiative. The learner-centered approach emphasizes the principal role of students and encourages them to actively explore, discover problems, and seek solutions. This method not only conforms to the country's teaching philosophy but has also been proven to effectively improve students' problem-solving skills in practice. According to the learning characteristics and needs of primary school students, the following learner-centered strategies and methods are selected to cultivate the problem-solving skills of primary school students, specifically as follows:

1) Gamification

Primary school students enjoy playing games, so transforming learning content into game formats can stimulate their interest and enthusiasm for learning. For example, using educational games, card games, and other interactive formats can effectively teach knowledge.

2) Cooperative learning

Primary school students are naturally lively and enjoy interacting with others. Group cooperation and collaborative exploration can stimulate their enthusiasm for participation and learning motivation. In such a learning environment, students can communicate, share ideas, and collaborate to solve problems together, thereby developing teamwork and problem-solving skills.

3) Problem-Based Learning

Inspire curiosity in primary school students by posing real and challenging questions to encourage active exploration and problem-solving.

4) Diversified evaluation methods

Primary school students often grow bored with a single evaluation method. Therefore, using a variety of assessment methods, such as oral expression, written homework, group discussions, can stimulate their learning motivation and creativity.

5) Incentives and rewards

Primary school students require timely incentives and rewards to enhance their learning motivation and enthusiasm. Teachers can establish small reward mechanisms, such as praise or small gifts, to encourage students to work hard.

1 . 1 . 3 Research and analyze the literature results related to curriculum development

Curriculum development is a comprehensive and complex process: it involves not only the selection and organization of teaching content but also consideration of learner characteristics, teaching objectives, resources, and evaluation methods. Therefore, effective curriculum development requires comprehensive consideration of various factors to ensure that teaching activities align with learner needs.

1) Emphasis on learner-centered curriculum development

A growing body of research emphasizes placing learners at the center of curriculum development, focusing on their individual differences, learning styles, and interests. This learner-centered curriculum development helps stimulate learners' initiative, engagement, and learning effectiveness.

2) Curriculum development needs constant reflection and improvement

Research points out that curriculum development is a process of continuous iteration and improvement. Teachers should continually reflect on and evaluate the effectiveness of the curriculum, making adjustments and improvements based on feedback.

1.2 The results of preliminary research

The researcher conducted site visits, immersed in classroom teaching, observed, and recorded the real situation of math problem-solving instruction. They identified current situations and existing issues in fostering students' problem-solving skills. Through semi-structured interviews, the researcher gained an in-depth understanding of teachers' perspectives on and awareness of primary school students' problem-solving skills, as well as the genuine thoughts and needs of students. The observation and interview results were analyzed using content analysis, summarized into two parts: 1.2.1 Site Visit Results and 1.2.2 Semi-structured Interview Results.

1.2.1 The site visits results

By using the content analysis method, this study summarized the behaviors of teachers and students observed in elementary school math problem-solving classrooms. It investigated the actual situation and identifies existing problems in cultivating elementary school students' mathematical problem-solving skills in experimental schools:

1.2.1.1 Teacher teaching behavior

1) Teaching materials

In terms of teaching materials, most teachers primarily rely on textbook examples as the sole basis for lesson content. This limits the diversity of situations presented during lessons. Only a few teachers can adapt teaching materials based on students' specific needs. Fewer still can integrate real-life situations with the teaching content to create their own instructional scenarios.

2) Teaching methods

Most teachers employ the expository method to categorize problem-solving questions into various types and teach them to students, followed by extensive practice for reinforcement. They emphasize standardized problem-solving steps and formats while providing less guidance on problem-solving methods and strategies. Some younger teachers adopt new teaching methods such as cooperative learning, situational teaching, gamified teaching, and questioning. Classroom observations reveal that these methods effectively stimulate student interest and participation in learning. However, challenges include lack of initiative from every group member, inability of some teacher-created scenarios to engage students fully, overly simplistic classroom discussions with excessive questioning, and students' strong interest in games but with poor discipline.

3) Classroom management

In classroom management, teachers exert significant control and enforce strict discipline among students using their authority. There is limited teacher-student interaction and student-student interaction; typically, teachers dominate the conversation while students participate less, and few students take the initiative to ask questions. Teachers place less emphasis on fostering students' learning interests and habits and provide limited guidance on learning methods and strategies during teaching.

4) Evaluation and Feedback

Many teachers often resort to simplistic words of encouragement when evaluating students, such as "very good", "you are great", "good answer", or "praise for you", without specifying what aspects the students have excelled in. Some teachers may prompt students to think about answers that extend beyond the scope of the lesson, but generally provide minimal evaluation or may even overlook student responses altogether.

1.2.1.2 Students' learning behavior:

1) Students' listening state in class

In the first few minutes of class, most students listen attentively to the teacher. However, as time progresses, more students become distracted. Some students glance around the room, while others engage in activities unrelated to their studies.

2) Class participation

Some students engage in classroom interaction, but there is a relatively small and consistent number of students who actively volunteer to answer questions. Communication between teachers and students, as well as among students themselves, is limited. While some students show high activity in cooperative learning, others appear disengaged with low interest and minimal participation.

3) Independent thinking

Students spend less time engaged in independent thinking; instead, they predominantly listen to the teacher and solve problems guided by them, leaving little room for self-exploration. Many students struggle to utilize various resources for independent learning.

4) Problem-solving

Most students can apply their knowledge to solve example problems presented by the teacher. However, when the problem situation changes slightly or resembles real-life scenarios, many students struggle to solve the problems effectively. They tend to adopt a single approach and cease thinking once they reach a solution. Few students demonstrate the ability to offer multiple problem-solving strategies.

1.2.2 The Semi-structured interview results

Content analysis was used to analyze the results of semi-structured interviews with teachers and students, aiming to understand experienced teachers' understanding of primary school mathematical problem-solving skills and training strategies, as well as students' actual needs for mathematics courses, which were summarized as follows:

1.2.2.1 Results of semi-structured interviews with teachers

1) Elements of Mathematical Problem-solving Skills

The teachers did not have a clear understanding of various aspects of mathematical problem-solving skills. However, they all mentioned that to solve a problem successfully, the first step is to understand its meaning, followed by using acquired knowledge to analyze the problem and attempt to solve it. Only one teacher mentioned the importance of reviewing the problem-solving process and assessing its validity. Despite varying levels of theoretical understanding, teachers generally agreed on the importance and complexity of mathematical problem-solving skills. Some viewed it as an extension of traditional word problems, while others emphasized its deeper role in fostering students' critical thinking and enhancing their practical application skills. It is noteworthy that all participating teachers highlighted the central role of mathematical problem-solving skills in students' mathematical learning, considering it a crucial gauge of students' mathematical literacy and practical ability. Through problem-solving activities, students not only reinforce and apply their mathematical knowledge but also cultivate logical, innovative, and critical thinking, thereby enhancing their overall mathematical literacy and comprehensive abilities.

"Problem-solving is essentially the word problem we typically work on, just labeled differently. To solve a problem successfully, students need to clearly understand which problem they are solving and the information provided. They need to know how to utilize this information to achieve the desired answers. Problem-solving skills is crucial for students as it reflects their overall quality". (Teacher 2)

"The problem-solving tasks introduced in the new curriculum standards have raised the bar for students. These problems are more closely aligned with real-life scenarios and demand a range of skills to answer accurately, such as life experience, comprehension, and calculation". (Teacher 4)

"I believe mathematics itself is the science of problem-solving, and problem-solving skills is a key metric for assessing students' mathematical literacy and their ability to apply mathematical concepts. The process of problem-solving is intricate." (Teacher 5)

"My approach to problem-solving involves numerous skills, including comprehension, reading, analysis, execution, and more. Through problem-solving tasks, students not only reinforce and apply their mathematical knowledge but also develop their logical, innovative, and critical thinking abilities, enhancing their overall mathematical literacy and comprehensive skills." (Teacher 6)

2) Curriculum Content

Teachers believe that the problem-solving lessons in textbooks as crucial resources for nurturing students' problem-solving skills, but they emphasize the need for thoughtful and strategic implementation. Textbooks are standardized and may not universally suit all contexts; some content can be abstract and fail to engage students. During teaching, teachers should prioritize cultivating students' thought processes and problem-solving skills over mere knowledge dissemination. It's essential for teachers to adopt flexible teaching designs tailored to students' actual needs and circumstances to enhance their problem-solving skills and mathematical literacy. However, teachers often face time constraints and multiple responsibilities beyond teaching, which may limit opportunities for creative lesson adaptations.

"When dealing with these lessons, I usually have students read and understand the problem independently first. Then, I encourage them to generate their own questions and reflections. I stimulate students' thinking through questions, guidance, discussions, and other methods to help them develop ideas and problem-solving approaches. However, sometimes time constraints in class may limit how much we can cover." (Teacher 3)

"I have encountered challenges in teaching math problem-solving. For instance, some students lack experience and confidence in solving complex problems, which can lead to confusion and frustration. Therefore, it's important to appropriately scaffold problem-solving tasks and guide students step by step. Additionally, emotional support and encouragement are crucial to building students' self-confidence and fostering a positive learning attitude. It's essential to enhance students' interest in learning." (Teacher 2)

3) Teaching Methods

Teachers generally believe that to effectively enhance students' problem-solving skills in mathematics, it is essential to employ a variety of teaching methods. These include heuristic teaching, cooperative learning, Problem-Based Learning, reverse thinking training, and reflective summary, with flexible adjustments based on the students' actual situations. By incorporating group cooperative learning, designing open-ended questions, and using engaging teaching methods such as competitions and games, teachers can successfully stimulate students' interest in learning and their desire for inquiry. This approach fosters logical, innovative, and critical thinking skills. These valuable teaching experiences not only have a significant impact on mathematics education but also offer useful insights for teaching other subjects.

"I often use heuristic pedagogy, asking questions and guiding students to discover solutions on their own rather than providing the answers directly. For example, when solving a geometry problem, I first ask students about the properties of shapes and then guide them step by step to use those properties to find the answer." (Teacher 4)

"I encourage students to work in groups to solve problems together. This way, they can learn from each other and exchange different ideas." (Teacher 2)

"I use real-life cases to teach math problems, helping students better understand the application of math in everyday life. For example, when teaching probability, I use examples such as weather forecasts, gambling games, or the stock market to illustrate the concept." (Teacher 5)

4) Learning Evaluation

The interviewed teachers agree that the current evaluation method is limited, primarily relying on final exams, unit tests, and other exam scores. Most teachers believe that the most effective way to evaluate the problem-solving skills of primary school students is to comprehensively apply multiple evaluation methods. This approach allows for a more thorough assessment of students' abilities, reducing the bias and errors associated with a single evaluation method. Additionally, comprehensive evaluation can encompass both the process and outcomes of problem-solving, emphasizing students' innovative thinking and individual differences. This provides more accurate and targeted feedback, which is conducive to the overall development of students.

"Examinations are still the main evaluation method adopted by many schools. The traditional evaluation method is relatively effective in assessing students' knowledge mastery, but it has limitations in assessing students' problem-solving skills. These tests tend to focus on memorization and repetition of knowledge points, and less on the analysis and solving of practical problems." (Teacher 6)

"A single assessment approach may indeed lead to an incomplete evaluation of a student's abilities. For example, a student may perform poorly in a traditional written exam but excel in teamwork or practical work. If you only rely on the

written test score, you may overlook the student's talents in other areas." (Teacher 1)

5) Curriculum Suggestions

To better develop students' problem-solving skills, the mathematics curriculum needs a series of improvements and innovations. These include increasing practical application content, encouraging active exploration by students, adjusting course progress, and offering supplementary courses. Additionally, the ideal mathematics curriculum should be interactive, personalized, and creative, implemented through project-based learning, the use of modern technology, and the provision of professional training for teachers.

"The existing mathematics curriculum can be more integrated with practical problems, allowing students to see the relevance of mathematics in everyday life. This helps them better understand the application of mathematics and develop their problem-solving skills." (Teacher 2)

"Sometimes, our lessons move so fast that students may not have enough time to digest and understand the material. I think we can adjust the course schedule appropriately or offer school-based courses that address practical problems, giving students more time to think and practice." (Teacher 1)

"I would like to see a more interactive math curriculum where students are no longer passively receiving knowledge but are actively participating in class, communicating and discussing with teachers and classmates." (Teacher 4)

1.2.2.2 Results of semi-structured interviews with students

1) Understanding of mathematical problem-solving skills

Students believe that math problem-solving skills play an important role in their lives. These skills not only enable them to solve mathematical problems but also to apply mathematical knowledge to real-life situations. By using mathematical knowledge, they can better address everyday challenges, improving the convenience and efficiency of their lives. However, students sometimes find it difficult to remember how to apply mathematical knowledge to real-life problems. They express a desire to learn more about how to apply what they have learned to solve practical issues.

"I think mathematical problem-solving skills is the ability to solve real problems in life." (Student 4)

"When shopping, I want to use mathematical knowledge to compare the prices of different brands and specifications of goods to choose the most cost-effective options. But sometimes my thinking gets confused, and I can't calculate accurately." (Student 8)

2) Learning Activities

Students do not enjoy single-mode learning activities and expect teachers to provide a variety of engaging learning experiences. They particularly value activities that allow them to get hands-on, work with peers, and solve problems. If the problems presented by teachers are closely connected to students' life experiences or are inherently interesting, it is easier to capture their attention and stimulate their interest in learning.

"Sometimes I like and sometimes I can't engage with the problem situations put forward by teachers. I hope teachers can provide more interesting learning activities that are applicable to daily life." (Student 3)

"When the teacher raises a question in a context relevant to my life experience, I am particularly interested and willing to actively participate. For example, if teachers can use math to explain some phenomena in daily life or devise interesting math problems for us to solve, I find it very attractive." (Student 1)

3) Learning Style

Students are more likely to learn math in a fun and interactive way, such as through games and activities. This approach can stimulate their interest and enthusiasm for learning. When learning mathematics, students need both guidance and explanations from teachers and the opportunity to try solving problems independently. This indicates that they need not only basic knowledge but also independent thinking and problem-solving skills. Students also recognize the benefits of working with their peers to learn mathematics, as it allows them to help each other and share knowledge. Cooperative learning can enhance their communication and social skills, as well as improve their math learning outcomes.

"I like to learn math through games and fun activities because it's more enjoyable, and I remember it faster." (Student 6)

"Sometimes I like to listen to the teacher because I can learn something new. But sometimes I want to try to solve problems on my own because I find it more challenging that way." (Student 4)

"Studying math with classmates helps each other. When I don't understand something, they can teach me; when they don't know, I can teach them." (Student 7)

4) Learning Evaluation

Students have a clear self-awareness of their performance in mathematics learning and can evaluate their learning outcomes based on homework completion and test scores. However, they also recognize that they may need the teacher's help in certain areas. In addition to traditional test results, elementary school students believe that regular classroom performance and homework completion are also important for evaluating their math learning achievements. This reflects their desire for a more comprehensive and objective evaluation. Students hope that teachers or parents will acknowledge their efforts and provide specific suggestions and guidance to help them improve their learning methods and outcomes.

"I think I did well in my math studies because I was able to complete the homework and exercises assigned by the teacher and did well in the exams. But sometimes I have problems and need the teacher's help." (Student 8)

"I believe that, in addition to test scores, teachers can also evaluate us based on our regular classroom performance and homework completion. Some people might be nervous or make mistakes during the exam, but they might still work very hard." (Student 3)

"I would like a teacher or parent to recognize my efforts and give me concrete advice on how to improve in math. I don't just want to hear 'you're doing a good job' or 'you need to work on it', but specific guidance on what to do better." (Student 9)

5) Curriculum requirements

Students expect mathematics courses to be more closely connected to real life and to include content related to practical applications. They enjoy learning math through fun activities such as games and challenges, and they appreciate learning in small groups because it promotes communication and cooperation. Additionally, students believe that math courses should address individual differences and provide personalized instruction.

"I wish there were more real-life math problems, like learning how to calculate discounts when shopping or planning pocket money. I would also like to have some math games or challenges where we can learn by playing." (Student 5)

"I also hope there will be more opportunities for group work so that we can discuss problems together and help each other." (Student 2)

Phase 2: The Results of Developing the Learner-centered Mathematics

2.1 The results of the learner-centered mathematics curriculum design

The learner-centered mathematics curriculum consists of six components: curriculum principles, curriculum objectives, curriculum content, teaching methods, instructional materials, and learning evaluation.

2.1.1 Curriculum principles

In curriculum design, this curriculum follows a series of principles to ensure the quality, effectiveness, and practicality of the course. These principles involve learner-centeredness, practicality, gradual and orderly progress, interactivity, fun, and diversified evaluation. The specific details are as follows:

1) Learner-Centered principles

Curriculum design should take the needs, interests and abilities of students as the starting point to ensure that the curriculum content is in line with the actual life experience and cognitive level of students. By understanding students' backgrounds, learning habits and mathematical foundations, we can customize a personalized learning path so that each student can find their own orientation and development space in the course.

2) The principle of practicality

Emphasize the practical application of mathematical problem solving skills, design mathematical problems with practical significance, so that students can master mathematical knowledge and methods in the process of solving problems. By utilizing Problem-Based Learning and case analysis, students are encouraged to apply their acquired knowledge to practical situations, thereby enhancing their practical skills and fostering innovative thinking.

3) Principle of gradual and orderly progress

According to the law of cognitive development of students, reasonable arrangement of course content and difficulty. Start with basic concepts and gradually introduce complex mathematical problems and solutions to ensure that students have the joy of success at every stage. At the same time, it pays attention to the coherence and systematicness of knowledge to help students build a complete mathematical knowledge system.

4) Principle of interactivity

Encourage cooperation and communication among students, design interactive links such as group cooperation and discussion, so that students can learn to listen, express and think in the interaction. Through the interaction between teachers and students, students and other forms, to create a positive learning atmosphere, stimulate students' learning interest and initiative. At the same time, teachers should actively participate in the interactive process of students and give timely guidance and help.

5) Principle of fun

Incorporate fun elements into the course design, such as games, competitions, etc. , so that students can learn math problem solving skills in a relaxed and pleasant atmosphere. Through the creation of vivid and interesting situations and problems, stimulate students' curiosity and desire to explore, so that they can enjoy the fun of learning while improving their mathematical literacy and ability level.

6) The principle of diversified evaluation

A variety of evaluation methods are used to evaluate students' mathematical problem-solving skills comprehensively and objectively. In addition to the traditional written test and homework, oral reports, group cooperation, practical operation and other evaluation methods can be introduced in order to gain a more comprehensive understanding of students' learning and ability development. At the same time, pay attention to the feedback and guidance of evaluation to help students find their shortcomings in time and make improvement plans.

2.1.2 Curriculum objectives

The overall objective of this curriculum is to enhance students' problem-solving skills through cooperative inquiry during the development and implementation of the course. The specific objectives are as follows:

1) To enable students to understand the relationship between mathematical knowledge and real life, and to understand, discover, and raise questions while exploring the connections present in real situations.

2) To experience independent thinking and collaboration with others while exploring ways to analyze and solve problems.

3) To be able to use mathematical knowledge and methods to analyze and solve problems.

4) To be able to preliminarily judge the rationality of results and develop an initial sense of modeling, geometric intuition, and application awareness.

2.1.3 Curriculum content

The curriculum encompasses four learning modules, namely: 1) Four arithmetic operations, 2) Rectangle and square, 3) Averages, bar charts, and probability, and 4) Nutrition lunch. Each module is divided into two parts: basic knowledge and practical application. The specific curriculum content is shown in Table 21:

TABLE 21 Learning unit for the mathematics in the fourth grade

Learning modules and units	Learning content	
Module 1: Numbers and Algebra 1. Four arithmetic operations	Basic Knowledge	1.1 The Meaning of Addition and Subtraction and the Relationship Between the Parts 1.2 The Meaning of Multiplication and Division and the Relationship Between Each Part 1.3 24-Point Calculation Technique 1.4 The Relationship Among Unit Price, Quantity, and Total Price
	Practical Problems of Life	1.5 Promotion Activity 1.6 Chartering Problem
Module 2: Geometry and Graphics 2. Rectangle and square	Basic Knowledge	2.1 The Circumference of a Rectangle and a Square 2.2 Cognitive Understanding of Geometric Concepts 2.3 Area of a Rectangle and a Square
	Practical Problems of Life	2.4 Practical application
Module 3: Statistics and Probability 3. Averages, bar charts and possibility	Basic Knowledge	3.1 Average 3.2 Compound Bar Chart 3.3 Possibility
	Practical Problems of Life	3.4 Household Budget
Module 4: Synthesis and practice 4. Nutrition lunch	Synthetic Application	4. Nutrition Lunch

2.1.4 Teaching methods

This study is learner-centered and focuses on analyzing teaching content and carefully selecting appropriate teaching methods based on the actual needs and ability levels of students, as well as teaching principles and objectives. The study primarily adopts learner-centered teaching methods, such as cooperative learning, Problem-Based Learning, and gamification design, which offer diversified activities and content. Firstly, in the basic knowledge learning module, gamification and cooperative learning methods are chosen. Gamification is used to stimulate students' interest in learning, while cooperative learning is employed to develop students' problem-solving skills. The design flow of the teaching process based on basic knowledge learning is shown in the following Table 22:

TABLE 22 The design flow of the teaching process based on basic knowledge learning

Teaching process flow	Method specific application
Introduction and review:	At the beginning of the lesson or the start of the course, teachers can design short games to help students review the knowledge points they have learned before. Such games can be a form of questions and answers, guessing riddles, or role -playing, which aims to stimulate students' memories of previous learning content. Gamification can increase the fun of review here, allowing students to consolidate old knowledge in a relaxed atmosphere. At the same time, we can also design knowledge games related to the study of this lesson to introduce new lessons and stimulate students' interest in learning.
Situation creation and question raising	To make cooperative learning more effective, teachers can create a problem situation related to students' real life to stimulate students' interest in learning and desire to explore. Teachers raise questions and guide students to conduct cooperative learning.

TABLE 22 (CONTINUE)

Teaching process flow	Method specific application
Cooperative inquiry and problem solving	Use cooperative learning method to improve students' problem-solving skills from four aspects: understanding, analyzing, solving and reflecting on problems: Students are divided into groups, and members within each group work together to analyze and understand problems from multiple perspectives. According to the principle of "heterogeneity within the group and homogeneity between groups", combined with the pre-test results of problem-solving skills, students were divided into ten groups, each with 4 people (40 in total). In cooperative learning, each student in the group must have clear tasks, a certain division of labor, and a specific role. The roles can be the following four: 1) Group leader: coordinate various tasks within the group, guide group activities, and ensure that cooperative tasks are completed on time; 2) Recorder: record the results of group discussions; 3) Supervisor: supervise student learning and maintain group discipline; 4) Reporter: report learning results. Members of each group work together to analyze and understand problems from multiple perspectives. By brainstorming, students can analyze problems more comprehensively and find multiple possible solutions. Group members work together to solve problems. After the problem is solved, students reflect on the process, summarize the gains and losses, and further improve their problem-solving skills
Knowledge consolidation	In the final stage of the course or after class, teachers can use gamification teaching again to help students consolidate the knowledge learned in this lesson. These games can be in the form of knowledge questions and answers, role play, simulation exercises, etc. , aimed at allowing students to deepen their understanding and memory of knowledge points in a relaxed and pleasant atmosphere.

TABLE 22 (CONTINUE)

Teaching process flow	Method specific application
Evaluation and Reflection	Teachers guide students in conducting evaluations and reflections. Students are encouraged to assess their own performance in the current learning session, identify the knowledge and skills they have acquired during the class, and pinpoint areas where they lack proficiency and require improvement. Additionally, peer evaluation within groups is promoted, as it fosters mutual understanding, enables students to learn from each other's strengths, and collectively explores avenues for growth. This peer evaluation should be based on principles of respect and constructiveness, focusing on specific behaviors and suggestions to promote positive interaction and collaboration. Concurrently, teachers can adjust and optimize their teaching methods and content according to student performance and feedback, aiming to better meet the learning needs of students. By encouraging peer evaluation, students gain insights from their peers' perspectives, enhancing the overall learning experience.
Use game elements such as points, medals and other incentive students during the period	Throughout the teaching process, teachers can use game elements such as points and medals to motivate students to actively participate in learning and discussions. Students can obtain points and medals through answering questions, participating in group discussions, and putting forward innovative perspectives. These rewards can be used as recognition and encouragement of their learning results. This incentive mechanism can improve students' learning enthusiasm and participation, and create a positive learning atmosphere.

Secondly, in the practical application learning module, cooperative learning, Problem-Based Learning and gamification methods are selected. Problem-Based Learning is utilized to create real-world, complex, and open problem situations, and cooperative learning is employed to foster students' problem-solving skills, Use gamification to consolidate exercises. The design flow of teaching process based on practical application is shown in the following Table 23:

TABLE 23 The design flow of teaching process based on practical application

Teaching process flow	Method specific application
Preparation before class	Before class, teachers should analyze students' mathematical foundations, learning interests, and habits, and design a series of challenging and enlightening questions in conjunction with teaching objectives to guide students in thinking and exploration. Provide students with some pre-learning guidance to help them understand the content and focus of the class ahead of time, assisting them in better comprehending and mastering the knowledge.
Situation creation, problem introduction	Problem-Based Learning: Teachers can create a vivid and engaging problem scenario through stories, examples, multimedia tools, or other means, enabling students to discover and pose problems within the scenario and generate a desire to solve them. Selection of Problems: Teachers should choose problems that are related to students' life experiences and possess a challenging nature. These problems should stimulate students' exploration desires and possess a certain level of authenticity and value for contemplation. For instance, when learning to apply the four basic arithmetic operations to solve practical problems in life, teachers can propose questions such as "How to choose the most cost-effective method based on mall promotional activities?" When learning to solve practical problems related to area in life, questions like "How to purchase floor tiles based on the area of a house?" can be raised. Design of Problems: Problems should be designed with a hierarchical structure, ranging from easy to difficult, gradually guiding students into deeper thinking. Simultaneously, there should be logical connections between problems, aiding students in constructing a complete knowledge system. When designing problems, teachers also need to consider students' cognitive levels and thinking characteristics, ensuring that the problems are neither too simple nor overly complex.

TABLE 23 (CONTINUE)

Teaching process flow	Method specific application
Cooperative learning, problem solving	Cooperative learning: Use cooperative learning method to improve students' problem-solving skills from four aspects: understanding, analyzing, solving and reflecting on problems: Students are divided into groups, and members within each group work together to analyze and understand problems from multiple perspectives. According to the principle of "heterogeneity within the group and homogeneity between groups", combined with the pre-test results of problem-solving skills, students were divided into ten groups, each with 4 people (40 in total). In cooperative learning, each student in the group must have clear tasks, a certain division of labor, and a specific role. The roles can be the following four: 1) Group leader: coordinate various tasks within the group, guide group activities, and ensure that cooperative tasks are completed on time; 2) Recorder: record the results of group discussions; 3) Supervisor: supervise student learning and maintain group discipline; 4) Reporter: report learning results. Members of each group work together to analyze and understand problems from multiple perspectives. By brainstorming, students can analyze problems more comprehensively and find multiple possible solutions. Group members work together to solve problems. After the problem is solved, students reflect on the process, summarize the gains and losses, and further improve their problem-solving skills.
Present results and evaluation	Group presentation: Class optimization Master App randomly select some groups to report. Each group selects a representative to present their solution and exploration process to the whole class. This facilitates mutual learning and inspiration among students. Evaluation and Feedback: Teachers and students jointly evaluate the solutions presented by each group and provide constructive feedback. Evaluation criteria can include aspects such as the innovation, practicality, and logic of the solutions.
Summary and reflection	Teacher Summary: The teacher summarizes the entire problem-solving process, emphasizing the strengths demonstrated by the students during the exploration process as well as areas that require improvement .Student Reflection: Students are encouraged to engage in personal and group reflection, contemplating their own performance during the problem-solving process and how they can improve and enhance their skills in the future.

TABLE 23 (CONTINUE)

Teaching process flow	Method specific application
Knowledge consolidation	In the final stage of the course or after class, teachers can use gamification teaching again to help students consolidate the knowledge learned in this lesson. These games can be in the form of knowledge questions and answers, role play, simulation exercises, etc. , aimed at allowing students to deepen their understanding and memory of knowledge points in a relaxed and pleasant atmosphere.

The use of learning content corresponding to teaching methods is shown in the Table 24:

TABLE 24 The use of learning content corresponding to teaching methods

Learning content		Teaching method		
		Cooperative learning	Problem-Based Learning	Gamification
Basic knowledge	1.1 The meaning of addition and subtraction and the relationship between the parts	√		√
	1.2 The meaning of multiplication and division and the relationship between each part	√		√
	1. 3 24-point calculation technique	√		√
	1.4 Relationship among unit price, quantity and total price	√		√

TABLE 24 (CONTINUE)

Learning content		Teaching method		
		Cooperative learning	Problem-Based Learning	Gamification
Practical problems of life	1.5 Promotion activity	√	√	√
	1.6 Chartering problem	√	√	√
Basic knowledge	2.1 The circumference of a rectangle and a square	√		√
	2.2 Cognitive area	√		√
	2.3 Area of rectangle and square	√		√
Practical problems of life	2.4 Practical application	√	√	√
Basic knowledge	3.1 Average	√		√
	3.2 Compound bar chart	√		√
	3.3 Possibility	√		√
Practical problems of life	3.4 Household budget	√	√	√
Synthetic application	4. Nutrition lunch	√	√	√
	Total	15	5	15

2.1.5 Instructional materials

The instructional materials used in the teaching process include 15 lesson plans, learning task lists, instructional PPTs, teaching aids, and other teaching resources.

2.1.6 Learning evaluation

There were two categories of evaluation: formative evaluation and summative evaluation. Formative evaluation was used throughout the classroom teaching process through various methods such as questioning, observation, timely feedback, classroom performance, student group discussions, student presentations, and self-evaluations. Summative evaluation was used at the end of the course in the form of a test, where each student was required to demonstrate their mathematical problem-solving skills.

2.2 The results of mathematics curriculum evaluation by experts

The results from the data analysis are presented as follows:

2.2.1 The appropriateness evaluation of the mathematics curriculum

Initially, a group of five experts (refer to Appendix A) assessed the appropriateness of the mathematics curriculum. Subsequently, data were gathered using SPSS software (refer to Appendix B), and descriptive statistics were compiled, including the calculation of the average score and standard deviation for each item. The level of appropriateness was determined by referring to the appropriateness evaluation score able. The results are presented in Table 25 below:

TABLE 25 The expert assesses the results for appropriateness

Category	Items	Mean	Std. Deviation	Level of appropriateness
Curriculum principles	1.1 Reasonable	4.8	.45	Very high
	1.2 Theoretical concepts used to support	4.6	.55	Very high
	1.3 Lead to practice	4.6	.55	Very high
Curriculum objectives	2.1 Clear and concrete	4.6	.55	Very high
	2.2Can be measured and evaluated	4.4	.55	High
	2.3 Suitable for the target group	4.4	.55	High
Curriculum content	3.1 Meet the curriculum objectives	4.4	.55	High
	3.2 Academically correct	4. 2	.45	High
	3.3 Suitable for the target group	4. 2	. 45	High
Learning activities	4.1 Meet the curriculum objectives	4. 4	.55	High
	4.2 Suitable for the target group	4. 4	.55	High
	4.3 Interesting and possible	4. 4	.55	High

TABLE 25 (CONTINUE)

Category	Items	Mean	Std. Deviation	Level of appropriateness
Teaching method	5.1 Meet the learning activities	4. 6	.55	Very high
	5.2 Suitable for the target group	4.4	.55	High
	5.3 Interesting and possible	4.2	.45	High
Curriculum evaluation	6.1 Meet the curriculum objectives	4.4	.55	High
	6.2 Suitable for the target group	4.4	.55	High
	6.3 Possible to practice	4.2	.45	High

The results indicated that the average scores for each item ranged from 4.2 to 4.8, with a standard deviation of 0.45 to 0.55. The evaluated level is classified as very high or high. The mean score for the appropriateness evaluated by the group of experts was higher than 3.51, indicating that the components of the mathematics curriculum had a good quality of appropriateness.

Specifically, the curriculum principles are reasonable and can guide practice, and the theoretical concepts selected effectively support the curriculum. The curriculum objectives are clear and concrete, measurable and evaluable, and suitable for the target group. The curriculum content and learning activities meet the curriculum objectives. The learning activities and teaching materials are engaging and achievable for the learning objectives. The curriculum evaluation aligns with the curriculum objectives, is suitable for the target group, and is practical for implementation.

2.2.2 The consistency evaluation of the mathematics curriculum

Five experts evaluated the developed mathematics curriculum, assessing the consistency of its various components. After collecting the data (see Appendix B), the researcher analyzed the curriculum evaluation form to assess the consistency of the curriculum components. The results of the Index of Item Objective Consistency (IOC) are shown in Table 26:

TABLE 26 The results of the mathematics curriculum consistency evaluation

No.	Items	IOC	Interpretation
1	Curriculum principles and curriculum objectives	0. 8	Consistent
2	Curriculum principles and learning activities	1. 0	Consistent
3	Curriculum objectives and curriculum content	0. 8	Consistent
4	Curriculum objectives and learning activities	0. 8	Consistent
5	Curriculum content and learning activities	0. 8	Consistent
6	Curriculum content and learning materials	1. 0	Consistent
7	Curriculum content and learning resources	1. 0	Consistent
8	Curriculum content and learning duration	0. 6	Consistent
9	Curriculum evaluation and curriculum objectives	0. 8	Consistent

The evaluation results for the coherence of the mathematics curriculum indicate that the Index of Item Objective Consistency (IOC) for project objectives among different components ranges from 0.6 to 1.0, surpassing the standard of 0.5. This signifies that the coherence among various components of the mathematics curriculum meets the required standard.

2.2.3 Curriculum evaluation experts' suggestions for curriculum revision

Five experts put forward their views and suggestions on the curriculum. The results are summarized as follows:

1) Curriculum objectives should adhere to principles of curriculum design and establish clear and specific learning goals for students so that they understand what they will learn.

2) Adjust curriculum objectives based on the diverse needs of learners to ensure that each individual can achieve their own goals.

3) Decompose curriculum objectives into smaller sub-objectives to allow learners to pursue and achieve progress step by step.

4) The curriculum content should include more practical application problems to enable students to apply mathematical knowledge to real life and enhance their mathematical thinking and problem-solving skills.

5) Incorporate practical tasks or projects into learning activities to strengthen learners' hands-on abilities and problem-solving skills.

2.3 Results of the Pilot Study

Through the pilot study, we obtained an initial assessment of the quality and feasibility of the draft curriculum, evaluated the accuracy of lesson plans and learning materials, and identified potential problems and challenges in the curriculum's implementation. These findings provide valuable guidance and feedback for further improving and optimizing the curriculum. The details are as follows:

1) Adjust the appropriateness of activity time to ensure that the teaching progress aligns with students' absorptive capacity.

2) Improve the instructional steps in the teaching plan to make them clearer and easier for students to understand and follow.

3) Optimize the teaching content and methods to better meet the actual needs and interests of students;

4) Strengthen the interaction and communication between teachers and students to create a positive learning environment.

Phase 3: The Results of Studying the Effectiveness of the Learner-centered Mathematics Curriculum

3.1 Curriculum implementation results

The curriculum was implemented at the First Primary School in Zhoukou City, Henan Province, with 40 fourth-grade students as the target audience. This group consisted of 22 boys and 18 girls, all from the same classroom. The specific implementation results are as follows.

3.1.1 Comparison of students' problem-solving skills pretest-posttest scores

Prior to and following the implementation of the curriculum, the students underwent assessments to evaluate their math problem-solving skills. The assessment consisted of seven situational questions closely linked to real-life scenarios and aligned with the students' existing knowledge base. Each question was answered in four steps, with a full score of 4 for each step, making the total possible score 28 points (4×7).

SPSS Statistics software was used to conduct descriptive statistics on the pre-test and post-test scores of the students' mathematical problem-solving skills. The mean scores and standard deviations (S.D.) are shown in Table 27:

TABLE 27 Descriptive statistics results of pretest-posttest score for mathematics problem-solving skills

List of evaluation	Full score	Sample (N=40)			
		pre-test		Post-test	
		Mean	S.D	Mean	S.D
Understanding	28	19.20	3.291	21.40	3.373
Analyzing	28	18.00	3.195	19.98	3.697
Solving	28	17.23	3.363	19.23	3.899
Reviewing	28	15.40	3.011	17.68	3.583
Overall performance	112	69.83	12.378	78.28	13.778

From Table 27, it is evident that students' mathematical problem-solving skills had a pretest mean score of 69.83 (S.D. = 12.378) and a posttest mean score of 78.28 (S.D. = 13.778). Furthermore, the mean scores for the four elements of understanding, analyzing, solving and reviewing increased from 19.20 (S.D. = 3.291), 18.00 (S.D. = 3.195), 17.23 (S.D. = 3.363) and 15.40 (S.D. = 3.011) to 21.40 (S.D. = 3.373), 19.98 (S.D. = 3.697), 19.23 (S.D. = 3.899) and 17.68 (S.D. = 3.583) respectively. These results indicate that the mean scores for each element of students' problem-solving skills and the overall mean score increased after the curriculum implementation compared to before.

To further investigate the changes in students' problem-solving skills before and after participating in the learner-centered mathematics courses, a paired-samples t-test was conducted using SPSS Statistics software, and the effect size (Cohen’s d) was calculated using JASP software.

TABLE 28 Results of mathematical problem-solving skills pretest-posttest t-test and cohen's d

Paired posttest-pretest	Mean Difference	S. D. Difference	t	df	P-Value	Cohen's d
Understanding	2.200	2.301	6.048	39	<0.001	0.956
Analyzing	1.975	2.201	5.674	39	<0.001	0.897
Solving	2.000	2.699	4.687	39	<0.001	0.741
Reviewing	2.275	2.572	5.594	39	<0.001	0.885
Overall performance	8.450	8.482	6.301	39	<0.001	0.996

Note. Student's t-test; $p < 0.05$.

The larger the Cohen's d value is, the larger the difference is.

When 0 < Cohen's d <= 0.2, the effect is small (the difference is small).

When 0.2 < Cohen's d <= 0.8, the effect is medium (the difference is medium).

When Cohen's d > 0.8, the effect is large (the difference is large).

The results indicated that the mean difference between posttest and pretest scores was 8.450, with a standard deviation difference of 8.482. The T-value was 6.301, and the p-value was less than 0.001. This finding suggests that students' mathematics problem-solving skills significantly improved after the implementation of a learner-centered mathematics curriculum. Specifically, the mean differences in posttest-pretest scores for the four elements of understanding, analyzing, solving and reviewing were 2.00, 1.975, 2.000, 2.275, with T-values of 6.048, 5.674, 4.687, and 5.594, respectively, and p-values less than 0.05. These results demonstrate that the curriculum was significantly effective in enhancing various elements of students' mathematical problem-solving skills. Comparing Cohen's d for each stage of problem-solving revealed that the effect sizes, from smallest to largest, were: solving, reviewing analyzing and understanding. This suggests that the learner-centered curriculum is especially effective in developing students' understanding. This effectiveness may be attributed to the curriculum's focus on stimulating thinking through problem discussions and cooperative learning, which enhances students' communication skills and self-awareness, thereby promoting their understanding abilities.

TABLE 29 Results of mathematical problem solving skills pretest-posttest t-test correlation

Paired posttest-pretest	N	Correlation	P-Value
Understanding	40	.762	<0.001
Analyzing	40	.806	<0.001
Solving	40	.733	<0.001
Reviewing	40	.709	<0.001
Overall performance	40	.795	<0.001

Based on the analysis of the data in the above table, we found that the correlation coefficient between the post- and pre- test scores of problem-solving skills is as high as 0.795, with a p-value less than 0.05. This significantly indicates a positive correlation between the post- and pre-test scores. Upon further observation of the pre- and post-test scores for the skills involved in the four processes of comprehension, analysis, resolution, and review, we discovered that their correlation coefficients are 0.762, 0.806, 0.733, 0.709, and 0.795, respectively, and each of their p-values is less than 0.05. This data suggests that there is also a close positive correlation between the various element of problem-solving skills.

3.1.2 The results of the qualitative data analysis

3.1.2.1The teacher teaching record form

According to the researchers' in-depth observation of the curriculum implementation process and their communication and reflection with students after teaching, the results are described from four aspects: students' learning attitudes, cooperation, class participation, and homework feedback:

1) Students' learning attitude

Generally good: Most students demonstrate a positive and proactive attitude towards learning. They are curious about the material and are willing to actively explore and solve math problems. However, there are also students who struggle to adapt to the new learning techniques or complete the assigned tasks, which results in lower enthusiasm towards learning.

Sustained interest: Students maintain a strong interest in learning throughout the course, and their exploration of mathematical concepts and problems extends beyond the classroom. In conversations with students after class, I discovered that they enjoy the games used during lessons. After a lesson on probability, one student said, “It turns out that learning can be so interesting. Through the activities, I learned how to judge the likelihood of events happening". Reflecting on the boat rental lesson, another student who previously did not enjoy studying remarked, “I found this lesson very interesting, and I now know how to rent a boat for the lowest cost next time I go out".

2) Cooperation

The overall effect of cooperative learning is positive: Classroom observations indicate that, in general, students exhibit a positive spirit of cooperation during group activities. They work together to discuss problems, share opinions, and effectively contribute to solving issues. However, there are also instances where some students in certain groups were initially less active and reluctant to cooperate at the beginning of the curriculum. When asked about their lack of participation, one student expressed dissatisfaction with their role in the group, stating, “I didn’t want to be the recorder". Following adjustments to the group dynamics, this student adopted a more positive cooperative attitude.

Communication skills have improved: Through cooperative learning, students not only tackle math problems but also enhance their ability to communicate effectively with team members and articulate their opinions. When asked, "What have you learned in this class?” one student responded, "Through collaborative learning, I have discovered that my communication skills have improved. I used to be afraid to speak up in a team, but now I can express my ideas more confidently and have learned to listen to and respect others’ opinions".

3) Class participation

Increased Engagement: Students are significantly more engaged in class, actively participating in discussions and taking the initiative to ask questions and share insights. According to data from the classroom management optimization program, there is a clear upward trend in the extra points awarded for class discussion participation. In conversations with students, the teacher noticed that a previously quiet student has become very active in class recently. When asked about the change, the student explained, “I have been previewing the new course material at home, so I am better prepared for cooperative learning. Our group also earns points because of my contributions!”

Attention Focus: Students are able to maintain focus for extended periods, actively participating in class activities and reducing distractions. Classroom observations reveal that most students are actively engaged in learning, with only a few occasionally showing signs of inattention. The teacher reflects on their teaching practices and discusses with students to understand the reasons for any inattention, aiming to improve students’ focus through targeted strategies.

4) Homework feedback

Quality of Work: The overall quality of students' work has improved, demonstrating a deeper understanding and application of the content studied. For example, teachers have observed that students who initially relied on a single method for solving problems have gradually become more willing to explore multiple approaches. One student with an excellent assignment said, “Recently, I have found that I can understand and apply formulas better, rather than just using them mechanically as I did before. For example, when solving a complex payment problem, I was able to use quantitative relationships to identify the key points of the problem and solve it successfully".

Timely Feedback: Students are consistently submitting their homework on time, responding positively to teacher feedback, and correcting mistakes in a timely manner to address their weaknesses. Teachers are observing a significant reduction in missed assignments, with almost all students completing their homework. A student who previously struggled with homework has recently been consistent with their submissions. The student said, “I appreciate the teacher’s use of tiered homework. Before, I wanted to complete my homework, but the questions were too difficult, and I often got stuck. Now, I choose questions within my capability and follow a homework schedule to avoid procrastination and ensure that I have enough time to complete my assignments".

3.1.2.2 Student semi-structured interview form

In order to comprehensively evaluate the effectiveness of the course, the researchers conducted semi-structured interviews and gathered students' opinions on four aspects: course content, teaching methods, learning experiences, and learning evaluations. At the end of the course, eight students with diverse learning styles, ability levels, and backgrounds were selected through purposeful sampling for interviews, providing a broad range of perspectives and feedback. A content analysis of these interviews was conducted, and the findings have been synthesized as follows:

1) Curriculum content

Students generally report that the course content is closely related to real-life problems and helps them recognize the importance of problem-solving in daily life. Through studying the course material, they not only understand the basic steps and strategies of problem-solving but also learn how to apply these strategies to real situations. Students have commented that the content was designed to systematically improve their problem-solving skills.

"The content of the course is very relevant to our lives, and the examples and problems involved are ones we would encounter in our daily lives". (Student 2)

"I think this content setting makes it easier for me to understand and apply what I have learned, which greatly helps improve my problem-solving skills". (Student 4)

"I believe that what I learn in class has many practical applications in real life, such as solving practical problems through mathematical modeling". (Student 5)

2) Teaching methods

In terms of teaching methods, students generally agree with learner-centered approaches. They believe that these methods stimulate their interest in learning and encourage more active participation. Through techniques such as gamified learning, cooperative learning, and case analysis, students not only improve their problem-solving skills but also develop teamwork and communication abilities. However, one student expressed confusion, saying that the new methods made him feel lost.

"The teacher used a lot of games for interaction, which allowed us to actively participate in the class." (Student 5)

"I think the group discussion method is very interesting; by communicating with other students, I can view problems from different perspectives, which is very helpful for my studies." (Student 8)

"I like problem-solving-based learning because tackling real-world problems makes me feel that mathematics is present everywhere." (Student 3)

"I don't like this approach very much; I often felt lost during many activities and didn't know what to do." (Student 6)

3) Learning experience

The overall learning experience is positive, with a harmonious classroom atmosphere and rich practical activities. Students said they felt loved and supported by their teachers during the learning process, which made them more confident in facing learning challenges. At the same time, the practical activities in the course provided them with opportunities to apply what they had learned in real life, thus enhancing their sense of achievement and satisfaction with the learning process. Students believe that this learner-centered approach made them enjoy the learning experience more. However, some individual students struggled to integrate into classroom activities.

"I think the learning atmosphere in the class is very good, and the teachers are very patient in answering our questions." (Student 7)

"I like practical activities because they give me the opportunity to solve problems with my own hands. The learning experience is very impressive." (Student 1)

"Discussions annoy me, and I don't want to communicate with others." (Student 6)

4) Learning evaluation

The way of learning evaluation is comprehensive and objective, effectively reflecting students' learning outcomes.

"The assessment method used in the course is very comprehensive, including regular assignments, group discussions, and final tests. I think this is a true reflection of my learning, as it tests not only my mastery of knowledge but also my teamwork and problem-solving skills." (Student 2)

"I like that the teachers use overall performance as a way to evaluate students, so that we are not judged solely on our performance in the final test." (Student 7)

3.2 Curriculum evaluation and revision results

3.2.1 Curriculum evaluation findings

The pretest mean score for students' mathematical problem-solving skills was 69.83, with a standard deviation of 12.378. After the intervention, the posttest mean score increased to 78.28, with a corresponding standard deviation of 13.778. The p-value <0.001, as shown in Table 28, is below the significance level of .05, indicating that the increase in mean scores from pretest to posttest is statistically significant. These results support the study's hypothesis that the learner-centered mathematics curriculum effectively enhances mathematical problem-solving skills among primary school students.

3.2.2 Curriculum revision results

Following its implementation, the curriculum underwent further revision, taking into account the outcomes of teachers' observations during instruction and semi-structured interviews conducted with students. The revision process included the following steps:

1) Revise the lesson plan according to the teaching process

During the teaching process, teachers should pay close attention to students' learning, including their understanding, interest, and motivation. Based on students' feedback and performance, teachers should assess whether the difficulty of the teaching content is suitable for the students and make adjustments according to their needs. For example, teachers should consider questions such as: Did the students understand the content? Is there a need to increase or decrease the amount of practice? Should the order of instruction be adjusted? Through reflecting on these issues, teachers can better modify the lesson plan to meet the actual teaching needs.

2) Check the effectiveness of teaching methods

Teachers should reflect on the teaching process and evaluate the effectiveness of the adopted teaching methods. If it is found that students are not actively engaged with a certain teaching method or that the method does not achieve the desired teaching outcomes, alternative methods should be explored to better engage students and foster their interest and initiative.

3) Increase inquiry learning

The curriculum should focus on inquiry-based learning, aiming to cultivate students' problem-solving skills through independent exploration and problem-solving processes. Open-ended questions should be designed to prompt students to think critically and seek solutions, with appropriate support and guidance provided.

4) Adjust the time for student presentations

The schedule for student presentations should be adjusted to avoid formalities and ensure that each group has the opportunity to present their research results.

5) Ensure detailed and specific descriptions of learning activities

Descriptions of learning activities should be detailed and specific, with tasks assigned based on students' abilities and interests. This approach ensures that each student understands the tasks to be completed, allowing everyone to participate and make progress.

6) Check and improve the wording of teaching materials

The wording of teaching materials should be checked and improved, with simplified language and sentence structures used to enhance students' comprehension. More understandable vocabulary and sentence structures should be employed.

7) Add examples and cases

Examples and cases should be incorporated into teaching materials to help students better understand concepts and knowledge points and apply their knowledge to practical situations.

8) Increase diversified teaching resources

A variety of teaching resources, such as videos, audio materials, and online resources, should be introduced to enrich the teaching content and stimulate students' interest in learning.

CHAPTER 5
CONCLUSION AND DISCUSSION

This chapter primarily presents our discussion and analysis of the research results, elaborates on the research objectives and methods, and offers suggestions for future research in this field. The specific summary is as follows:

Research Objectives

1. To study the current situation of mathematical problem-solving skills of primary school students.

2. To develop the learner-centered mathematics curriculum for cultivating mathematical problem-solving skills of primary school students.

3. To study the effectiveness of the learner-centered mathematics curriculum for cultivating mathematical problem-solving skills of primary school students.

Research Methodology

The researcher divided the development of the learner-centered mathematics curriculum aimed at cultivating mathematical problem-solving skills in primary school students into the following three phases:

Phase 1: Studying the current situation of mathematical problem-solving skills of primary school students

The purpose of this phase is to understand the current state of mathematical problem-solving skills among primary school students and to explore effective strategies and methods for their development. This will provide essential foundational information for the development and design of a learner-centered curriculum. Data were collected through a review of relevant literature, site visits, and semi-structured interviews with mathematics teachers and students.

Phase 2: Developing the learner-centered mathematics curriculum

This phase involves using the information collected in Phase 1 to design the learner-centered mathematics curriculum. The researcher conducted by 3 steps and the detail was following:

Step 1: Designing a learner-centered mathematics curriculum. The curriculum framework comprises several key elements: curriculum principles, curriculum objectives, curriculum content, teaching methods, instructional materials, and learning evaluation. The process of formulating this curriculum in this study encompassed seven fundamental stages, as enumerated below:

1) Assess the needs of learners to ensure that the objectives, content, teaching methods, and assessment methods of the curriculum design are aligned with the actual situation of the students.

2) Follow the learner-centered educational concepts and curriculum principles that advocate a learner-centered approach, ensuring each student receives quality mathematics education and enabling diverse student developmental levels in mathematics.

3) Develop scientific, reasonable, and operable curriculum objectives to provide teachers with a clear instructional framework, aiding them in organizing teaching activities more effectively.

4) Set up the curriculum content with interesting, easy-to-understand, and vivid real-life scenarios, taking into account the characteristics of fourth-grade students.

5) Choose appropriate teaching methods consistent with curriculum objectives and principles. The researcher adopted three learner-centered teaching methods in classroom teaching: cooperative learning, Problem-Based Learning, and gamification, aiming to provide authentic problem situations, foster a positive and interactive learning environment, mobilize students' interest in learning, and improve students' problem-solving skills.

6) Preparation of Teaching Materials. To improve learning results, the preparation of teaching materials should consider: personalized materials to meet the needs of students; authenticity and connection to real life; coherence with the course progress to ensure that the content system is consistent; interactivity to promote communication; and stimulation of self-reflection and adjustment of learning strategies.

7) Determine the learning evaluation methods to understand the learning

situation of students, evaluate the learning effects, help teachers adjust the teaching content in a timely manner, and assist students in achieving their learning goals more effectively.

Step 2: Curriculum evaluation by experts

Five experts relevant to this research field were invited to conduct a comprehensive evaluation of the developed mathematics curriculum. Initially, they assessed the appropriateness of each component of the curriculum. Following this, they evaluated the inherent consistency among the various components of the curriculum. Ultimately, targeted modifications and optimizations were implemented based on the feedback and recommendations provided by the experts. The “Mathematics Curriculum Quality Evaluation Form” served as the research tool for data collection, enabling a systematic and comprehensive analysis.

Step 3: Undertaking a pilot study

The researcher conducted a three-week pilot study with 40 fourth-grade students to evaluate the viability of the curriculum. The findings from the study were utilized to refine and enhance the course. The tools used were six lesson plans developed by the researcher.

Phase 3: Studying the effectiveness of the learner-centered mathematics curriculum

This Phase is completed in 2 steps:

Step1: Curriculum implementation

This research was conducted at the First Primary School in Zhoukou City, Henan Province, using a one-group pretest-posttest experimental design. The sample consisted of 40 students from Grade 4, comprising 22 boys and 18 girls, selected through a multi-stage sampling method. The study utilized an optimized and adjusted mathematics curriculum for the selected students, consisting of a total of 23 class periods taught over 11 teaching weeks, with each class period lasting 40 minutes. Various data collection tools were employed to evaluate the course's effectiveness and gather student feedback, including a mathematical problem-solving skills test, a teacher classroom observation form, and a student semi-structured interview form. SPSS and

JASP software were used to quantitatively analyze the test data on mathematical problem-solving skills, aiming to scientifically verify the effectiveness of the curriculum implementation. Additionally, a content analysis method was used to analyze teachers' classroom observation records and students' interview records, with the goal of identifying potential issues with the course and understanding students' attitudes towards it. This provided a basis for further optimization of the curriculum.

Step2: Curriculum Evaluation and Revision

After collecting mathematical problem-solving test scores following the implementation of the curriculum, a thorough analysis was conducted to examine the research hypotheses and evaluate the effectiveness of the mathematics curriculum. Based on feedback from teachers' classroom observations and students' semi-structured interviews, further revisions were made to refine the curriculum.

Conclusion

Phase 1: The results of studying the current situation of mathematical problem-solving skills of primary school students

Through the review of relevant literature, site visits to schools, and semi-structured interviews with teachers and students, the researcher found that the country attaches great importance to cultivating pupils' problem-solving skills. However, current research shows that primary school students face a series of problems in mathematical problem-solving skills, such as a weak grasp of basic knowledge, a lack of independent thinking and innovation awareness, and insufficient opportunities for practical application. These problems are related to many factors, including societal influences, teachers, students, and parents.

From the perspective of teachers, there are several issues affecting their ability to cultivate pupils' mathematical problem-solving skills, including outdated teaching concepts, traditional teaching methods, neglect of students' individual differences, and undiversified student evaluation methods.

To address these problems effectively, teachers need to actively change their teaching concepts, abandon traditional cramming methods, and adopt teaching strategies that align with students' cognitive processes and learning characteristics. Learner-centered teaching methods, such as gamification, cooperative learning, and Problem-Based Learning, can not only stimulate students' interest and enthusiasm for learning but also help them master mathematical knowledge in a relaxed and enjoyable environment, thereby improving their problem-solving skills.

At the same time, teachers should use a variety of evaluation methods and reward mechanisms to comprehensively and objectively assess students' learning outcomes, identify and correct problems in students' problem-solving processes, and provide timely feedback and effective rewards. This approach can further stimulate students' motivation and encourage more active engagement in math learning, ultimately leading to an improvement in their problem-solving skills.

Phase 2: The results of developing the learner-centered mathematics curriculum

2.1 The results of the learner-centered mathematics curriculum design

This study comprehensively uses various learner-centered teaching techniques to design diversified activities and encourage students to actively explore and solve problems. In classroom practice, we applied three learner-centered teaching methods: cooperative learning, Problem-Based Learning, and gamification. These methods were used to make classroom teaching livelier and more interesting, thereby effectively improving students' learning outcomes and problem-solving skills. The learner-centered mathematics curriculum consists of six components: curriculum principles, curriculum objectives, curriculum content, teaching methods, instructional materials, and learning evaluation.

2.2 The results of the mathematics curriculum evaluation by experts.

The results indicate that the average scores for each item range between 4.2 and 4.8 (higher than 3.51), with a standard deviation of 0.45 to 0.55. The evaluated level is classified as very high or high. This demonstrates that the components of the mathematics curriculum are of good quality and appropriateness. The evaluation results for the coherence of the mathematics curriculum indicate that the Index of Item Objective Consistency (IOC) among different components ranges from 0.6 to 1.0, which surpasses the standard of 0.5. This signifies that the coherence among various components of the mathematics curriculum meets the standard.

2.3 Results of the pilot study

Through the pilot study, it was found that the teaching content and teaching activity design of this course meet the curriculum requirements, and the selection of teaching methods is suitable. However, there are also some problems, such as the duration of some activities being too long or too short, the design of some teaching steps being unclear, and the communication between teachers and students needing improvement. These results provide valuable guidance and feedback for us to further improve and optimize the curriculum.

Phase 3: The results of studying the effectiveness of the learner-centered mathematics curriculum

3.1 The results of curriculum implementation

1) Comparison of students' problem-solving skills pretest-posttest scores

Students who learned through the learner-centered mathematics curriculum had post-test scores on mathematics problem-solving that were higher than their pre-test scores, with a statistically significant difference at the 0.05 level.

2) The results of the qualitative data analysis.

The learner-centered mathematics curriculum achieved significant results in improving student learning attitudes, promoting cooperation, increasing classroom engagement, and optimizing homework feedback. These changes not only helped to improve students' mathematical abilities but also had a positive impact on their overall development. Through the analysis of students' feedback, we believe that the learner-centered approach to improving pupils' problem-solving skills is effective. The course content is closely related to real-life problems, the teaching methods stimulate students' learning interest and initiative, the learning experience makes students feel cared for and supported, the evaluation methods comprehensively and objectively reflect the learning results, and the students' suggestions also provide direction for the further improvement of the curriculum.

3.2 Curriculum evaluation and revision results

The research results validate the research hypothesis, indicating that the developed curriculum significantly improves students' problem-solving skills. Based on the teaching records of teachers and the results of semi-structured interviews with students, the course was revised. The researchers adjusted the teaching plan, evaluated and optimized the teaching methods, increased inquiry-based learning, rationally allocated students' demonstration time, clarified the assignment of learning tasks, and simplified the language of teaching materials to improve the teaching effect and students' understanding ability.

Discussion

According to the research process, the research results can be discussed in three main points as follows:

1) The current situation of mathematical problem-solving skills of primary school students

Mathematical problem-solving skills are one of the important goals of students' learning in mathematics and serve as a key indicator of students' mathematical accomplishment and application abilities. The state attaches great importance to the cultivation of students' problem-solving skills, but the actual cultivation situation is not optimistic. Through site visits and semi-structured interviews with teachers and students, it was found that primary school students face a series of problems in their mathematical problem-solving skills, such as a weak grasp of basic knowledge, a lack of independent thinking and innovation consciousness, and a lack of practical operation opportunities. This finding is consistent with Zhang’s (2020) survey results, which indicate that "primary school students are relatively weak in math problem-solving, and students do not have good problem-solving habits; problem-solving ideas and methods are not flexible".

The emergence of these problems is related to a variety of factors. From the perspective of teachers, issues such as a lack of diversity and innovation in context creation, outdated teaching modes that fail to stimulate students' interest in learning, single teaching methods, insufficient attention to students, simplistic evaluation language, and a lack of relevance are prevalent. This finding aligns with research indicating that teachers' teaching behaviors significantly impact students' problem-solving skills (Cao, 2020; Li, 2022; Zhang, 2020). At the same time, students themselves also face challenges, such as low interest in mathematics learning, incomplete understanding of basic knowledge and concepts, weak grasp of mathematical principles, a lack of confidence in problem-solving, and insufficient opportunities for effective cooperative learning and discussion. These issues are supported by researchers who suggest that students' problem-solving skills are influenced by internal factors (Shang, 2020; Su, 2021; Zhang, 2020).

Shang (2020) studied the influence of curriculum and teaching factors on students' mathematical problem-solving skills and found that curriculum and teaching factors indirectly affect mathematical problem-solving skills by influencing individual factors. Teachers can design math courses to improve students' problem-solving skills by clarifying the focus of curriculum design, such as strengthening students' training in problem understanding, strategy selection, and reflection verification. Through targeted teaching activities and exercises, teachers can help students improve these key skills. By using diversified teaching methods and strategies, teachers can enhance students' interest in learning, increase their participation, and stimulate active learning. Teachers should adopt individualized teaching strategies to address differences among students. For instance, students with strong computational abilities can be guided to explore more efficient problem-solving strategies, while students with weaker comprehension skills may need additional examples and situations to connect problems with real-life contexts. In summary, teachers need to transition from traditional knowledge providers to facilitators and supporters of students' learning, creating an environment conducive to active learning and exploration, providing necessary resources and support, and helping students take a principal role in solving problems independently.

2) The learner-centered mathematics curriculum

The aim of this study is to develop a learner-centered mathematics curriculum to support educational reform, curriculum principles, and learner-centered teaching for primary and secondary school students, with the goal of enhancing students' mathematical problem-solving skills. The curriculum development process in this study draws on both the objectives model and the process model. The curriculum design consists of seven steps: Step 1: Assess the needs of learners; Step 2: Develop the principles of the curriculum; Step 3: Develop scientific and reasonable curriculum objectives; Step 4: Create interesting and understandable curriculum content; Step 5: Select appropriate teaching methods; Step 6: Organize learning activities and teaching materials; Step 7: Determine learning evaluation.

In the 21st century, there is an increasing demand for talents who not only have solid professional knowledge but also possess strong innovation and problem-solving skills (Zhou & Lu, 2009). In this context, the essence of primary school mathematics education is to cultivate students' problem-solving skills (Wu, 2020). Developing these abilities can enhance students' mathematical thinking, cooperative spirit, and innovative consciousness, and it can also effectively promote students' overall quality development (Y. Zhang, 2020). Through planned and purposeful thinking training, students can gradually form good thinking habits and improve their problem-solving skills.

Teachers can offer math courses designed to improve students' problem-solving skills, with the most effective cultivation method being to allow students to solve problems independently (Huang & Chen, 2004). Current educational reform emphasizes a learner-centered approach, highlighting students' subjectivity and initiative ("Decision of The State Council on the Reform and Development of Basic Education", 2001; "Outline of the National Medium- and Long-Term Plan for Education Reform and Development (2010-2020)", 2017; Ren, 1999). According to the Primary Mathematics Curriculum Standard, the process of teaching and learning aims to enhance students' ability to construct their own knowledge through various learning activities (Ministry of Education of the People's Republic of China, 2022).

The learner-centered teaching concept emphasizes the dominant position of students, encouraging teachers to fully stimulate students' learning enthusiasm and initiative during the teaching process and guiding them to engage in solving practical problems (Li, 2021). Guided by this educational philosophy, the researcher first conducted an in-depth analysis of students' characteristics and then formulated specific, reasonable, and operable teaching objectives based on their cognitive development (Shi, 2018b). The researcher also designed interesting and easy-to-understand course content. In traditional mathematics teaching, teachers often use a lecturing method to infuse knowledge points into students, requiring them to memorize and apply the knowledge without addressing individual differences in learning styles (Shi, 2018b). Learner-centered pedagogy, however, fosters an environment that resonates with the essence of learning by encouraging students to immerse themselves in the subject matter, engage in meaningful discussions, and reflect on their learning experiences (Patel-Junankar, 2017; Weimer, 2002). During the teaching process, the researcher employed three learner-centered teaching methods: cooperative learning, Problem-Based Learning, and gamification. Additionally, diversified learning evaluations were used to stimulate students' interest in learning, promote their all-round development, and improve teaching efficiency (Xu, 2018).

In summary, to address the problems in the current mathematics curriculum and meet societal needs, we developed a learner-centered mathematics curriculum. This curriculum is based on core principles aimed at clarifying objectives, optimizing content, innovating teaching strategies, integrating media and resources, and implementing comprehensive evaluation. Through these improvements, we aim to help students apply their mathematical knowledge and skills more flexibly to solve real-life problems, thereby effectively improving their mathematical problem-solving skills.

3) The effectiveness of the learner-centered mathematics curriculum

The research results show that students who learn through the learner-centered mathematics curriculum have post-test scores on mathematical problem-solving that are significantly higher than their pre-test scores, with a statistically significant difference at the 0.05 level. This indicates that using a learner-centered mathematics curriculum to enhance the mathematical problem-solving skills of primary school students is effective, and students who participated in the problem-solving instruction training have improved their problem-solving skills. This finding is consistent with the results of Shang (2020). According to Wang et al. (2021), students who have received Problem-Based Learning training achieve higher scores in their problem-solving skills compared to those who have not received such training. These research findings support the implementation of learner-centered educational practices as a viable approach to engage learners with their peers and surroundings.

In the implementation of the curriculum, the improvement in students' mathematical problem-solving skills benefits from the use of learner-centered teaching methods, as these methods better meet students' learning needs and interests, and improve their motivation and engagement (Ruan & Cai, 2020). According to Deci and Ryan's Self-Determination Theory, students are more engaged when they perceive their learning as meaningful (Deci & Ryan, 2012). Problem-Based Learning is a learner-centered, contextualized teaching method that uses real problems as a starting point for students' learning activities (Bridges, 1992), which effectively improves students' problem-solving skills (Amalia et al., 2017; Valdez & Bungihan, 2019; Wang et al., 2021). Cooperative learning not only helps teachers create a positive teaching environment and reflect the central role of students (Cai, 2022; Zhang, 2017) but also enhances students' classroom participation and cohesion (Trujillo-León et al., 2022), thereby positively impacting their problem-solving skills (Poore, 2008; Trujillo-León et al., 2022). Incorporating gamification elements into mathematics teaching increases students' interest in learning mathematics (Chen, 2019a; He, 2020), improves their understanding of the subject (Wu, 2015), and boosts their motivation and engagement (Papp & Theresa, 2017).

According to teaching records during course implementation and semi-structured interviews with students after the course, the learner-centered mathematics curriculum has achieved remarkable results in improving students' learning attitudes, promoting cooperation, enhancing class participation, and optimizing homework feedback. Therefore, we believe that the learner-centered approach to developing students' problem-solving skills is effective. This effectiveness is attributed to the curriculum's development and organization to meet the practical needs of students and provide enjoyable and beneficial learning activities. Students enjoyed participating in teaching, engaging in hands-on learning activities, and working in small groups to discuss, exchange ideas, and complete assignments together. They preferred team collaboration and enjoyed acquiring knowledge through interactive discussions, hands-on practical activities, and peer-to-peer learning experiences. This approach allows students to engage physically, intellectually, emotionally, and socially, with teachers acting as facilitators or advisors. This finding aligns with Hu and Wu (2015). Fan (2020) highlighted that the teacher's role in a learner-centered classroom is crucial for promoting student learning. Furthermore, several studies support the notion that learner-centered approaches are effective methods for fostering learning skills (Chen & Xu, 2021). Students engage in discussions, communicate their thoughts, and independently derive conclusions from their learning experiences. This process fosters their ability to articulate their ideas clearly and boosts their confidence, which is consistent with research outcomes indicating that learners engaged in learner-centered pedagogy develop enhanced critical thinking and problem-solving skills (Li, 2019).

Recommendations

1) Recommendations for the application of research conclusions

To ensure the successful implementation of the learner-centered mathematics curriculum in the classroom, teachers need to prepare in advance, continuously learn, and improve their teaching practices. By adopting a variety of teaching methods, encouraging students to collaborate and communicate, and implementing strategies such as authentic assessment, teachers can create a positive, interactive, and meaningful learning environment for students. Specific suggestions are as follows:

1) To study courses and materials in advance

Before class, teachers should delve deeply into the content, objectives, lesson plans, and teaching materials of the course to be taught to ensure a comprehensive and thorough understanding of the teaching activities to be carried out, thereby ensuring a smooth and efficient teaching process. It is also crucial to prepare the required teaching hardware and software in advance, such as teaching aids for gamified teaching, study sheets for cooperative learning, and badges or gifts for motivating students. Such meticulous preparation not only contributes to the orderly progress of teaching but also enhances the learning experience and effectiveness for students.

2) To be proficient in three teaching methods:

Teachers should be proficient in cooperative learning, Problem-Based Learning, and gamification methods so that they can choose the most appropriate teaching methods according to different teaching contents and student groups. However, in order to realize the full potential of these three teaching methods, there are many points to pay attention to. For cooperative learning, teachers need to focus on reasonable grouping, ensure the heterogeneity of members within each group, and clarify the tasks and goals so that each group can cooperate in a targeted way. In addition, teachers should pay attention to the distribution of roles and clear responsibilities within the group to avoid excessive dependence of some students on others. For Problem-Based Learning, teachers need to craft questions that are both closely related to the course content and capable of stimulating students' interest in inquiry. At the same time, teachers should focus on cultivating students' problem-solving skills and critical thinking skills, and guide them to constantly discover new problems and propose new ideas in the process of problem-solving. As for the gamification method, teachers need to ensure that the design of games aligns with the teaching content and objectives, rather than being solely for the sake of games. Additionally, teachers should also pay attention to the fairness and enjoyment of the game to ensure that every student can have a positive experience and gain from it. Only in this way can teachers fully utilize the advantages of various teaching methods, improve the teaching effect, and promote the all-round development of students.

3) In-depth understanding of authentic and diverse assessments:

Authentic and diverse assessments play a pivotal role in modern education by focusing on the assessment of students' ability to apply knowledge in real situations. Compared with traditional assessment methods, these assessments are more aligned with real-world needs and effectively promote the cultivation of students' practical abilities and innovative thinking. In implementing this assessment approach, teachers should employ a variety of evaluation methods to ensure a comprehensive and accurate reflection of students' learning outcomes. Among these methods, observation is indispensable. By observing students' performance in various contexts (such as the classroom, laboratory, or real-life scenarios), teachers can intuitively grasp students' learning progress and ability levels. Oral reports also hold unique evaluative value, as they not only enhance students' oral expression and logical thinking skills but also provide teachers with more in-depth feedback on students' mastery of knowledge. Additionally, group projects are a very practical evaluation method. During the evaluation process, teachers can assess students' participation, contribution, and the quality of the project completion to evaluate learning outcomes more comprehensively. Through these diverse assessment methods, teachers can gain a more accurate understanding of students' learning dynamics and offer robust support for subsequent teaching.

2) Recommendations for further research study

1) Learner-centered teaching has become the core of contemporary educational reform. In response to this change, we should focus on developing learner-centered math programs to enhance students' learning skills. In this study, we developed a math curriculum to develop problem-solving skills in primary school students, but there are still many other ability-building programs that need to be developed. For example, it can explore how to apply learner-centered concepts to cultivate students' innovative thinking, critical thinking, communication, and cooperation skills. By designing courses for different abilities, we can more comprehensively upgrade students' learning skills and help them better cope with future challenges.

2) In the process of implementing a learner-centered mathematics curriculum, the lack of participation from experienced mathematics curriculum experts

leads to the inadequacy of the design of many mathematics courses and lesson plans. Therefore, we urgently need more experienced mathematics teaching experts to participate deeply in the creation of the mathematics curriculum to ensure its quality and teaching effectiveness. This will help address the shortcomings of the existing curriculum and lesson plans, and enhance students' learning experiences and mathematical literacy.

3) In the learner-centered mathematics course, the researcher only selected 6 teachers from a school in Zhoukou City for interviews, resulting in a small sample size and lack of diversity. This may limit the depth and breadth of the research, and some issues may not be fully explored. To reach more comprehensive and accurate conclusions, it is recommended to expand the scope of the study to interview more mathematics teachers from different schools and regions to ensure wider representation and higher research reliability.

4) An important principle of using learner-centered instruction is the application of multiple teaching techniques. In this study, we used three teaching methods: cooperative learning, Problem-Based Learning, and gamification. However, teaching technology is changing rapidly, and we should continue to explore other emerging teaching techniques to develop students' mathematical problem-solving skills. For example, exploring how advanced technologies such as virtual reality (VR) and augmented reality (AR) can be integrated into mathematics teaching could provide students with a richer and more vivid learning experience.

To sum up, the researchers will make continuous efforts in future teaching practice to improve the shortcomings of the current research. We believe that with the rapid development of information technology and the wide application of big data technology, learner-centered mathematics courses will play an increasingly important role in cultivating students' ability to solve mathematical problems. We look forward to further optimizing mathematics curriculum design through continuous research and practice, improving students' learning outcomes, and laying a solid foundation for their future in mathematics.

REFERENCES

Allen, D., Donham, R. S., & Bernhardt, S. A. (2011). Problem-Based Learning. *New Directions for Teaching and Learning*, *2011*(128), 21-29.

Alvior, M. G. (2014, December 13). *The meaning and importance of curriculum development. Simply Educate*. https://simplyeducate.me/2014/12/13/the-meaning-and-importance-of-curriculum-development/

Amalia, E., Surya, E., & Syahputra, E. (2017). The effectiveness of using Problem-Based Learning (PBL) in mathematics problem-solving skills for junior high school students. *International Journal of Advance Research and Innovative Ideas in Education*, *3*(2), 3402-3406.

Anderson, J. R. (2005). *Cognitive psychology and its implications*. New York: Worth Publishers.

Bai, X., & Gu, X. (2019). Construction and application of computational thinking evaluation tool for K12 students. *China audio-visual Education*, (10), 83-90.

Barrow, R., & Milburn, G. (1990). *A critical dictionary of education concepts* (2nd ed.). New York: Teachers College Press.

Barrows, H. S., & Tamblyn, R. M. (1980). *Problem-Based Learning: An approach to medical education*. New York: Springer Publishing Company.

Best, J. W. (1981). *Research in Education.* New Jersey: Prentice Hall.

Birt, J. (2023, March 11). *Cooperative learning strategies: Definition, benefits and tips*. Indeed. https://www.indeed.com/career-advice/career-development/cooperative-learningstrategies?__cf_chl_rt_tk=y3pxjriN0hYQ_NGZomUZzwKiw_onrROJmCeVfdfv1Qw-1718003221-0.0.1.1-3946.

Bridges, E. M. (1992). *Problem-Based Learning for administrators*. ERIC.

Briggs, S. (2015, May 23). *10 Tips For Effective Problem-Based Learning: The Ultimate Instructional Solution*. Open colleges. https://www.opencolleges.edu.au/informed/features/problem-based-learning/

Cai, J. (2007). *A series of empirical studies on Chinese and American students' learning* *in mathematics*. Beijing: Education Science Press.

Cai, M. (2022). The application of group cooperative learning in primary school mathematics classroom. *Chemical Week magazine*, (02), 99-100.

Caixin. (2014, April 4). *PISA problem-solving skills test: Shanghai's outstanding student is not as good as Japan and South Korea*. Data news. https://datanews.caixin.com/2014-04-04/100661590.html

Cambell, D. T., & Stanley, J. C. (1963). *Learner-Based Teaching*. Oxford: Oxford University Press.

Cao, M. (2020). The present situation and strategy of mathematics problem-solving teaching in primary school. *Scientific Consulting (Technology and Management),* (11), 186.

Cao, Y., Huang, Q., & Ma, B. (2001). *Mathematical Pedagogy*. Beijing: Higher Education Press.

Che, W. (2003). *Humanistic psychology*. Hangzhou: Zhejiang Education Press.

Chen, C. (2017). *Primary school mathematics case design and practice based on Gamification* [Master's thesis, Central China Normal University].

Chen, C. (2019a). Discussion on the necessity of gamification in primary education. *Examination weekly*, (07), 12.

Chen, C. (2019b). On the necessity of gamification in primary education. *Examination weekly*, (07), 12.

Chen, D., & Xu, Z. (2021). Innovation in Technology-enabled education: Learner-centered pedagogy: An interpretation of the Open University's Innovative Teaching Report (2020 edition). *Continuing education*, *41*(01), 20-24.

Chen, J. (2019). *Research on Cooperative Teaching Design of primary school Mathematics to cultivate problem-solving skills* [Master's thesis, Chongqing Normal University].

Chen, K. (1995). A Preliminary study on the thinking process of solving mathematical problems. *General education research*, (01), 41-42+27.

Chen, Q., & Liu, R. (1997). *Contemporary Educational Psychology*. Beijing: Beijing Normal

University Press.

Chen, Q., & Liu, R. (2019). *Contemporary Educational Psychology 3rd Edition*. Beijing: Beijing Normal University Press.

Chen, Q., Xu, W., & Li, Y. (2022). A comparative study on the Mathematics Curriculum Standards of the third Edition of Compulsory Education. *Curriculum, teaching materials, teaching methods*, *42*(12), 117-123.

Chen, Y. (1999). National skills Revitalization Strategy. *Human resource development in China*, (02), 4-7+49.

Chen, Y. (2018). Present situation and strategy of mathematics problem-solving teaching in primary school. *Examination weekly*, (87), 67.

Chen, Z. (2022). An Analysis of teaching strategies for mathematical problem-solving in primary school. *Journal of Fujian Institute of Education*, *23*(08), 85-87.

Cheng, J. (2022). Research on Gamification Practice of primary school mathematics. *New course teaching*, (05), 154-155.

Cheng, Y., Zhou, X., Jiang, H., & Pan, S. (2017). The research and enlightenment of middle school biology teaching under the curriculum reform of basic education. *Science Education*, (01), 7.

Christenson, S. L., Reschly, A. L., & Wylie, C. (2012). *Handbook of research on student engagement*. New York: Springer.

Committee of the Communist Party of China. (2010, July 29). *Outline of the National Medium - and Long-Term Plan for Education Reform and Development (2010-2020)*. Gov.cn. https://www.gov.cn/jrzg/2010-07/29/content_1667143.htm

Deci, E. L., & Ryan, R. M. (2012). Self-determination theory. *Handbook of theories of social psychology*, *1*(20), 416-436.

Decision of The State Council on the reform and development of basic education. (2001). *People's education*, (07), 4-9.

Deterding, S. (2011). *Situated motivational affordances of game elements: A conceptual model*. In Proceedings of the CHI Gamification Workshop 2011.

Dewey, J. (1994). *School and society The school of tomorrow* (X. Zhao, Trans.). Beijing:

People's Education Press. (Original work published 1915)

Dong, C. (1985). *Encyclopedia of China Education*. Beijing: Encyclopedia of China Publishing House.

Dong, G., & Yan, L. (2013). Rethinking and exploring the role of traditional Chinese teachers. *Modern Education Science*, *364*(04), 75-76.

Du, Y. (2020, December 14). *Concepts needed to build a learner-centered teaching model*. Fx361. https://www.fx361.com/page/2020/1214/7667626.shtml

Du, Y., Sun, J., & Cai, Y. (2019, October 21). *The role of the teacher in a 'learner-centered' model of teaching and learning*. Fx361. https://www.fx361.com/page/2019/1021/7818188.shtml

Erhel, S., & Jamet, E. (2013). Digital game-based learning: Impact of instructions and feedback on motivation and learning effectiveness. *Computers & Education*, *67*, 156-167.

Fan, Z. (2020). *A Study on the Current Situation of Primary School Students' Mathematical Problem-Solving Skills and Strategies for Their Development* [Master's thesis, Ningbo University].

Fang, Z. (1990). *A review of Rogers' "learner-centered" teaching theory*. Beijing: Education Science Press.

Fischer, A., Greiff, S., & Wüstenberg, S. (2015). Assessing analytic and interactive aspects of problem-solving competency. *Learning and Individual Differences*, *39*, 172–179.

Gao, X., & Zhao, J. (2022). Concepts, principles, methods and recommendations of cooperative learning method. *Teaching at Chinese Universities*, (05), 87-96.

Gillard, D. (2007, October 14). *The Cockcroft Report (1982)*. Education England. http://www.educationengland.org.uk/documents/cockcroft/cockcroft1982.html#05

Guan, X. (2022). *The influence of mind mapping application strategy on cultivating junior high school students' problem-solving skills* [Master's thesis, Hefei Normal University].

Guo, Y. (2020). *A study on the diagnosis of mathematical problem-solving skills of* *primary school students driven by data* [Master's thesis, Central China Normal University].

He, S. (2020). The application of Gamification in primary school mathematics teaching. *Curriculum education research*, (25), 123-125.

Hmelo-Silver, C. E. (2004). Problem-Based Learning: What and How Do Students Learn? *Educational Psychology Review*, (3), 235-266.

Hu, S. (2017). Present situation and strategy of mathematics problem-solving teaching in primary school. *Reading and Writing (Journal of Educational Teaching)*, *14*(01), 192. https://doi.org/10.16071/j.cnki.cn51-1650/g4.2017.01.156

Hu, X., & Wu, Z. (2015). Dewey's idea of problem-based teaching and its implications for modern teaching. *Curriculum and Teaching Research*, (06), 23-26.

Hua, D. (2014). Education thought /ideas on education /educational ideology. *Journal of Lanzhou University (Social Sciences Edition)*, (04), 152-155.

Huang, M., & Chen, W. (2004). "Problem-solving" skills. *Science Education Monthly*, (273), 21-41.

Ibrahim, I., Sujadi, I., Maarif, S., & Widodo, S. A. (2021). Increasing mathematical critical thinking skills using advocacy learning with mathematical problem-solving. *Jurnal Didaktik Matematika*, *8*(1), 1-14.

Ince, E. (2018). An Overview of Problem-Solving Studies in Physics Education. *Journal of Education and Learning*, *7*(4), 191-200.

Jia, W. (2021). Insisting on learner-centered classroom changes. *Shanghai Curriculum and Teaching Research*, *65*(01), 3-4+57.

Jiang, M. (2021). *A study on the design of game-based teaching activities for problem-solving skills development* [Master's thesis, Qufu Normal University].

Jiang, S. (1991). *Concise Encyclopedia of International Education Courses*. Beijing: Education Science Press.

Jin, C. (2005). *Primary Mathematics Curriculum and Pedagogy*. Nanjing: Nanjing University Press.

Johnson, D. W., & Johnson, R. T. (2008). Social interdependence theory and cooperative learning: The teacher's role. *The teacher's role in implementing cooperative learning in the classroom*, 9-37.

Jonassen, D. H. (2003). *Learning to Solve Problems: An Instructional Design Guide*. Jossey-Bass Inc.,U.S.

Kember, D., & Gow, L. (1994). Orientations to teaching and their effect on the quality of student learning. *The Journal of Higher Education*, *65*(1), 58-74.

Kong, F., & Ceng, Z. (2009). *The psychology of learning mathematics*. Beijing: Peking University Press.

Lai, S. (2018). Learner-centered classroom teaching. *Journal of Northwestern Polytechnical University (Social Science Edition)*, *137*(03), 39-42.

Lewy, A. (1991). *National and School-Based Curriculum Development*. Paris: UNESCO: International Institute for Educational Planning.

Li, C. (1995). Experimenting with the nature of activity courses. *Courses. Teaching materials. Teaching methods*, (12), 9-16.

Li, F. (2019). Evaluation of students' problem-solving skills: an online accompaniment perspective. *Distance Education in China*, (08), 79-84.

Li, G., & Ren, H. (2004). *Chemical problem-solving studies*. Jinan: Shandong Education Publishing House.

Li, S. L. (2017). *Study on "learner-centered" teaching models based on "real problems" orientation*. In Proceedings of the 2017 Academic Annual Meeting of Liaoning Higher Education Society: Excellent Paper Collection for Third Prize (pp. 799-804). Liaoning Higher Education Society.

Li, S. (2022). The present situation and model of mathematics problem-solving teaching in primary school. *New Course Teaching (electronic version)*, (02), 128-129.

Li, X. (2021). "Learner-centered" theoretical review and practical reflection. *Journal of Higher Education Research*, *44*(01), 1-7.

Li, Y. (2013). *Action research on gamified learning in high school Information technology curriculum teaching* [Master's thesis, Shaanxi Normal University].

Liang, Y. (2020). Elementary school mathematics "problem-solving" teaching strategy implementation. *Science and technology trend*, (07), 61.

Liao, X. (1991). *Course Studies*. Wuhan: Huazhong Normal University Press.

Liao, Y. (2022). The influence of cognitive style on secondary school students' English learning. *Basic Education Studies*, *597*(23), 34-37.

Lin, C., Yang, Z., & Huang, X. (2003). *Great Dictionary of Psychology*. Shanghai: Shanghai Education Publishing House.

Liu, C. (2009). On learner-centered curriculum design. *Journal of Changchun University of Science and Technology (Higher Education Edition)*, *4*(12), 127-128.

Liu, H. (2019). The application of gamification in primary school mathematics teaching. *Inner Mongolia education*, (20), 46-47.

Liu, J. (2013). On Cultivating students' problem-solving skills as early as possible. *Tianjin Education*, (02), 9-10.

Liu, J., & Zhu, Z. (2015). gamification -- making fun promote learning the new pursuit of educational technology. *Research on visual education*, *36*(10), 69-76+91.

Liu, N. (2020). To explore the application of cooperative learning in junior high school English teaching. *English for middle school students*, (40), 53-54.

Liu, Y. (2015). *An empirical study on the development of high school students' problem-solving skills* [Doctor, East China Normal University].

Lyu, Y., & Luo, L. (2018). The German Abitur examination course selection model based on educational standards and its insights. *Exploring Higher Education*, (09), 73-78+85.

Ma, Y. (2013). *Elementary School Mathematics Teaching Theory (4th Edition)*. Beijing: People's Education Press.

Mayer, R. E. (2013). Problem-Solving. In D. Reisberg (Ed.), *The Oxford Handbook of Cognitive Psychology*. Oxford: Oxford University Press.

Mayo, P., Donnelly, M. B., Nash, P. P., & Schwartz, R. W. (1993). Student perceptions of tutor effectiveness in a problem-based surgery clerkship. *Teaching and Learning in Medicine*, *5*(4), 227–233.

Mccombs, B. L., & Whisler, J. S. (1997). *The learner-centered classroom and school :*

strategies for increasing student motivation and achievement. San Francisco: Jossey-Bass.

McKeachie, W. J. (2023, October 23). *Wilbert J. McKeachie Quotes*. Retrieved 23 October, 2021 from https://www.azquotes.com/author/31823-Wilbert_J_McKeachie

Ministry of Education of the People's Republic of China. (2002). Outline of Curriculum Reform of Basic Education (Trial). *Teaching Research of curriculum materials. Elementary education research*, (Z1), 7-9.

Ministry of Education of the People's Republic of China. (2012). *Compulsory Mathematics Curriculum Standards 2011 Edition*. Beijing: Beijing Normal University Press.

Ministry of Education of the People's Republic of China. (2022). *Compulsory Mathematics Curriculum Standards 2022 Edition*. Beijing: Beijing Normal University Press (Group) Co.

Ministry of Education of the People's Republic of China. (2023, December 29). *Number of Students in Primary Schools (Total)*. Gov.cn. http://www.moe.gov.cn/jyb_sjzl/moe_560/jytjsj_2019/qg/202006/t20200611_464829.html

Mtitu, E. A. (2014). *Learner centred teaching in Tanzania: Geography teachers' perceptions and experiences.* Wellington: Faculty of Education, Victoria University of Wellington.

NCTM. (2000). *Principles and Standards for School Mathematics.* Virginia: National Council of Teachers of Mathematics.

Nebesniak, A. (2007). *Using cooperative learning to promote a problem-solving classroom*. (Summative Projects for MA Degree, Paper 3). University of Nebraska-Lincoln. https://digitalcommons.unl.edu/mathmidsummative/3

Niu, Z. (2019). Elementary school mathematics problem-solving teaching and strategy. *Examination weekly*, (12), 77.

Niyazi, A. (2015). The elementary school mathematics teaching present situation and countermeasure analysis. *Nobody (occurrence peak),* (14), 192.

NoprianiLubis, J., Panjaitan, A., Surya, E., & Syahputra, E. (2017). Analysis Mathematical

Problem-Solving Skills of Student of the Grade VIII-2 Junior High School Bilah Hulu Labuhan Batu. *International Journal of Novel Research in Education and Learning*, *4*(2), 131-137.

OECD. (2003). *The PISA 2003 assessment framework: Mathematics, reading, science and problem-solving*. OECD Publishing.

OECD. (2012). *The PISA2012 Assessment Framework- Mathematics, Problem-solving and Financial literacy*. Paris: OECD Publishing.

Oganesyan, B. A. (1983). *Mathematics teaching method in primary and secondary schools* (Y. Liu, C. Guang, & Z. Qin, Trans.). Beijing: Surveying and Mapping Press.

Ou, C., & Liao, Q. (2018). Effective strategies of Cooperative Learning based on the Core literacy of Mathematics -- A case study of the teaching of "binary one-time Equations" in the seventh grade of Human Education Edition. *Middle school mathematics*, (16), 8-10+13.

Outline of the National Medium - and Long-Term Plan for Education Reform and Development (2010-2020). (2017). *Laboratory research and exploration*, *36*(12), 222.

Pan, H. (2020). An Empirical Study on Assessment of "problem-solving" skills in primary school mathematics. *Primary school teaching research,* (28), 23-28.

Papp, T. A., & Theresa, A. (2017). gamification effects on motivation and learning: Application to primary and college students. *International Journal for Cross-Disciplinary Subjects in Education*, *8*(3), 3193-3201.

Patel-Junankar, D. (2017). Learner-Centered Pedagogy: Teaching and Learning in the 21st Century. *The Health Professions Educator: A Practical Guide for New and Established Faculty*, 3-11.

PateŞan, M., Balagiu, A., & Zechia, D. (2016). The Benefits of Cooperative Learning. *International conference KNOWLEDGE-BASED ORGANIZATION*, *22*(2), 478-483.

Pei, H. (2019). The promoting effect of mathematical language on thinking development of critical age children. *Primary school teaching reference*, (05), 55-57.

Polya, G. (1962). *Mathematical discovery, 1962*. John Wiley & Sons.

Polya, G. (2007). *How to solve problems A new approach to mathematical thinking* (Hongtu & C. Feng, Trans.). Shanghai: Shanghai Science and Technology Education Press.

Poore, S. (2008). *Cooperative learning in relation to problem-solving in the mathematics classroom*. (Action Research Projects, Paper 44). University of Nebraska-Lincoln. https://digitalcommons.unl.edu/mathmidactionresearch/44

Qi, C. (2007). *Mathematics comparative education*. Nanning: Guangxi Education Press.

Qiu, X. (2017). A brief analysis of the present situation and strategy of mathematics problem-solving teaching in primary school. *Jilin education*, (01), 111.

Rahmah, K., Inganah, S., Darmayanti, R., Sugianto, R., Choirudin, & Ningsih, E. F. (2022). Analysis of Mathematics Problem-solving skills of Junior High School Students Based on APOS Theory Viewed from the Type of Learning Styles. *Indonesia Mathematics Education*, *5*(2), 109-122.

Ranido, O. (2023). *Benefits of Learner-centered Approach: Learner-Centered Education*. Retrieved May 28, 2023 from https://tokyo.globalindianschool.org/blogdetails/benefits-of-learner-centered-approach

Ren, C. (1999). The new round of compulsory education curriculum and teaching materials reform: 18 suggestions. *Educational Theory and Practice*, (10), 32-36.

Ruan, N., & Cai, Y. (2020). Learner-centered" -- breaking the silence in adult education classroom. *Journal of Northwest College of Adult Education*, (02), 15-18+46.

Savery, J. R. (2006). Overview of Problem-Based Learning: Definitions and distinctions. *Interdisciplinary Journal of Problem-Based Learning*, *1*(1), 9-20.

Schneider, C. (2016, April 14). *7 Traits of Learner-Centered Teachers*. Getting smart. https://www.gettingsmart.com/2016/04/14/7-traits-learner-centered-teachers/

Schoenfeld, A. H. (1985). *Mathematical Problem-Solving*. Orlando: Academic Press， INC.

Shang, J.,& Jiang, Y. (2018). Gamified learning: Make learning more scientific, happier and more effective. *People's education* (13), 3.

Shang, Y. F. (2020). Research on the current situation and cultivation strategies of mathematical problem-solving skills of ninth-grade students [Master's thesis, Northwest Normal University]. https://link.cnki.net/doi/10.27410/d.cnki.gxbfu.2020.000676

Shi, X. (2018a). Elementary school mathematics teaching status and improvement measures. *New Curriculum*, *1*(10), 61.

Shi, X. (2018b). Talking about the current situation of primary school mathematics teaching and improvement measures. *New Curriculum*, (10), 61.

Smith, R. (2022, October 13). *Learner-Centered Instructional Strategies* | *Learner-Centered Teaching*. Study. https://study.com/academy/lesson/learner-centered-teaching-strategies-methods.html

Song, L. (2018). Current situation analysis and countermeasure of pupils' mathematical problem-solving skills. *Science and technology information*, *16*(32), 207-208.

Song, Q. (2022). *Research on the design and Practice of gamification Learning Activities in primary school programming Curriculum* Mudanjiang Normal University].

Stenhouse, L. (1989). *Introduction to Curriculum Studies and Curriculum Development* (P. Zhu, L. Sun, & S. Yang, Trans.). Beijing: Spring and Autumn Publishing House.

Su, Q. (2021). *Cultivation and enhancement of inquiry-based learning abilities in elementary school mathematics* [Master's thesis, Central China Normal University].

Sun, J. (2012). A case study of Mathematics Extension Course teaching based on Cooperative Learning. *Global Education Outlook*, *41*(05), 94-96.

Sun, L. (2018). The present situation and Strategy of mathematics problem-solving teaching in primary school. *Extramural education in China*, (07), 88.

Sun, Y. (2018). A brief analysis of the present situation and strategy of mathematics problem-solving teaching in primary school. *Reading and Writing (Journal of Educational Teaching)*, *15*(03), 172.

Sun, Z. (2022). An effective way to improve the evaluation of mathematical problem-solving skills of pupils. *Modern education*, (07), 20-24.

Taba, H. (1962). *Curriculum Development; Theory and Practice*. New York: Harcourt Brace & World.

TeacherPediaNG. (2021, April 15). *Benefits of Problem-Based Learning to Students and Teachers*. Teacher pedia. https://teacherpedia.net/2021/04/15/benefits-of-problem-based-learning-to-students-and-teachers/

TeachThought Staff. (2020, May 15). *28 Learner-centered Instructional Strategies*. Teachthought. https://www.teachthought.com/pedagogy/learner-centered-methods/

The Central Committee of the Communist Party of China and the State Council. (1999). *The Decision on deepening educational reform and comprehensively promoting quality-oriented Education*. Beijing: China State Council.

Trujillo-León, U., Delgado-Arenas, R., Delgado-Corazao, S., Corazao-Marroquín, N., & Farfán-Pimentel, J. F. (2022). Cooperative learning and its effects on the development of problem-solving skills in secondary school students, Callao. *NVEO-Natural Volatiles & Essential Oils Journal* | *NVEO*, 1109-1121.

Tyler, R. W. (1994). *Basic principles of curriculum and instruction* (F. Shi, Trans.). Beijing: People's Education Publishing House. (Original work published 1911)

Valdez, J., & Bungihan, M. (2019). Problem-Based Learning approach enhances the problem-solving skills in Chemistry of high school students. *Journal of Technology and Science Education*, *9*(3), 282.

Valdez, J. E., & Bungihan, M. E. (2019). Problem-Based Learning approach enhances the problem-solving skills in chemistry of high school students. *JOTSE*, *9*(3), 282-294.

Waltman, K. K., Kahn, A. B., & Koency, G. (1998). *Alternative approaches to scoring: The effects of using different scoring methods on the validity of scores from a performance assessment* (CSE Technical Report No. 488). University of California, Los Angeles. https://www.cse.ucla.edu/products/reports/R488.pdf

Wan, X. (2011). Developing students' thinking in "Enlightenment" -- Teaching and reflection on the Number of Stamps in Volume 2 of Grade 4. *Education and research forum*, (02), 46-47.

Wang, C. (2005). *Teaching treatise* (2nd ed.). Beijing: People's Education Press.

Wang, C. (2005). *Theories and strategies of cooperative learning* [Master’s thesis, Shandong Normal University].

Wang, D. (2018). Present situation and strategy of mathematics problem-solving teaching in primary school. *Popular science fairy tale*, (36), 47.

Wang, H., Cao, L., & He, M. (2021). The effect of Problem-Based Learning on students' problem-solving skills--a meta-analysis based on 34 domestic and international studies. *Open Education Research*, *27*(05), 91-98.

Wang, J. (2016). On the Nature of the Flipped Classroom. *Higher Education Research*, *37*(08), 53-59.

Wang, S., & Wang, A. (1992). *Cognitive Psychology*. Beijing: Peking University Press.

Wang, X. (2017). *Research on the influencing factors of middle school students' mathematical problem-solving skills* [Master's thesis, Yanbian University].

Wang, X. Y. (2022). *Exploration of a Problem-Based Learning model for junior high school mathematics teaching*. In J. H. Zhang (Ed.), Connecting Beijing and Tianjin: New Era Basic Education Conference Proceedings. Beijing: Beijing Normal University Press.

Wang, Y. (2019). The present situation and strategy of mathematics problem-solving teaching in primary school. *Academic weekly*, (15), 55.

Wang, Y. (2021). *Design and practice of open-source hardware project-based learning for cultivating problem-solving skills in elementary school* [Master’s thesis, Northeast Normal University].

Wang, Y., & Wang, A. (1992). *Cognitive Psychology*. Beijing: Peking University Press.

Wang, Z. (2009). The course reform is the great innovation of our basic education work. *Basic education curriculum*, (Z1), 6-9.

Wang, Z., Yue, H., Jiang, L., & Xie, Z. (2023). Course design and practice of engineering organic chemistry with the concept of "learner-centered" education. *Contemporary chemical research*, (09), 148-150.

Weimer. (2006).Learner-centered *teaching: Five key changes to teaching practice*. Hong

Gang translation.

Weimer, M. (2002). *Learner-centered teaching: Five key changes to practice.* San Francisco, CA: Jossey-Bass.

Woods, D. (1994). *Problem-Based Learning: how to gain the most from PBL water down*. Edmonton: DR Woods.

Wu, G. (2012). A Review of the Problem-Based Learning (PBL) Model. *Shaanxi Education (Higher Education Edition)*, (4), 3-7.

Wu, J. (1986). *Pedagogy - the historical development of teaching theory*. Changchun: Jilin Education Publishing House.

Wu, J. (2017). *A study on the effect of PBL chemistry teaching model on secondary school students' chemistry problem-solving skills*. [Master's thesis, Huazhong Normal University].

Wu, M. (2015). The application value of gamification in primary school mathematics teaching. *Education in Fujian*, (35), 41-42.

Wu, Q. (2022). *An Investigative Study of Grade 8 Students' Problem-Solving Skills in Mathematics* [Master's thesis, Shanghai Normal University].

Wu, Y. (2020). Strategies to cultivate students' problem-solving skills in primary school mathematics teaching. *Scientific Consulting (Technology and Management)*, (10), 267.

Xiao, J. (2011). *Research on learner-centered college curriculum design* [Master's thesis, East China Normal University].

Xiao, J. (2020a). Exploring the "learner-centered" blended teaching reform. *Heilongjiang Education (Higher Education Research and Evaluation)*, *1330*(10), 11-14.

Xiao, J. (2020b). A probe into the "learner-centered" blended teaching reform. *Education in Heilongjiang (Higher Education Research and Evaluation)*, *1330*(10), 11-14.

Xiao, W. (2017). "Learner-centered teaching principles. *Elementary school language teacher*, *361-362*(Z1), 16-21.

Xu, J., Yang, W., Li, M., & Ma, Y. (2018). A Perspective on the hot spots of international gamification learning and its Inspiration to our country -- Based on the analysis of

Computers & Education(2013-2017). *Journal of distance education*, *36*(06), 73-83.

Xu, L., & Huang, X. (2019). Application of Problem-Based Learning in children's activities -- A case study of "Our Fire Engine" activity in senior class. *Early childhood education research*, (04), 11-13.

Xu, M. (2018). A probe into the "learner-centered" teaching model. *Jiangxi Education*, *1040*(18), 61.

Xu, Z., & Qi, C. (2018). An Investigation and Research on Mathematical Problem-Solving skills of Junior Secondary School Students and the Factors Affecting Them - A Case Study of Grade 8 Students in S City, Hebei Province. *Educational Measurement and Evaluation*, (07), 41-46+56.

Yang, B. (2016). *Research on the application model of online "teaching space" for developing students' problem-solving skills* [Doctoral thesis, Northwest Normal University].

Yang, D. (2022). The current situation of elementary school mathematics teaching and improvement strategies under the background of core literacy. *In Connecting Beijing-Tianjin—Social Forms: Basic Education Conference Proceedings* (pp. 2425-2428).

Yang, F. (2017). Present situation and strategy of mathematics problem-solving teaching in primary school. *New Education Times Student edition*, *5, 10-11*.

Yang, Q. (2003). *Mathematics curriculum and teaching in primary school*. Shanghai: Shanghai Science and Technology Education Press.

Yang, Y. (2017). Present situation and strategy of mathematics problem-solving teaching in primary school. *Era education*, (24), 179-180.

Yi, X. (2018). *Investigation and research on the present situation of mathematics "problem-solving" teaching in primary school* [Master's thesis, Huanggang Normal University].

Yu, P. (2002). *A study of cognitive models of mathematical problem-solving and teaching theory* [Doctoral thesis, Nanjing Normal University].

Yu, P., Lian, S., & Wu, X. (2011). *30 Years of Psychological Research in Chinese*

Mathematics Education. Beijing: Science Press.

Yu, Z. (2017). Implications of mathematical problem-solving and teaching suggestions. *Education in Hubei (Education Teaching)*, (04), 49-51.

Yuan, T. (2015). A review of mathematical problem-solving research. *Mathematics Learning and Research*, (05), 4-5.

Zhan, F., & Ding, F. (2020). To construct a new pattern of teaching reform of "learner - centered". *Jiangsu Education*, *50*, 40-42.

Zhang, C. (2015). Research on effective strategies of classroom group cooperative learning. *success*, *300*(09), 24-26.

Zhang, H. (2012). Principles and methods of learning-centered online course design -- taking "Principle of Automatic Control and System Online Course" as an example. *Science and Technology Innovation Herald*, (18), 128+130.

Zhang, H. (2014). *Curriculum and Teaching Methodology* (2nd ed.). Shanghai: Shanghai Education Press.

Zhang, J. (2005). Learner-centered curriculum design principles: A case study of junior high school mathematics. *Global Education Outlook*, *34*(06), 46-48.

Zhang, J. (2011). *Problem-solving skills training full programme*. Beijing: People's Post and Telecommunications Publishing House.

Zhang, K. (2022). Study on the development of population education level in Henan Province. *Modern trade industry*, *43*(24), 35-37.

Zhang, L. (2005). On the essence and characteristics of question-based learning. *Cultural and educational materials*, (26), 59-62.

Zhang, L. (2017). Research on the application of group cooperative learning in mathematics teaching. *Suntech Power CLO*, (32), 55.

Zhang, L., & Wang, G. (2018). Computational thinking: The core issue of Information Technology discipline core literacy training. *Research on visual education*, *39*(05), 115-121.

Zhang, X. (2020). *A study on the current situation and countermeasures of mathematical problem-solving skills of upper primary school students* [Master's thesis, Loudoun

University].

Zhang, Y. (2020). *A Study on the Current Situation of Mathematics Problem-Solving Skills of Primary School Students in Year 5* [Master's thesis, Tianjin Normal University].

Zhang, Y., & Zhang, L. (2018). Study on "Learner-centered" college Talent training mode. *Higher Education Research in Heilongjiang Province*, (08), 83-86.

Zhao, H. (2020). Talking about cooperative learning in junior high school English classroom teaching. *Campus English*, *520*(28), 147-148.

Zhao, T. (2006). *To interpret humanistic educational thought*. Guangzhou: Guangdong Education Press.

Zhao, X. (2021). *Research on the Cultivation of Mathematical Problem-solving skills of middle and high grade students in primary school* [Master's thesis, Southwest University].

Zheng, J., & Zhang, E. (2007). *A theory of mathematical learning* (3rd ed.). Nanning: Guangxi Education Publishing House.

Zheng, Y. (2009). “Problem-Solving" and Mathematics Education (2008). *Journal of Mathematics Education*, *18*(01), 1-4.

Zhong, L. F. (2023). *Discussion on effective strategies for implementing gamified teaching in elementary school mathematics*. In L. X. Chen (Ed.), *Proceedings of the 2023 Curriculum Education Exploration Academic Forum* (Vol. 1). Hunan Normal University Press.

Zhou, J. (2023). The application of gamification in primary school mathematics teaching. *Test questions and research*, (05), 182-184.

Zhou, M., & Lu, Y. (2009). Focusing on the cultivation of Basic skills of Talents in the 21st Century -- Policy Transformation and Practice in the United States. *Peking University Review of Education*, (2), 110-117+191.

Zhou, M., & Yu, L. (2009). Focusing on the Development of Basic Skills for the 21st Century Workforce - Policy Shifts and Practices in the United States. *Peking University Education Review*, *7*(02), 110-117+191.

Zhu, X. (2016). *Research on students' problem-solving skills based on PISA* [Doctoral thesis, East China Normal University].

Zhu, Y., Fei, L., & Shang, J. (2017). Research on the integration approach of gamification and MOOC course videos -- A Case study of gamification Method MOOC. *Journal of distance education*, *35*(06), 95-103.

Zhuang, S., Jiang, Y., & Dong, A. (2015). *Game-based learning.* Beijing: Beijing Normal University Press.

APPENDIX

APPENDIX A

1. The Classroom observation record

<table>
<tr><td colspan="3">Information about the teacher</td><td>Subject</td><td>Class and grade</td><td>Time</td></tr>
<tr><td>Name</td><td>Sex</td><td>Teaching age</td><td></td><td></td><td></td></tr>
<tr><td colspan="6"></td></tr>
<tr><td>Time</td><td>Teaching link</td><td>Observed events
(Teacher)</td><td>Observed events
(Student)</td><td colspan="2">Observer's interpretation
And question</td></tr>
<tr><td></td><td></td><td></td><td></td><td colspan="2"></td></tr>
<tr><td colspan="6">Interactive communication after class:</td></tr>
<tr><td colspan="6">Explanation: 1. Research problem: What is the current situation of mathematics problem solving teaching?
2. The purpose of observation: Through observation, collect teachers' effective, inefficient and ineffective practices in classroom teaching, organize, analyze and give feedback, aiming to understand teachers' cultivation of students' problem-solving skills
3. Observation object and content: teacher's behavior and student's behavior in classroom teaching
4. Observation method: notes
5. Observation point:
(1) Teacher teaching behavior:
1. Handling of teaching materials: observe how teachers choose teaching materials, how to interpret and analyze teaching materials, how to use teaching materials, whether they can use teaching materials innovatively, and whether they can adapt teaching materials according to students' specific situations.
2. Teaching methods and strategies: Observe whether the teaching methods and strategies used by teachers can help students better understand mathematical concepts and solve problems.
3. Classroom management: Observe the teacher's management ability in the classroom, including how to control classroom discipline, how to deal with students' problems and challenges, etc.
4. Interaction between teachers and students: Observe the interaction between teachers</td></tr>
</table>

and students, including how teachers answer students' questions, the quality of communication with students, etc.

5. Attention to students: Observe whether teachers pay attention to cultivating students' interest in learning, whether they pay attention to students' participation, whether they pay attention to the cultivation of students' learning habits, and whether they pay attention to the cultivation of students' learning methods and learning strategies.

6. Teacher Evaluation and Feedback: Observe how teachers evaluate and give feedback on student performance, including whether feedback is tailored to each student's learning needs and abilities.

7. Technology Use: Observe the teacher's ability to use technology in the classroom, including the use of computers, the Internet, and other learning software.

(2) Students' learning behavior:

1. Students' attitude towards lectures: Observe whether the students listen carefully and pay attention to the teacher's explanation.

2. Students' classroom participation: Observe whether students actively participate in classroom interaction, answer questions actively, and communicate with teachers and classmates.

3. Students' thinking ability: Observe whether students can think independently, analyze problems, and whether they have the spirit of inquiry.

4. Students' cooperation ability: Observe whether the students can actively participate in cooperation in the cooperation group, and whether they have good communication and cooperation skills.

5. Students' problem-solving skills: Observe whether students can skillfully use the knowledge they have learned to solve problems and whether they have innovative thinking ability.

6. Students' independent learning ability: observe whether students have independent learning ability and whether they can use various resources for independent learning.

2. Semi-structured interview form with teachers and students

2.1 Purpose of interview

1) To understand teachers' understanding of mathematical problem-solving skills in primary school and the challenges and difficulties in mathematics teaching, and to explore their experience and practice in cultivating students' problem-solving skills;

2) To understand students' understanding of mathematical problem solving skills, investigate their learning attitude, learning interest and difficulties in learning, and reveal their real needs in the process of mathematical problem solving;

3) To collect teachers' and students' expectations and suggestions on the learner-centered mathematics curriculum and provide direction and guidance for curriculum development.

2.2 Interviewees

2.2.1 Served as a primary school mathematics course teacher

The study included three fourth-grade math teachers and one teacher each in third, fifth, and sixth grade. The selection principles include the following four points:

1) Representativeness

In order to ensure the diversity and comprehensiveness of the interview results, mathematics teachers of different genders, different teaching ages and different grades were selected in this study.

2) Professional background

In order to better understand and analyze the relevant knowledge of elementary school students' mathematical problem-solving skills, teachers with professional background in mathematics education were selected for this study.

3) Teaching experience

In order to understand the characteristics and performance of primary school students' mathematical problem-solving skills, teachers with more than 5 years of teaching experience and rich teaching experience were selected, and these teachers' teaching achievements were outstanding and well received by students.

4) Voluntariness

In order to understand the real thoughts of teachers, the teachers selected in this study are all teachers with the spirit of inquiry and desire for research, and are willing to cooperate with the research.

2.2.2 Fifth grade students

In this study, 9 Grade 5 students was selected , and the selection principles included the following three points:

1) Grade and ability level

The research object is the fourth grade students. In order to understand the real situation of the students, this study selects the fifth grade students who are consistent with the target grade (fourth grade) and have certain mathematical problem-solving skills, and they have just learned relevant knowledge of the course to ensure that they can understand and participate in the discussion related to the course content.

2) Diversity

In order to obtain a more comprehensive perspective and feedback, students with different learning styles and ability levels were selected for this study.

3) Voluntariness

In order to understand the true thoughts of students, ensure the rights of students, and comply with relevant laws and ethical norms, the students selected for this study are all voluntary participants.

Semi-structured interview statement: Introduce myself and ask interviewees to introduce themselves. Explain the purpose of the interview. And asked interviewees to express their opinions freely. Take the form of notes to record.

2.3 Interview question design

In order to achieve the above purpose, the following semi-structured interview questions are designed in this paper:

2.3.1 Teacher semi-structured interview questions

Teachers are interviewed from five aspects: elements of mathematical problem solving skills, teaching content, teaching method, teaching evaluation and curriculum suggestions.

1) Elements of mathematical problem solving skills

Talk about your understanding of the problem solving proposed in the new curriculum standard? For example, what are the aspects of problem solving? What is the process?

In your experience, is math problem solving an important part of how students learn math? Why?

2) Course content

Do you think the problem solving examples in the textbook can develop students' problem solving skills? Why?

How do you handle these lessons? Have you encountered any problems or obstacles in teaching math problem solving? How did you handle it?

3) Teaching methods

How do you think to enhance students' math problem solving skills? Are there any particularly effective teaching methods or practical experiences you can share?

4) Learning Evaluation

How do schools evaluate the problem solving skills of pupils at present?

What do you think is the most effective way to evaluate students' problem-solving skills? Why?

5) Curriculum Suggestions

In what areas do you think the existing mathematics curriculum could be improved to better develop students' problem-solving skills?

What are the characteristics of your ideal learner-centered math curriculum? How would you like to implement such a curriculum?

2.3.2 Students' semi-structured interview questions

Students' interview questions were conducted from five aspects: understanding of mathematical problem solving skills, learning activities, learning styles, learning evaluation and course needs.

1) Understanding of mathematical problem solving skills

How do you understand math problem solving? Do you think it's useful in your life?

Do you use the math you learn in class to solve problems in your own life? Can you give me an example?

2) Learning Activities

Do you enjoy the problem situations your math teacher provides you with? Why?

What math content do you think will improve your problem-solving skills? Why?

3) Learning style

How do you like to study math?

In math class, do you prefer listening to the teacher or trying to solve problems by yourself?

What do you think are the advantages of studying math with your classmates?

4) Learning Evaluation

How do you think you are doing in math?

What kind of evaluation do you think can better reflect your mathematics learning results?

How would you like a teacher or parent to evaluate your math learning?

5) Curriculum requirements

What are your expectations for the math course?

How do you think the math curriculum should be improved to better meet your learning needs?

3. Basic statistics of interviewed teachers

Teacher	Sex	Teaching age	Teach grade now
1	Female	6	3th grade
2	Male	7	4th grade
3	Female	15	4th grade
4	Female	11	4th grade
5	Male	18	5th grade
6	Female	12	6th grade

4. The teacher teaching record form

Lecture topics		Time	
Student performance	1. Students' learning attitude 2. Classroom participation 3. Cooperation 4. Operation situation		
Communication and reflection after teaching			

5. Student semi-structured interview form

1) Purpose of interview

Understand students' attitudes and opinions about the course and evaluate the effectiveness of the course.

2) Interview objects

Fourth grade students participating in this course

Selection Principle: Select students with different learning styles, ability levels, and backgrounds to obtain a more comprehensive perspective and feedback. Specific method: Divide students into four levels according to their learning style, ability level and background. Randomly select 2 students from each level, and a total of 8 people will be interviewed. In order to protect the privacy of the students, numbers from 1 to 8 will be used. Students are numbered.

3) Interview questions

Interviews were conducted from five aspects: course content, teaching methods, learning experience and learning evaluation .

1. Course content

Question: Do you feel the course content matches your learning needs? Why?

2. Teaching methods

Question: What do you think about the teaching methods used by teachers?

Does it help you study?

3. Learning experience

Question: How was your learning experience in the classroom? What aspects impressed you?

4. Learning Assessment

Question: Do you think the evaluation method used in the course can truly reflect your learning results? Why?

6. Mathematics problem-solving skills test and Scoring criteria

6.1 Mathematical problem-solving skills test paper for fourth-grade students

Instruction: The test takes 80 minutes and consists of 7 seven real life problems, each answered in as much detail as possible in the following four steps:

1. Understand the problem (What do you know by reading the test questions? What data do you use? What is the unknown quantity in this problem? What is the problem to be solved? etc.).

2. Analyze the problem Write your solution? For example, what do you need to do first to solve the problem? What quantitative relations do we use in the test? What strategies are needed to solve the problem (drawing, listing, substitutions, assumptions, etc.)?

3. Solve the problem (detailed process of solving the problem, write out as many solutions as possible).

4. Review after solving the problem (Do you have any thoughts after solving the problem? For example, do you think your answer is correct and why? Review to solve this question Where are the key points of this question, what methods or strategies are used? How do you feel about solving the problem? etc.)

Topic 1:

Topic 1:

Xiao Ming had a fever, and his mother took him to the hospital to see a doctor. The doctor did a basic examination and suggested taking antipyretics and anti-inflammatory drugs.

Xiao Ming's basic information: six years old, height 120cm, weight 20g, body temperature 38. 7℃

Description of antipyretics:

[Product name and structural formula]

Official product name: ibuprofen suspension

Product name: Merrill Lynch

English name: Ibuprofen Suspension

The main ingredient of this product is ibuprofen, whose chemical name is 2-(4-isobutylphenyl)propionic acid

[Properties]This product is orange suspension, sweet in taste.

[Indications] It is used for fever caused by common cold or influenza in children. Also used to relieve mild to moderate pain in children, such as headache, joint pain, migraine, toothache, muscle pain, neuralgia, dysmenorrhea.

[Usage and Dosage] Take orally. The dosage for children under 12 years old is shown in the table below:

Age (years)	Body weight (kg)	A dosage (ml)	Time
1-3	10-15	4	If pain or fever persists, repeat the medication once every 4-6 hours and no more than 4 times in 24 hours.
4-6	16-21	5	
7-9	22-27	8	
10-12	28-32	10	

[Adverse reactions]

This product is well tolerated and has low side effects, generally mild intestinal and gastric discomfort, occasional rash and tinnitus, headache and elevated transaminases, etc. , and it has also been reported to cause gastrointestinal bleeding and aggravate ulcers.

[Contraindications]

1. Those who have allergic reactions to this product or other non-steroidal anti-inflammatory drugs are forbidden.

2. It is contraindicated for patients with active peptic ulcer.

Problem: How many milliliters can Xiao Ming take at most in a day?

Topic 2:

"Children's Day" is coming, and all major bookstores have launched promotional activities. The promotion plan of Xinxin Bookstore is "Subtract 20 from 100", and the promotion plan of Ruirui Bookstore is "buy 3 get 1 free" for all books. Teacher Liu wants to buy 16 copies of "Fun Mathematics" for the students in Class1grade 4. The price of each book in the two bookstores is 13 yuan.

Problem: Could you please help Mr. Liu choose which store is more cost-effective to buy books from?

Xinxin Bookstore   Ruirui Bookstore   13 yuan each book

Topic 3: Yang Ming wants to learn badminton and is going to buy a badminton racket and a cylinder of balls. The sporting goods store provides the following information:

Badminton racket		A brand	B brand	C brand
		120 yuan	80 yuan	100yuan

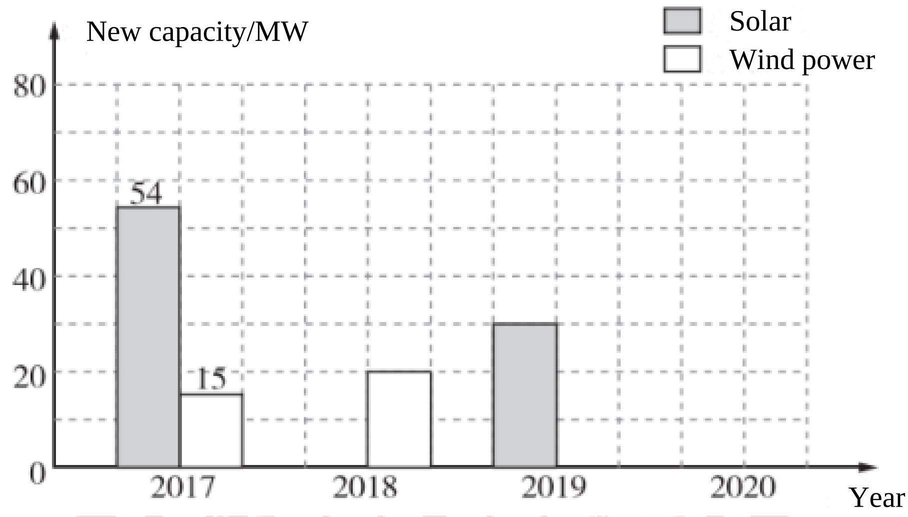
Badminton thread		18 lb thread	22 lb thread
		20yuan	30yuan
Hand glue		PU hand glue	
		16 yuan	
Badminton		Goose Feather Material (Pack of 10)	
		20yuan	

Problem: If you want to configure a set of badminton rackets (including two badminton rackets, a roll of badminton string, a roll of hand glue) and a can of balls, what is the difference between the highest and lowest prices in this shop?

Topic 4:

China has entered a new era of ecological development, and by 2060, it will achieve carbon neutrality (carbon dioxide emission and absorption offset, that is, zero emission). To reduce carbon emissions, we must vigorously develop green energy such as solar energy and wind power. The following are the statistical tables and charts of the newly added capacity of solar and wind power generation in my country from 2017 to 2020.

Year / New capacity/MW / Category	2017	2018	2019	2020
Solar	54	44		48
Wind power	15		25	72



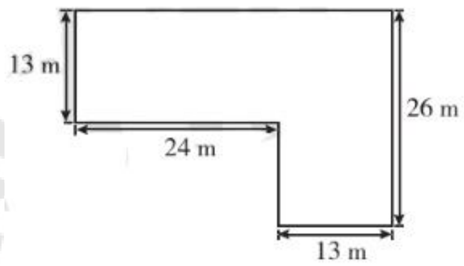
Problem: Compared with the average annual new capacity of solar power generation and the average annual new capacity of wind power generation, which one is more?

Topic 5:

According to media reports:

In September 2019, pork prices in all provinces were roughly the same, about 28 yuan/kg. As of December 2019, the price of pork in my country continued to rise, and the price of pork in most provinces in East China increased by 6 yuan/kg compared with September. Among them, the increase in Zhejiang is even closer to 7 yuan/kg, and the increase in Shaanxi Province in the northern region is 5 yuan/kg.

Problem: A primary school cafeteria in Hangzhou needs to purchase 40 kilograms of pork in December. If the price of pork in September is used and the

budget is not changed, how many kilograms of pork can be purchased with this money?
Topic 6: Labor is the basis of life, the source of happiness, and the only way for everyone to achieve success and glory. Labor is not only a way of survival, but also the basis for the formation of a good character. Problem: In order to strengthen the labor awareness and skills of the students, Guanghua Primary School opened up a labor practice base (pictured below) for the students to carry out labor practice. How many square meters is the area of this labor base? 
Topic 7: There is a rectangular public green space that is 150 meters long and five times as long as it is wide. In order to beautify the environment and provide a comfortable place for residents to relax, it is planned to use artificial square lawns with a side length of 3 decimeters to pave the green space. Problem: How many of these artificial squares would it take to cover an entire public green space?
Note: In order to more clearly test the students' ability to review, the following options to assist this question marking Did you reflect or validate after doing the problem?A. I substituted the answer into the formula to check the calculation B. I not only brought the answer into the verification, but also sorted out the idea C. I not only brought the answer into the verification, sorted out the idea of understanding the question, but also compared it with the previous questions and made a comparison.D. I didn't reflect or validate

Item	1	2	3	4	5	6	7
Option							

6.2 Scoring criteria of mathematics problem-solving skills test paper

Topic 1: 20g is between 16-21g, so Xiao Ming can drink 5ml at a time,No more than 4 times in 24 hours. It is concluded that Xiao Ming drinks up to 4 times a day, 5×4=20 (ml) Answer: Xiao Ming should not take more than 20 milliliters a day.	Understanding the problem: know the known and unknown quantities (2 points); know that Xiao Ming takes medicine up to 4 times a day (2 points). Analyzing the problem: If you want to figure out the answer clearly, you should choose 5ml each time according to your age and weight (2 points); when you know how much to drink four times, use multiplication (2 points). Solving the Problem: write the correct formula (2 points); the calculation result is correct (1 point); the unit is correct (1 point). Reviewing after problem solving: Choose A to get 1 point; 2 points for choosing B; Choose C to get 3 points; Choose D to get 0 points; If the result of the calculation is correct, one point will be added to the result of the option.
Topic 2: Xinxin Bookstore: 16×13-20-20=168 (Yuan) Rui Rui Bookstore: 12×13=156 (Yuan) 156 < 168 Choose Rui Rui Bookstore to buy books. It cost 156 Yuan at least.	Understanding the problem: know the known and unknown quantities (1 point); Know the meaning of Xinxin Bookstore promotion plan (1 point); Know the meaning of Rui Rui Bookstore promotion program (1 point); Know how much each book costs (1 point). Analyze the problem: Clearly figure out how much money Xinxin Bookstore and Ruirui Bookstore each need, and then compare the cost of the two programs (1 point); Know the algorithm of Xinxin Bookstore fee (1 point); Know the algorithm of Xinxin Bookstore (2 points). Solve the problem: Correctly write the Xinxin Bookstore formula (1 point); Correctly write the Xinxin Bookstore formula (2 points); Results are obtained (1 point).

Topic 3: Highest price: 120×2+30+16+20=306 (yuan) Lowest price: 80×2+20+16+20=216 (yuan) Answer: The highest price configured in this store is 306 yuan, and the lowest price is 216 yuan	Understanding the problem: Be able to understand the meaning of the question and know the known and unknown quantities (2 points); when you know the highest price, choose brand A for badminton rackets, and choose 22 lb thread, for badminton strings (1 point); when you know the lowest price, choose brand B for badminton rackets, 18 lb thread, for badminton strings (1 point); Analyzing the problem: clear the algorithm when the price is the highest (2 points); know the algorithm when the price is the lowest (2 points). Solving the problem: The formula at the highest price is correct (1 point), and the answer is correct (1 point); the formula at the lowest price is correct (1 point), and the answer is correct (1 point). Reviewing: self-conscious calculation (2 points);Correct calculation (1 point); review thinking (1 point).
Topic 4: Solar power generation: (54+44+30+48) ÷ 4=44 (million watts) Wind power generation: (15+20+25+72) ÷ 4=33 (million watts) Answer: The average annual capacity of solar power generation is more	Understanding the problem: can read the question to know the known and unknown quantities (2 points); knows that 30 megawatts of new solar capacity will be added in 2019 (1 point); knows that 20 megawatts of new wind capacity will be added (1 point; Analyzing the problem: Know that the new capacity of each type of power generation is the sum of four years (2 points); average new capacity per year = total new capacity ÷ 4 (2 points). Solving the problem. Calculate the average annual additions of solar power (1.5 points); Calculate the average annual additions of wind power (1.5 points). Derive the result (1 point). Reviewing: self-conscious calculation (2 points);Correct

than that.	calculation (1 point); review thinking (1 point).
Topic 5: The unit price of 12 pieces of pork in Zhejiang is: 28+7=35 (yuan) 40×35=1400 (yuan) 1400÷28=50 (kg) Answer: This money can buy 50 kilograms of pork.	Understanding the question: able to understand the meaning of the question and know the known and unknown quantities (2 points); know the meaning of the question (2 points). Analyzing the problem: know the unit price of pork in Zhejiang in December = unit price in September + 7 (1 point); know the budget amount = quantity of pork × unit price of pork in December (1 point); know the quantity of pork purchased = budget amount ÷ The unit price of pork in September (2 points). Solving the problem: Calculate the unit price of pork in Zhejiang in December (1 point); calculate the budget amount (1 point); calculate the quantity of pork purchased (2 points) Reviewing: self-conscious calculation (2 points);Correct calculation (1 point); review thinking (1 point).
.Topic 6: Method 1: 13×24+13×26=650 (m2) Method 2: 13×26+13×(24+13)-13×13=650 (m2) Method 3: 13×(24+13)+13×(26-13)=650(m2) Answer: The area of this labor base is 650 square meters.	Understanding the question: able to understand the meaning of the question and know the known and unknown quantities (2 points); know the meaning of the question (2 points). Analyzing the problem: know the formula of the area of a rectangle = length × width (2 points); be able to divide the figure into two rectangles for calculation. (2 minutes). Solving the problem: the column formula is correct (2 points): the answer is correct (1 point); provide the second algorithm (1 point). Reviewing: self-conscious calculation (2 points);Correct calculation (1 point); review thinking (1 point).
The width of the	Understanding the problem: Can understand the meaning of the

rectangle=150÷5=30 (meters) The area of the rectangle=150×30=4500 (square meter)=450000 (square decimeter) Area of a square = 3 × 3 = 9 (square decimeters) Number of lawn blocks=450000÷9=50000 (blocks)	question and know the known and unknown quantities (2 points); know the relationship between length and width, 3 decimeters are the side length of a square (2 points). Analyzing the problem:Know the width of a rectangle = length ÷ 5 (1 point), the area formula of a rectangle = length × width (1 point), the area of a square = side length × side length (1 point), the number of lawn blocks = area of a rectangle ÷ square area (1 point) Solving the problem: the method is correct (3 points) provide the second algorithm (1 point). Reviewing: self-conscious calculation (2 points);Correct calculation (1 point); review thinking (1 point).

7. Expert Information form

No.	Gender	Teaching age	Professional title	Workplace	Research area
Expert 1	Male	35	Professor	School of Mathematics and Statistics, Zhoukou Normal University	Mathematics education
Expert 2	Male	25	Associate Professor	School of Mathematics and Statistics, Zhoukou Normal University	Mathematics education
Expert 3	Female	25	Senior teacher	Silver joo primary	Primary mathematics education
Expert 4	Male	19	Associate	School of Education	Curriculum

			Professor	Science, Jiangsu Normal University	and Teaching Methodology
Expert 5	Female	26	Associate Professor	School of Education Science, Zhoukou Normal University	Educational measurement and evaluation

8. Mathematical problem-solving skills test evaluation form

The evaluation form consists of two parts: Part 1: Basic information of the experts and Part 2: Evaluation form for Mathematical problem-solving skills test.

Part 1: Basic Information of experts: Name: Major:

Teaching Age: Work unit: Phone:

E-mail Address: Address:

Part 2: Evaluation form for Mathematical problem-solving skills test.

Note: Please mark √ in the evaluation results according to your opinion.

There are three levels:

1 indicates that the problem situation is consistent with the content.

0 indicates that the uncertain problem situation is consistent with the content.

-1indicates that the problem situation is inconsistent with the content.

Items	Evaluation results		
	Consistent(+1)	Unsure(0)	Inconsistent(-1)
1			
2			
3			
4			
5			
6			
7			

Calculate mean score of each item then interpret the consistency following criteria

> 0. 5 consistency

< 0. 5 inconsistency (improve it before implementation)

9. Checking the quality of the curriculum before implementation

Basic Information of experts: Name: Major:

Teaching Age: Work unit: Phone:

E-mail Address: Address:

2. Appropriate checking

Using 5 levels of the rating scale and evaluating by external expertise (5 people) who have knowledge and experience relevant your curriculum. Appropriate checking form as follows.

Appropriate checking form of the curriculum

Direction: Please mark √ in the evaluation results according to your opinion.

No.	Items	Evaluation results				
		5	4	3	2	1
1	Curriculum principles					
	1. 1 Reasonable					
	1. 2 Theoretical concepts used to support					
	1. 3 Lead to practice					
2	Curriculum objectives					
	2. 1 Clear and concrete					
	2. 2 Can be measured and evaluated					
	2. 3 Suitable for the target group					
3	Curriculum content					
	3. 1 Meet the curriculum objectives					
	3. 2 Academically correct					
	3. 3 Suitable for the target group					
4	Learning activities					
	4. 1 Meet the curriculum objectives					

	4. 2 Suitable for the target group					
	4. 3 Interesting and possible					
5	Curriculum materials					
	5. 1 Meet the learning activities					
	5. 2 Suitable for the target group					
	5. 3 Interesting and possible					
6	Curriculum evaluation					
	6. 1 Meet the curriculum objectives					
	6. 2 Suitable for the target group					
	6. 3 Possible to practice					

Calculate mean score and interpret of each item. If the mean score below 3. 50 then improves it before implementation.

3. Consistency checking

Using the IOC (Index of item consistency) and evaluating by external expertise (5 people) who have knowledge and experience relevant your curriculum. Consistency checking form as follows.

Consistency checking form of the curriculum

Direction: Please mark √ in the evaluation results according to your opinion.

No.	Items	Evaluation results		
		Consistent (+1)	Unsure (0)	Inconsistent (-1)
1	Curriculum principles and curriculum objectives			
2	Curriculum principles and learning activities			
3	Curriculum objectives and curriculum content			
4	Curriculum objectives and learning activities			
5	Curriculum content and learning activities			
6	Curriculum content and learning materials			
7	Curriculum content and learning resources			
8	Curriculum content and learning duration			

9	Curriculum evaluation and curriculum objectives			

Calculate mean score of each item then interpret the consistency following criteria

> 0. 5 consistency

< 0. 5 inconsistency (improve it before implementation)

Do you have any other suggestions? Please write it down!

APPENDIX B

1.Results of the classroom observation record

1.1 Teacher teaching behavior

1) Handling of teaching materials

Most teachers mainly focus the situation shown by the textbook examples, which is basically the only situation in a class, without providing broader materials for students to find problems. A few teachers are able to adapt the material to the specific situation of the student. Few teachers can rely on the teaching material situation and create their own situation from real life in combination with specific teaching content, and it is difficult to draw inferences about other cases from one instance.

2) Teaching methods and strategies

The teaching methods and strategies used by teachers are relatively unitary. Most teachers use the teaching method. Experienced teachers are used to summarize the problems in the problem solving part into various types of problems and teach them to students, and then consolidate them through a lot of exercises. Teachers pay more attention to the standard requirements of the procedure and format of problem solving, and give less guidance to the methods and strategies of problem solving. Some teachers, especially young teachers, tend to use new teaching methods, such as cooperative learning, situational teaching, gamification teaching, questioning and so on. Through classroom observation, it is found that these methods can effectively stimulate students' learning interest and participation. But there are some problems, for example, not every member of the group is proactive; Not all problem situations created by teachers can stimulate students' learning enthusiasm; Some classes discuss too many questions and are too simple; The students' interest in playing games is high, but the discipline is poor.

3) Classroom management

In the classroom management, teachers show certain control, strict requirements on students, and control the classroom discipline with the authority of teachers. Some teachers usually ask students to think about the answers beyond the scope of teaching, and generally do not make evaluation or even ignore them.

4) Interaction between teachers and students

The teacher-student interaction is not good, and the student-student interaction is very little. The teacher talks too much and the students talk less. Usually, the students answer the questions raised by the teachers, and few students ask questions on their own initiative.

5) Attention to students

Teachers pay little attention to students, pay little attention to the cultivation of students' learning interests and learning habits, and provide limited guidance to students' learning methods and strategies in the teaching process. Some teachers lack patience and detail in answering students' questions, resulting in students not being able to fully understand the answers.

6) Teacher evaluation and feedback

Most teachers give verbal encouragement when evaluating students, but the language is too simple, usually using "very good", "you are great", "good answer", etc. , can not be specific to what students do well. Some teachers give points to students.

7)Technology use

Most teachers are proficient in operating computers. With the help of multimedia-assisted teaching, the use of the Internet in the classroom is seldom. Usually, the content of the teaching design is displayed in PPT in class.

1.2 Students' learning behavior

1) Students' attitude towards lectures

In the first few minutes of class, most students can listen to the teacher carefully. With the increase of time, the number of students with inattention increases. Some students look around and some students do things that have nothing to do with study.

2) Students' classroom participation

Some students participate in classroom interaction, and the number of students who take the initiative to answer questions is relatively small and fixed, and the communication between teachers and students is less.

3) Students' thinking ability

Students spend less time thinking independently, most of the time listening to the teacher and solving problems under the guidance of the teacher, lacking the spirit of active exploration.

4) Students' cooperation ability

Some students are very active in cooperative learning, while some students have nothing to do, low interest and low participation.

5) Students' problem-solving skills

Most students can use their knowledge to solve the example problems presented by the teacher, but when the problem situation changes slightly, or when similar situations occur in life, they cannot solve the problem well, and their innovative thinking ability is not good.

6) Students' independent learning ability

Students' independent learning ability is weak, and most of them can not use various resources for independent learning.

2. Results of curriculum appropriateness evaluation

Category	Items	Evaluation expert number					Mean	Std. Deviation	Level of appropriateness
		1	2	3	4	5			
Curriculum principles	1.1 Reasonable	5	4	5	5	5	4.8	.45	Very high
	1.2 Theoretical concepts used to support	5	4	5	4	5	4.6	.55	Very high
	1.3 Lead to practice	5	4	5	4	5	4.6	.55	Very high
Curriculum objectives	2.1 Clear and concrete	5	5	4	4	5	4.6	.55	Very high
	2.2 Can be measured and evaluated	4	4	5	4	5	4.4	.55	High
	2.3 Suitable for the target group	5	4	5	4	4	4.4	.55	High

Curriculum content	3.1 Meet the curriculum objectives	5	4	4	4	5	4.4	.55	High
	3.2 Academically correct	5	4	4	4	4	4.2	.45	High
	3.3 Suitable for the target group	5	4	4	4	4	4.2	.45	High
Learning activities	4.1 Meet the curriculum objectives	4	5	4	4	5	4.4	.55	High
	4.2 Suitable for the target group	5	4	4	4	5	4.4	.55	High
	4.3 Interesting and possible	4	5	4	4	5	4.4	.55	High
Teaching method	5.1 Meet the learning activities	5	4	5	4	5	4.6	.55	Very high
	5.2 Suitable for the target group	4	4	5	4	5	4.4	.55	High
	5.3 Interesting and possible	4	4	4	4	5	4.2	.45	High
Curriculum evaluation	6.1 Meet the curriculum objectives	4	4	4	5	5	4.4	.55	High
	6.2 Suitable for the target group	5	4	4	4	5	4.4	.55	High
	6.3 Possible to practice	4	4	4	4	5	4.2	.45	High

Note: The appropriateness level in the mathematics curriculum is explained as follows:

Mean scores 4. 51 – 5. 00 indicates Very high level;

Mean scores 3. 51 – 4. 50 indicates High level;

Mean scores 2. 51 – 3. 50 indicates Moderate level;

Mean scores 1. 51 – 2. 50 indicates Low level;

Mean scores 1. 00 – 1. 50 indicates Very low level;

3. Results of curriculum Consistency evaluation

No.	Items	Evaluation expert number					IOC	Meaning
		1	2	3	4	5		
1	Curriculum principles and curriculum objectives	1	1	1	1	0	0. 8	Consistent
2	Curriculum principles and learning activities	1	1	1	1	1	1. 0	Consistent
3	Curriculum principles and Teaching method	1	1	0	1	1	0. 8	Consistent
4	Curriculum objectives and curriculum content	1	0	1	1	1	0. 8	Consistent
5	Curriculum objectives and learning activities	1	1	1	0	1	0. 8	Consistent
6	Teaching method and learning activities	1	1	0	1	1	1. 0	Consistent
7	Curriculum content and learning resources	1	1	1	1	1	1. 0	Consistent
8	Curriculum content and learning duration	1	0	1	0	1	0. 6	Consistent
9	Curriculum evaluation and curriculum objectives	1	1	1	0	1	0. 8	Consistent

4. Results of Mathematical problem-solving skills test evaluation

No.	Evaluation expert number					IOC	Meaning
	1	2	3	4	5		
1	1	1	1	1	0	0. 8	Consistent
2	1	1	0	1	1	0. 8	Consistent
3	1	1	1	1	1	1. 0	Consistent
4	1	0	1	1	1	0. 8	Consistent
5	1	1	1	0	1	0. 8	Consistent

6	1	1	1	1	1	1. 0	Consistent
7	1	1	1	1	1	1. 0	Consistent

Calculate mean score of each item then interpret the consistency following criteria

> 0. 5 consistency

< 0. 5 inconsistency (improve it before implementation)

5. The difficulty (p), discriminability (r) and reliability of Mathematical problem-solving skills tests items

Item	difficulty (p)	discriminability (r)	result
1	0. 41	0. 26	Apply to experiment
2	0. 47	0. 37	Apply to experiment
3	0. 59	0. 29	Apply to experiment
4	0. 45	0. 32	Apply to experiment
5	0. 45	0. 33	Apply to experiment
6	0. 42	0. 42	Apply to experiment
7	0. 56	0. 35	Apply to experiment

The reliability of the problem-solving test is 0. 72.

Note:

Ttem difficulty (p) between 0. 20 to 0. 80

Ttem discriminability (r) above 0. 20

A total of 40 students took the test

6. Mathematical problem-solving skills pretest scores

NO.	Understanding Scores (28)	Analyzing scores(28)	Solving Scores(28)	Reviewing scores(28)	Total scores(112)
1	19	19	17	16	71
2	15	14	13	12	54
3	13	11	9	10	43
4	15	14	15	14	58
5	22	19	19	18	78

6	18	17	15	14	64
7	18	18	18	16	70
8	17	14	15	15	61
9	20	18	18	14	70
10	21	20	20	14	75
11	18	17	15	15	65
12	20	19	18	16	73
13	23	21	21	18	83
14	19	18	18	17	72
15	20	18	17	12	67
16	18	16	15	15	64
17	26	24	23	20	93
18	22	21	21	20	84
19	19	17	18	18	72
20	20	18	15	12	65
21	17	15	14	13	59
22	18	18	17	13	66
23	19	18	16	14	67
24	18	18	18	17	71
25	25	23	21	20	89
26	19	19	17	15	70
27	24	22	22	18	86
28	21	21	20	19	81
29	20	19	18	16	73
30	22	22	21	17	82
31	21	20	19	16	76
32	25	24	24	21	94
33	20	19	18	18	75
34	21	20	17	15	73

35	20	19	19	17	75
36	19	16	17	17	69
37	15	14	13	12	54
38	18	17	18	15	68
39	12	13	11	10	46
40	11	10	9	7	37

7. Mathematical problem-solving skills posttest scores

NO.	Understanding Scores (28)	Analyzing scores(28)	Solving Scores(28)	Reviewing scores(28)	Total scores(112)
1	21	19	20	15	75
2	20	19	19	16	74
3	18	13	12	12	55
4	21	19	18	16	74
5	23	21	22	20	86
6	18	17	16	16	67
7	17	16	15	12	60
8	24	22	21	16	83
9	22	20	20	16	78
10	21	21	21	15	78
11	20	19	18	17	74
12	20	21	22	19	82
13	23	22	18	20	83
14	20	18	17	18	73
15	17	16	11	10	54
16	21	20	17	20	78
17	26	25	25	23	99
18	23	22	22	19	86
19	18	15	15	17	65
20	23	20	19	17	79

21	18	15	14	12	59
22	21	21	20	19	81
23	24	21	20	18	83
24	24	24	24	22	94
25	28	26	25	24	103
26	23	22	22	16	83
27	26	25	24	23	98
28	24	22	23	22	91
29	24	22	22	18	86
30	25	24	23	20	92
31	21	20	20	18	79
32	27	26	27	25	105
33	24	24	22	23	93
34	25	22	20	18	85
35	24	24	21	18	87
36	16	16	14	15	61
37	17	18	17	21	73
38	20	19	18	15	72
39	15	12	12	13	52
40	14	11	13	13	51

8.Certificate in Ethical Principle to Research Involving Human Subject

คณะศิลปกรรมศาสตร์
มหาวิทยาลัยศรีนครินทรวิโรฒ

คณะศิลปกรรมศาสตร์

ร่วมกับ

คณะกรรมการจริยธรรมสำหรับพิจารณาโครงการวิจัยที่ทำในมนุษย์ มหาวิทยาลัยศรีนครินทรวิโรฒ

ประกาศนียบัตรฉบับนี้ให้ไว้เพื่อแสดงว่า

Dongmei Lyu

ได้ผ่านการฝึกอบรมโครงการจริยธรรมการวิจัยในมนุษย์ เรื่อง "หลักจริยธรรมการวิจัยในมนุษย์"
(Ethical Principle to Research Involving Human Subject)

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9.Certificate of Ethical Committee Approval

AF20-03-03.0
May, 2023

Certificate of Ethical Committee Approval

This is to certify that:

Protocol Title: The Development of learner-centered mathematics curriculum for cultivating mathematical problem-solving skills in primary school students.
Principal investigator: Ms.DONGMEI LYU
Institution: Graduate School of Srinakharinwirot University
Protocol code: SWUEC-672228
Documents approved:

1. Submission form — version no. 2 date 17 April 2024
2. Full research proposal — version no. 1 date 16 February 2024
3. Participant information sheet and consent form — version no. 2 date 17 April 2024
4. Questionnaire/data collection form — version no. 1 date 16 February 2024
5. Investigator's biography

have been reviewed and approved by the Human Research Ethics Committee of Srinakharinwirot University based on Declaration of Helsinki, Belmont Report, International Conference on Harmonization in Good Clinical Practice (ICH-GCP), International Guidelines for Human Research, along with laws and regulations of Thailand. Thus, the approval for conducting the study is granted.

Date of approval: 22/04/2024
Date of expiration: 21/04/2025

(Associate Professor Sittipong Wattananonsakul, Ph.D.)
Chairman, Social Science and Behavioral Science Research Sub-Committee
of Srinakharinwirot University (Panel 2)

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APPENDIX C

The learner-centered mathematics curriculum for cultivating mathematical problem-solving skills in primary school students

1. Curriculum principles

The learner-centered mathematics curriculum for cultivating mathematical problem-solving skills in primary school students is a developed curriculum. The curriculum follows the provisions of the Outline of the National Medium and Long-term Education Reform and Development Plan (2010-2020) and the Compulsory Education Mathematics Curriculum Standards (2022 edition), advocating student-oriented, so that every student can get a good mathematics education, and different students get different development in mathematics.

The curriculum is learner-centered and deeply integrated with the needs, interests and experiences of students, with a variety of carefully designed learning activities. We use a variety of teaching methods such as gamification, cooperative learning and problem-based teaching to maximize students' interest in learning and ensure that every student can actively participate in deep learning. In the process of teaching, teachers will act as facilitators and facilitators to help students build their own mathematical knowledge system, improve their independent learning ability and the ability to solve practical problems. At the same time, we use a variety of evaluation methods, provide timely and effective feedback, and comprehensively evaluate the development of students, in order to promote their comprehensive and balanced growth. The following points should be done as far as possible in the course design and implementation process:

1) Learner-Centered principles

Curriculum design should take the needs, interests and abilities of students as the starting point to ensure that the curriculum content is in line with the actual life experience and cognitive level of students. By understanding students' backgrounds, learning habits and mathematical foundations, we can customize a personalized learning path so that each student can find their own orientation and development space in the course.

2) The principle of practicality

Emphasize the practical application of mathematical problem solving ability, design mathematical problems with practical significance, so that students can master mathematical knowledge and methods in the process of solving problems. Through project-based learning and case analysis, students are guided to apply what they have learned to real life and cultivate their practical ability and innovative thinking.

3) Principle of gradual and orderly progress

According to the law of cognitive development of students, reasonable arrangement of course content and difficulty. Start with basic concepts and gradually introduce complex mathematical problems and solutions to ensure that students have the joy of success at every stage. At the same time, it pays attention to the coherence and systematicness of knowledge to help students build a complete mathematical knowledge system.

4) The principle of diversified evaluation

A variety of evaluation methods are used to evaluate students' mathematical problem-solving skills comprehensively and objectively. In addition to the traditional written test and homework, oral reports, group cooperation, practical operation and other evaluation methods can be introduced in order to gain a more comprehensive understanding of students' learning and ability development. At the same time, pay attention to the feedback and guidance of evaluation to help students find their shortcomings in time and make improvement plans.

5) Principle of interactivity

Encourage cooperation and communication among students, design interactive links such as group cooperation and discussion, so that students can learn to listen, express and think in the interaction. Through the interaction between teachers and students, students and other forms, to create a positive learning atmosphere, stimulate students' learning interest and initiative. At the same time, teachers should actively participate in the interactive process of students and give timely guidance and help.

6) Principle of fun

Incorporate fun elements into the course design, such as games, competitions, etc. , so that students can learn math problem solving skills in a relaxed and pleasant atmosphere. Through the creation of vivid and interesting situations and problems, stimulate students' curiosity and desire to explore, so that they can enjoy the fun of learning while improving their mathematical literacy and ability level.

2. Curriculum objectives

The overall objective of this curriculum: to improve students' ability to solve mathematical problems in the process of cooperative inquiry through the development and implementation of this course.

Specific objectives:

To enable students to understand the relationship between mathematics knowledge and life, and to understand, discover and raise questions in exploring the relationship contained in real situations;

Experience independent thinking and cooperation with others to solve problems in the process of exploring ways to analyze and solve problems;

Able to use mathematical knowledge and methods to analyze and solve problems;

Able to preliminarily judge the rationality of the result;

Form a preliminary model consciousness, geometric intuition and application consciousness.

3. Curriculum content

The selection of the curriculum content should be based on the curriculum objectives, which aim to improve the mathematical problem solving ability of primary school students. Students' problem-solving skills is influenced by their own factors, such as knowledge base, problem-solving strategy, metacognition, belief, motivation, functional fixation, thinking set and self-efficacy, etc. At the same time, problem factors, such as familiarity, structural characteristics and situational complexity, cannot be ignored. Therefore, when selecting course content, We pay special attention to the combination of basic knowledge and life examples. Guided by the "Compulsory Education Curriculum Standards (2022) Edition", we deeply analyze the learning standards, core content, expected learning outcomes and elements related to curriculum content design of basic mathematics education curriculum. On this basis, combining with the existing textbooks of basic mathematics education, we divide the course content into four areas: Numbers and Algebra; Geometry and Graphics; Statistics and Probability; Synthesis and Practice. These four areas are progressively developed to ensure that students are exposed to topics appropriate to their cognitive level at each stage.

According to the cognitive development characteristics and interests of the fourth grade students, we have carefully designed the curriculum content in combination with the curriculum objectives. The content of the course is based on restoring real life situations, focusing on fun and vividness, aiming at stimulating students' interest in learning. We have designed four units respectively: Four arithmetic operations; Rectangle and square; Averages, bar charts and possibility; Nutrition lunch. The first three units all contain two parts of basic knowledge and life examples, so that students can master mathematical knowledge and methods in the process of problem solving, and enhance their problem-solving skills. The Nutrition lunch module is integrated and practical, requiring students to apply their previous knowledge and interdisciplinary knowledge to solve practical problems. This design is designed to allow students to experience the practical application of mathematics in real problem situations and to cultivate their interdisciplinary comprehensive literacy. The specific curriculum content is set as follows:

3.1 Before curriculum revision

Learning unit	Content
Module 1: numbers and algebra	
1.four arithmetic operations	1.1 The meaning of addition and subtraction and the relationship between the parts
	1.2 The meaning of multiplication and division and the relationship between each part

	1.3 Relationship among unit price, quantity and total price
	1.4 Promotion activity
	1.5 24-point calculation technique
	1.6 Chartering problem
Module 2: geometry and graphics	
2: rectangle and square	2.1 The circumference of a rectangle and a square
	2.2 Cognitive area
	2.3 Area of rectangle and square
	2.4 Practical application
Module three: statistics and probability	
3. averages, bar charts and possibility	3.1 Average
	3.2 Compound bar chart
	3.3 Possibility
Module four: synthesis and practice	
4. nutrition lunch	4. Nutrition lunch
5. posttest	Pupils do the posttest

According to the opinions of five course experts, the curriculum content has been revised, and the revised curriculum is as follows:

3.2 After curriculum revision

Learning modules and units	Learning content

Module 1: Numbers and Algebra 1. Four arithmetic operations	Basic knowledge	1. 1 The meaning of addition and subtraction and the relationship between the parts 1. 2 The meaning of multiplication and division and the relationship between each part 1. 3 24-point calculation technique 1. 4 Relationship among unit price, quantity and total price
	Practical problems of life	1. 5 Promotion activity 1. 6 Chartering problem
Module 2: Geometry and Graphics 2. Rectangle and square	Basic knowledge	2.1 The circumference of a rectangle and a square 2. 2 Cognitive area 2. 3 Area of rectangle and square
	Practical problems of life	2. 4 Practical application
Module 3: Statistics and Probability 3. Average, bar chart and possibility	Basic knowledge	3. 1 Average 3. 2 Compound bar chart 3. 3 Probability
	Practical problems of life	3. 4 Household budget
Module 4: Synthesis and practice 4. Nutrition lunch	Synthetic application	4. Nutrition lunch

4. Teaching methods

The choice of instructional technology must be consistent with the principles and objectives of the curriculum. The teaching design of this study has carried out the core concept of "learner-centered". Under the guidance of this concept, teachers should comprehensively consider the characteristics of students, learning goals and educational requirements, flexibly adopt a variety of teaching methods, aimed at stimulating students' learning interest and improving learning results. This research mainly adopts three innovative teaching methods: cooperative learning, Problem-Based Learning and gamification teaching. In Problem-Based Learning, we craft mathematical problems that are both real and complex. Firstly, in the basic knowledge learning module, gamification and cooperative learning methods are chosen. Gamification is used to stimulate students' interest in learning, while cooperative learning is employed to develop students' problem-solving skills. The design flow of the teaching process based on basic knowledge learning is shown in the following table:

Teaching process flow	Method specific application
Introduction and review:	At the beginning of the lesson or the start of the course, teachers can design short games to help students review the knowledge points they have learned before. Such games can be a form of questions and answers, guessing riddles, or role -playing, which aims to stimulate students' memories of previous learning content. Gamification can increase the fun of review here, allowing students to consolidate old knowledge in a relaxed atmosphere. At the same time, we can also design knowledge games related to the study of this lesson to introduce new lessons and stimulate students' interest in learning.
Situation creation and question raising	To make cooperative learning more effective, teachers can create a problem situation related to students' real life to stimulate students' interest in learning and desire to explore. Teachers raise questions and guide students to conduct cooperative learning.
Cooperative inquiry and problem solving	Use cooperative learning method to improve students' problem-solving skills from four aspects: understanding, analyzing, solving and reflecting on problems: Students are divided into groups, and members within each group work

	together to analyze and understand problems from multiple perspectives. According to the principle of "heterogeneity within the group and homogeneity between groups", combined with the pre-test results of problem-solving skills, students were divided into ten groups, each with 4 people (40 in total). In cooperative learning, each student in the group must have clear tasks, a certain division of labor, and a specific role. The roles can be the following four: 1) Group leader: coordinate various tasks within the group, guide group activities, and ensure that cooperative tasks are completed on time; 2) Recorder: record the results of group discussions; 3) Supervisor: supervise student learning and maintain group discipline; 4) Reporter: report learning results. Members of each group work together to analyze and understand problems from multiple perspectives. By brainstorming, students can analyze problems more comprehensively and find multiple possible solutions. Group members work together to solve problems. After the problem is solved, students reflect on the process, summarize the gains and losses, and further improve their problem-solving skills
Knowledge consolidation	In the final stage of the course or after class, teachers can use gamification teaching again to help students consolidate the knowledge learned in this lesson. These games can be in the form of knowledge questions and answers, role play, simulation exercises, etc. , aimed at allowing students to deepen their understanding and memory of knowledge points in a relaxed and pleasant atmosphere.
Evaluation and Reflection	Teachers guide students in conducting evaluations and reflections. Students are encouraged to assess their own performance in the current learning session, identify the knowledge and skills they have acquired during the class, and pinpoint areas where they lack proficiency and require improvement. Additionally, peer evaluation within groups is promoted, as it fosters mutual understanding, enables

	students to learn from each other's strengths, and collectively explores avenues for growth. This peer evaluation should be based on principles of respect and constructiveness, focusing on specific behaviors and suggestions to promote positive interaction and collaboration. Concurrently, teachers can adjust and optimize their teaching methods and content according to student performance and feedback, aiming to better meet the learning needs of students. By encouraging peer evaluation, students gain insights from their peers' perspectives, enhancing the overall learning experience.
Use game elements such as points, medals and other incentive students during the period	Throughout the teaching process, teachers can use game elements such as points and medals to motivate students to actively participate in learning and discussions. Students can obtain points and medals through answering questions, participating in group discussions, and putting forward innovative perspectives. These rewards can be used as recognition and encouragement of their learning results. This incentive mechanism can improve students' learning enthusiasm and participation, and create a positive learning atmosphere.

Secondly, in the practical application learning module, cooperative learning, Problem-Based Learning and gamification methods are selected. Problem-Based Learning is utilized to create real-world, complex, and open problem situations, and cooperative learning is employed to foster students' problem-solving skills, Use gamification to consolidate exercises. The design flow of teaching process based on practical application is shown in the following table:

Teaching process flow	Method specific application

Preparation before class	Before class, teachers should analyze students' mathematical foundations, learning interests, and habits, and design a series of challenging and enlightening questions in conjunction with teaching objectives to guide students in thinking and exploration. Provide students with some pre-learning guidance to help them understand the content and focus of the class ahead of time, assisting them in better comprehending and mastering the knowledge.
Situation creation, problem introduction	Problem-Based Learning: Teachers can create a vivid and engaging problem scenario through stories, examples, multimedia tools, or other means, enabling students to discover and pose problems within the scenario and generate a desire to solve them. Selection of Problems: Teachers should choose problems that are related to students' life experiences and possess a challenging nature. These problems should stimulate students' exploration desires and possess a certain level of authenticity and value for contemplation. For instance, when learning to apply the four basic arithmetic operations to solve practical problems in life, teachers can propose questions such as "How to choose the most cost-effective method based on mall promotional activities?" When learning to solve practical problems related to area in life, questions like "How to purchase floor tiles based on the area of a house?" can be raised. Design of Problems: Problems should be designed with a hierarchical structure, ranging from easy to difficult, gradually guiding students into deeper thinking. Simultaneously, there should be logical connections between problems, aiding students in constructing a complete knowledge system. When designing problems, teachers also need to consider students' cognitive levels and thinking characteristics, ensuring that the problems are neither too simple nor overly complex.

Cooperative learning, problem solving	Cooperative learning method Use cooperative learning method to improve students' problem-solving skills from four aspects: understanding, analyzing, solving and reflecting on problems: Students are divided into groups, and members within each group work together to analyze and understand problems from multiple perspectives. According to the principle of "heterogeneity within the group and homogeneity between groups", combined with the pre-test results of problem-solving skills, students were divided into ten groups, each with 4 people (40 in total). In cooperative learning, each student in the group must have clear tasks, a certain division of labor, and a specific role. The roles can be the following four: 1) Group leader: coordinate various tasks within the group, guide group activities, and ensure that cooperative tasks are completed on time; 2) Recorder: record the results of group discussions; 3) Supervisor: supervise student learning and maintain group discipline; 4) Reporter: report learning results. Members of each group work together to analyze and understand problems from multiple perspectives. By brainstorming, students can analyze problems more comprehensively and find multiple possible solutions. Group members work together to solve problems. After the problem is solved, students reflect on the process, summarize the gains and losses, and further improve their problem-solving skills.
Present results and evaluation	Group presentation: Class optimization Master App randomly select some groups to report. Each group selects a representative to present their solution and exploration process to the whole class. This facilitates mutual learning and inspiration among students. Evaluation and Feedback: Teachers and students jointly evaluate the solutions presented by each group and provide constructive feedback. Evaluation criteria can include aspects such as the innovation, practicality,

	and logic of the solutions.
Summary and reflection	Teacher Summary: The teacher summarizes the entire problem-solving process, emphasizing the strengths demonstrated by the students during the exploration process as well as areas that require improvement. Student Reflection: Students are encouraged to engage in personal and group reflection, contemplating their own performance during the problem-solving process and how they can improve and enhance their skills in the future.
Knowledge consolidation	In the final stage of the course or after class, teachers can use gamification teaching again to help students consolidate the knowledge learned in this lesson. These games can be in the form of knowledge questions and answers, role play, simulation exercises, etc. , aimed at allowing students to deepen their understanding and memory of knowledge points in a relaxed and pleasant atmosphere.

The use of learning content corresponding to teaching methods is shown in the table:

Learning content		Teaching method		
		Cooperative learning	Problem-Based Learning	Gamification
Basic knowledge	1.1 The meaning of addition and subtraction and the relationship between the parts	√		√
	1.2 The meaning of	√		√

	multiplication and division and the relationship between each part			
	1. 3 24-point calculation technique	√		√
	1.4 Relationship among unit price, quantity and total price	√		√
Practical problems of life	1.5 Promotion activity	√	√	√
	1.6 Chartering problem	√	√	√
Basic knowledge	2.1 The circumference of a rectangle and a square	√		√
	2.2 Cognitive area	√		√
	2.3 Area of rectangle and square	√		√
Practical problems of life	2.4 Practical application	√	√	√
Basic knowledge	3.1 Average	√		√
	3.2 Compound bar chart	√		√
	3.3 Possibility	√		√
Practical problems of life	3.4 Household budget	√	√	√
Synthetic application	4. Nutrition lunch	√	√	√
	Total	15	5	15

5. Instructional materials

The instructional materials consisted of Teaching schedule, fifteen lesson plans, learning task list, instructional ppt, instructional aids, and other instructional materials for the instruction.

6. Learning evaluation

The curriculum adopts the combination of formative evaluation and summative evaluation, the combination of qualitative evaluation and quantitative evaluation to evaluate students' mathematical problem solving ability. Among them, the mathematical problem solving skills test was used to evaluate students' problem solving ability before and after the course, so as to understand the change of students' problem solving ability before and after the course. In each class, the teacher will arrange a lot of learning activities and homework after class. In class, teachers will evaluate students by observing their classroom performance, participation, cooperative learning and group display results. Homework is assigned after class, through which students can understand how they have mastered the knowledge. This is the situation that will be recorded in the teacher's record sheet, and this is the content of formative evaluation.

Course evaluation methods, evaluation contents and evaluation tools

Evaluation methods	Evaluation contents	Evaluation tools
Summative evaluation	Students' mathematical problem solving skills	Students' mathematical problem solving skills test
Quantitative evaluation		
Formative evaluation	Student performance in class and after class	Teacher's teaching record
Qualitative evaluation		

7. Curriculum implementation

7.1 The teaching schedule

The course will be implemented twice a week, one lesson at a time, 40 minutes per lesson, on Tuesday and Thursday respectively, with a total of 23 lessons, lasting for 11 weeks. Click on the teaching progress to implement, The teaching schedule is as follows:

The teaching schedule

Weeks	Class Periods	Lesson Plans

<table>
<tr><td>1</td><td>2</td><td>Introduction and Pretest (The mathematics problem-solving skills test)</td></tr>
<tr><td rowspan="2">2</td><td>1</td><td>1.1 The meaning of addition and subtraction and the relationship between the parts</td></tr>
<tr><td>1</td><td>1.2 The meaning of multiplication and division and the relationship between each part</td></tr>
<tr><td rowspan="2">3</td><td>1</td><td>1.3 24-point calculation technique</td></tr>
<tr><td>1</td><td>1.4 Relationship among unit price, quantity and total price</td></tr>
<tr><td>4</td><td>2</td><td>1.5 Promotion activity</td></tr>
<tr><td rowspan="2">5</td><td>1</td><td>1.6 Chartering problem</td></tr>
<tr><td rowspan="2">2</td><td rowspan="2">2.1 The circumference of a rectangle and a square</td></tr>
<tr><td rowspan="2">6</td></tr>
<tr><td>1</td><td>2.2 Cognitive area</td></tr>
<tr><td>7</td><td>2</td><td>2.3 Area of rectangle and square</td></tr>
<tr><td rowspan="2">8</td><td>1</td><td>2.4 Floor tile problem</td></tr>
<tr><td>1</td><td>3.1 Average</td></tr>
<tr><td rowspan="2">9</td><td>1</td><td>3.2 Compound bar chart</td></tr>
<tr><td>1</td><td>3.3 Possibility</td></tr>
<tr><td rowspan="2">10</td><td>1</td><td>3.4 Household budget</td></tr>
<tr><td rowspan="2">2</td><td rowspan="2">4 Nutrition lunch-rational combination</td></tr>
<tr><td rowspan="2">11</td></tr>
<tr><td>2</td><td>Posttest (The mathematics problem-solving skills test)</td></tr>
<tr><td>Total</td><td>23</td><td></td></tr>
</table>

7.2 Curriculum learning activities arrangement

According to the elements of course objectives, course content and course time, the curriculum learning activities are arranged as follows.

The curriculum learning activities

Topic of content	Learning content	Learning objectives	Class Periods
1. 1 The meaning of addition and subtraction and the relationship between the parts	1. The meaning of addition 2. Add the relationship between the parts 3. The meaning of subtraction 4. Subtract the relationship between the parts	1)Understand the meaning of addition and subtraction. 2)Know the relationship between the addition parts, the relationship between the subtraction parts and the relationship between addition and subtraction. 3) Be able to use addition and subtraction relationship to solve simple practical problems.	1
1. 2 The meaning of multiplication and division and the relationship between each part	1. The meaning of multiplication. 2. The relationship between the parts of multiplication. 3. The meaning of division. 4. The relationship between the parts of division.	1. Understand the meaning of multiplication and division. 2. Know the relationship between the parts of multiplication, the relationship between the parts of division and the relationship between multiplication and division. 3. Be able to use the relationship between multiplication and division to solve simple practical problems.	1
1. 3 24-point calculation technique	1. 24 point game rules 2. Understanding the meaning of addition, subtraction,	1. Understand the 24-point game rules. 2. Proficient in addition, subtraction, multiplication and	1

	multiplication and division 3. Addition, subtraction, multiplication and division algorithm	division. 3. Improve the speed of the mixed operation of addition, subtraction, multiplication and division	
1. 4 Relationship among unit price, quantity and total price	1. Meaning of unit price, quantity and total price 2. Quantitative relationship between unit price, quantity and total price.	1. Understand the meaning of "unit price, quantity, total price". 2. Know "unit price x quantity = total price", and can deduce the other two quantity relations of unit price, quantity and total price. 3. Can use this set of relationships to solve some simple practical problems in life.	1
1. 5 Promotion activity	Promotional activities "Full reduction activity" "buy and get free activity".	1. Understand promotional activities such as "Full discount" and "buy and get free". 2. Can calculate the current price of goods according to the original price and preferential method.	2
1. 6 Chartering problem	1. The application of the relationship between price, quantity and total price quantity 2. The method of solving the problem	1. Master the basic method of making gradual adjustments based on assumptions first. 2. Able to apply the learned knowledge to solve the cost problem of common "charter	1

	by making gradual adjustments based on the hypothesis results.	plan".	
2. 1 The circumference of a rectangle and a square	1. Meaning of circumference 2. Derivation method of circumference formula of rectangle and square 3. Apply the knowledge about the circumference of rectangular and square lines to solve practical problems in life.	1. Understand what girth means 2. Master the derivation method of circumference formula of rectangle and square 3. Can flexibly apply the knowledge about the circumference of rectangular and square lines to solve practical problems in life.	2
2. 2 Cognitive area	1. Meaning of area 2. Area of the plane figure 3. Compare the area size of the plane graphics	1. Understand the meaning of area. 2. Know the area of the plane figure. 3. Compare the area of the figure.	1
2. 3 Area of rectangle and square	1. The meaning of area 2. Area formula derivation method of rectangle and square 3. Apply the knowledge about the	1. Understand what girth means 2. Master the derivation method of circumference formula of rectangle and square 3. Can flexibly apply the knowledge about the	2

	area of rectangular and square rows to solve practical problems in life.	circumference of rectangular and square lines to solve practical problems in life.	
2. 4 Floor tile problem	Use area related knowledge to solve practical problems.	Be able to use area related knowledge to solve practical problems in life.	1
3. 1 Average	1. The meaning of average. 2. Method of average. 3. The use of averages in life.	1. Understand the meaning of averages. 2. Master averages. 3. Ability to use averages to solve practical problems in life.	1
3. 2 Compound bar chart	1. Characteristics of the compound bar chart 2. Drawing method of compound bar statistical chart 3. Application of compound bar chart in daily life	1. Know the characteristics of multiple bar charts. 2. Multiple bar charts will be drawn. 3. Flexible application of compound bar charts to solve practical problems in life.	1
3.3 Possibility	1.Experience certain events and uncertain events; 2.Feel the possibility is high or low 3.Use the list method to judge the possibility.	1.Knowing that some events occur with certainty and others with uncertainty; 2.Learn to judge the likelihood of events in your life. 3.Use the knowledge to solve simple problems in life.	1
3. 4 Household	Review the concept	1. Students can accurately	1

budget	and calculation method of average. Learn the basic structure and reading method of multiple statistical charts. Use averages and multiple charts to solve household budget problems.	calculate and understand the meaning of averages. 2. Students are able to recognize and interpret information in multiple statistical charts. 3. Students can apply their math knowledge to solve practical problems in the family budget. 4. Develop students' problem-solving skills, cooperation skills and critical thinking.	
4 Nutrition lunch-rational combination	. 1. Nutrients in common dishes 2. Some basic indicators of a nutritious lunch 3. Simple combinations 4. Simple statistical knowledge	1. Understand the nutrients needed by humans and some basic indicators of a nutritious lunch. 2. Can comprehensively use simple arrangement and combination, statistics and other related knowledge to solve problems.	2

7.3 Lesson plans

The lesson plan includes 8 parts: Topic of content, learning content, learning objectives, teaching methods, teaching process, homework assignment, learning evaluation, and teaching materials. The lesson plan design is as follows:

The lesson plans

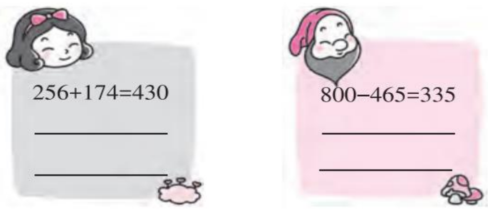
Lesson plan 1	1 Class period	Duration: 40 minutes
Topic of content	The meaning of addition and subtraction and the relationship between the parts	

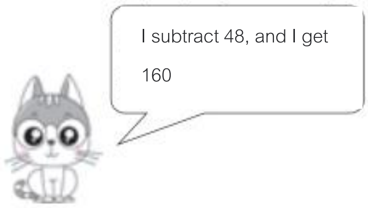
Learning content	1. The meaning of addition 2. Add the relationship between the parts 3. The meaning of subtraction 4. Subtract the relationship between the parts
Learning objectives	Understand the meaning of addition and subtraction. Know the relationship between the addition parts, the relationship between the subtraction parts and the relationship between addition and subtraction. Be able to use addition and subtraction relationship to solve simple practical problems.
Teaching method	Cooperative learning, Gamification 1. Use gamification teaching method to review old knowledge. Teachers design a "digital solitarine" game, review addition and subtraction operations, and stimulate students' interest in learning. 2. Create real situations, ask questions, and use cooperative learning to solve problems The teacher creates a real situation and asks the students to propose an addition problem and a subtraction problem according to the specific situation, so that the students can understand the application of addition and subtraction in real life. Use cooperative learning method to improve students' problem-solving skills from four aspects: understanding, analyzing, solving and reflecting on problems At the end of the course, the teacher designs a competition game. Consolidate students' knowledge of addition and subtraction Note: Incentives (Use game elements such as points and MEDALS to motivate students) Throughout the teaching process, teachers can use game elements such as points and MEDALS to motivate students to actively participate in learning and discussion. For example, students who answer questions

	correctly can get some points. Students who have outstanding performance in group cooperation can get the medal of "Cooperation Star"; The winning team in the competition game can earn game coins and so on. These rewards serve as recognition and encouragement for their learning achievements.
Teaching process	1) Introduction and review (3 minutes) At the beginning of class, the teacher designs a short "math soliton" game. The rules of the game are: At the beginning of the game, the teacher says a number, such as 100, which is the target number that everyone needs to add and subtract. The first student in the group then says a number and adds or subtracts it. For example, group member 1 can say "add 20" or "subtract 30" and come up with a new number. Group member 2 then adds or subtracts the number from group member 1, and so on. Each team member cannot add or subtract more than twice the target number or make the result negative. When the last team member adds and subtracts so that the result is equal to the target number, the game ends and the team wins. If none of the teams can add or subtract to make the result equal to the target number, the team closest to the target number wins. (Use the Class Management Optimization Master APP to give bonus points to the winning team) 2) Situation creation and question raising (5 minutes) Show a group of pictures of Qinghai-Tibet Railway (Picture source is shown in teaching materials section to attract students' attention). Introduce the Qinghai-Tibet Railway to stimulate students' interest in learning. (The Qinghai-Tibet Railway, referred to as the Qingzang Line, is a Class I national railway connecting Xining City of Qinghai Province to Lhasa City of Tibet Autonomous Region. It is one of the four major projects of China in the new century. It is the first railway to the hinterland

	of Tibet, and it is also the highest plateau railway with the longest route in the world.) Teacher: This summer my teacher went to Lhasa for a trip. The train I took was from Xining to Lhasa via Golmud. The railway from Xining to Golmud is 814km long, and the railway from Golmud to Lhasa is 1142km long. Can you do an addition problem and a subtraction problem based on this situation? Presuppose: Student 1: How many kilometers is the railway from Xining to Lhasa? Student 2: How many kilometers is the Golmud to Lhasa railway longer than the railway to Xining? Student 3: How many kilometers shorter is the Golmud to Xining railway than the one to Lhasa? 3) Cooperative inquiry and problem solving 1) Each study group can choose an activity task from Activity 1 and Activity 2 and work together to complete it. (8 minutes) Activity 1: Explore the meaning of addition. A train went from Xining to Lhasa via Golmud. The railway from Xining to Golmud is 814km long, and the railway from Golmud to Lhasa is 1142km long. How many kilometers is the railway from Xining to Lhasa? Team work to complete the task: 1. How do you understand the question in group communication? What is the known quantity? What are the unknowns? (Understanding) 2. How to solve this problem? What quantitative relationships do you use? What strategy did you adopt to solve the problem? (Analyzing) 3. Write your solution. (solving) 4. Is that right? Tell me what you think? (After reflection) 5. With the addition formula, say what is the meaning of this addition formula? What kind of operation do you think addition is? Can you give

	each part of addition a name? Activity 2: Explore the meaning of subtraction. (8 minutes) A train goes from Xining to Lhasa via Golmud. The railway from Xining to Golmud is 814km long, and the railway from Golmud to Lhasa is 1142km long. How many kilometers is the Golmud to Lhasa railway longer than the railway to Xining? Team work to complete the task: 1. How do you understand the question in group communication? What is the known quantity? What are the unknowns? (Understanding) 2. How to solve this problem? What quantitative relationships do you use? What strategy did you adopt to solve the problem? (Analyzing) 3. Write your solution. (solving) 4. Is that right? Say your reasons. (reflect on the solution) 5. What do they mean in combination with the subtraction formula? What kind of operation do you think subtraction is? Can you give each subtraction part a name? 2) A class optimization master was used to randomly select a group from the groups participating in activity 1 and Activity 2 to show the discussion results. (8 minutes) 3) Activity 3: Explore the relationship between the parts of addition and subtraction. (8 minutes) In the previous learning, we have understood the meaning of addition and subtraction, discuss the relationship between the parts of addition and subtraction in the group, and complete the following tasks: What is the relationship between the subtraction parts? A one-sentence summary of the relationship between addition and subtraction? Group presentation: Randomly select a group of presentations with the class optimization master. (If you select a group that has already been reported, select it again) 4) Knowledge consolidation and gamification teaching (5 minutes)

	Teachers design a competition game, the content is the meaning of addition and subtraction and the relationship between each part, choose the option you think is correct, two groups will compete, the group with the highest score wins. (The class optimization master randomly selected two groups to play the game) 5) Evaluation and Reflection (3 minutes) Teachers guide students to evaluate and reflect. Students can evaluate their own performance in this study, what knowledge they have learned in this lesson, and find out their shortcomings and areas for improvement. At the same time, teachers can adjust and optimize teaching methods and contents according to students' performance and feedback to better meet students' learning needs.
Homework assignment	Fundamental question: 1. What calculation method should be used to calculate the following questions? Why? This assignment: (1) The Science and Technology Museum had 540 visitors in the morning and 180 visitors in the afternoon. How many people visited the whole day? (2) There are 120 books in the class book corner, and 75 books are lent  out. How many books are left in the book corner? 2. Write two other equations based on the relationship between the addition and subtraction parts. Extension question: Guess what I am.

<table>
<tr><td></td><td>

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Promotion question:
In the Yimeng Mountain tourist area of the old revolutionary area, there is a pedestrian glass suspension bridge connecting Wanghai Tower and Yuhuangding. The total length of the bridge is about 506 meters, which is the world's longest and largest span of pedestrian glass suspension bridge, of which the middle span is 420 meters, the other is located at both ends of the side span of this pedestrian glass suspension bridge, the total length of the side span is about how many meters</td></tr>
<tr><td>Learning evaluation</td><td>1. Observe classroom activities and give appropriate verbal comments, encouragement or criticism according to students' classroom performance.
2. Observe the situation of group cooperative learning, such as students' learning behavior and enthusiasm for participating in activities. Use class optimization master to record student performance.
3. Students' performance in completing the group cooperative learning activity list and reporting problems.</td></tr>
<tr><td>Teaching materials</td><td>1. Qinghai-Tibet Railway Pictures:
 </td></tr>
</table>

Picture source: Picture source:

https: //www. vjshi. com/watch/6744387. html https: //www. meipian. cn/27hitul3

Picture source: Picture source:

https: //www. meipian. cn/3ao98no2 http: //www. sohu. com/a/548596326_121314565

2. Qinghai-Tibet Railway Introduction:

45. Qinghai-Tibet Railway Introduction:

Picture source:

https: //blog. mimvp. com/article/35343. html

Qinghai Tibet Railway (English name: Qinghai Railway), referred to as the Qingzang Line, is a national railway connecting Xining City of Qinghai Province to Lhasa City of Tibet Autonomous Region. It is one of China's four major projects in the new century. It is the first railway to the

	hinterland of Tibet and the highest plateau railway with the longest route in the world. Qinghai-tibet Railway from Xining Station to Lhasa Station; The total length of the line is 1, 956 kilometers, of which the Xining to Golmud section is 814 kilometers, and the Golmud to Lhasa section is 1, 142 kilometers. A total of 85 stations will be built, with a designed maximum speed of 160 km/h (Xining to Golmud section) and 100 km/h (Golmud to Lhasa section). As of March 2015, the Qinghai-Tibet Railway operates at 140 km/h (Xining to Golmud) and 100 km/h (Golmud to Lhasa). 3. Source of information: https: //www. baidu. com/s?ie=utf-8&f=8&rsv_bp=1&rsv_idx=1&tn=02003390_95_hao_pg&wd=%E9%9D%92%E8%97%8F%E9%93%81%E8%B7%AF&fenlei=256&rsv_pq=0x862d756e002c6ffe&rsv_t=19bdOcPJqMAHJmLIgBy5nmU1vQAEeS%2FqVyI7VoThz%2BowxisBKYO9UV1%2Fx5%2FVRzcTH6M3wMkrIQi%2F&rqlang=en&rsv_dl=tb&rsv_enter=0&rsv_sug3=5&rsv_sug1=2&rsv_sug7=101&rsv_btype=i&prefixsug=%25E9%259D%2592%25E8%2597%258F%25E9%2593%2581%25E8%25B7%25AF&rsp=0&inputT=1398&rsv_sug4=6715 4. Reference materials: 1). Primary Mathematics Grade 4 Volume 2 (RJ). Editor-in-chief: Zhijian Du. Web site: http: //press. njnu. edu. cn; 2). Primary school lesson plan and homework design. Editor-in-chief: Xie Guping. Publishing House: Xinjiang Youth Publishing House. 5. Student cooperative learning activity list Activity 1: A train from Xining to Lhasa through Golmud. The railway from Xining to Golmud is 814km long, and the railway from Golmud to Lhasa is 1142km long. How many kilometers is the railway from Xining to Lhasa? Communication within the group, how do you understand the question?

	What is the known quantity? What are the unknowns? (Understanding) How to solve this problem? What quantitative relationships do you use? What strategy did you adopt to solve the problem? (Analysis) Write your solution. Is it right to do so? Tell me what you think? (Reviewing after solving) Combined with the addition formula, say what is the meaning of this addition formula? What kind of operation do you think addition is? Can you give each part of addition a name? Activity 2: A train goes from Xining to Lhasa via Golmud. The railway from Xining to Golmud is 814km long, and the railway from Golmud to Lhasa is 1142km long. How many kilometers is the Golmud to Lhasa railway longer than the railway to Xining? How do you understand the question in group communication? What is the known quantity? What are the unknowns? (Understanding) How to solve this problem? What quantitative relationships do you use? What strategy did you adopt to solve the problem? (Analyzing) Write your solution. (solving) Is that right? Say your reasons. (reflect on the solution) What do they mean in combination with the subtraction formula? What kind of operation do you think subtraction is? Can you give each subtraction part a name? Activity 3: In the previous study, we have understood the meaning of addition and subtraction, discuss the relationship between the various parts of addition and subtraction in the group, and complete the following tasks: Add the relationship between the parts? What is the relationship between the subtraction parts? A one-sentence summary of the relationship between addition and subtraction?

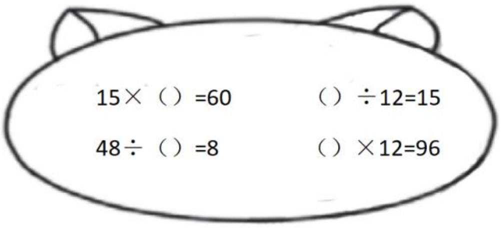
<table>
<tr><td>Lesson plan 2</td><td>1 Class period</td><td>Duration: 40 minutes</td></tr>
<tr><td>Topic of content</td><td colspan="2">The meaning of multiplication and division and the relationship between each part</td></tr>
<tr><td>Learning content</td><td colspan="2">1. The meaning of multiplication.
2. The relationship between the parts of multiplication.
3. The meaning of division.
4. The relationship between the parts of division.</td></tr>
<tr><td>Learning objectives</td><td colspan="2">1. Understand the meaning of multiplication and division.
2. Know the relationship between the parts of multiplication, the relationship between the parts of division and the relationship between multiplication and division.
3. Be able to use the relationship between multiplication and division to solve simple practical problems.</td></tr>
<tr><td>Teaching method</td><td colspan="2">Cooperative learning, Gamification teaching
1. Use gamification teaching method to review old knowledge. Teachers design a "digital solitarine" game, review addition and subtraction operations, and stimulate students' interest in learning.
2. Create real situations, ask questions, and use cooperative learning to solve problems
The teacher creates a real situation and asks the students to ask a question according to the specific situation, so that the students can understand the application of multiplication in real life. Use cooperative learning method to improve students' problem-solving skills from four aspects: understanding, analyzing, solving and reflecting on problems
3. Gamification teaching strengthens knowledge
At the end of the course, the teacher designs a competition game. Consolidate students' knowledge of multiplication and division
Note: Incentives (Use game elements such as points and MEDALS to motivate students)</td></tr>
</table>

<table>
<tr><td></td><td>Throughout the teaching process, teachers can use game elements such as points and MEDALS to motivate students to actively participate in learning and discussion. For example, students who answer questions correctly can get some points. Students who have outstanding performance in group cooperation can get the medal of "Cooperation Star"; The winning team in the competition game can earn game coins and so on. These rewards serve as recognition and encouragement for their learning achievements.</td></tr>
<tr><td>Teaching process</td><td>Situational introduction: (3 minutes)
Game activities: In the process of playing games to review the old knowledge, mobilize the enthusiasm of students to learn. (The class optimization master randomly selects 1 girl and 1 girl to participate in the competition) Add, subtract, multiply and divide the relevant knowledge, judge right and wrong, and answer more correctly to win. (The design

method is shown in the teaching materials section). (Use the Class Management Optimization Master APP to give bonus points to the winning team)
In the above game, we need to use the relevant knowledge of addition, subtraction, multiplication and division, only we are particularly skilled in these knowledge content can do fast and good, last class we studied the meaning of addition and subtraction and the relationship between the parts, today we will learn the meaning of multiplication and division and</td></tr>
</table>

	the relationship between the parts. Situation creation and question raising (5 minutes) A good environment can bring a good mood, today the teacher wants to buy a few bottles of flowers to decorate the room, please observe the characteristics of these vases carefully? Then, using courseware to show the vase scene, the vase appeared one by one (Picture source is shown in teaching materials section). Teacher: Can you write a mathematical problem using multiplication according to the above scenario? Presuppose: Student 1: There are three flowers in each vase. How many flowers are there in the four vases? Cooperative inquiry and problem solving Activity 1: Explore the meaning of multiplication. (8 minutes) There are three flowers in each vase. How many flowers are there in the four vases? Work in groups to complete tasks: 1. How do you understand the question? What is the known quantity? What are the unknowns? (Understanding) 2. How to solve this problem? (Analysis) 3. Write your solution. (Solution) 4. Compare the addition formula with the multiplication formula. Which formula is easier? What kind of operation is multiplication? Do you know the names of the parts of multiplication? 5. Can you give an example of a time when multiplication was used in your life? Group presentation: Randomly select a group of presentations with the class optimization master. Activity 2: Explore the meaning of division. (8 minutes) Show example question (2) : There are 12 flowers, every 3 bottles

	inserted, how many bottles can be inserted? Team work to complete the task: 1. Communication within the group, how do you understand the question? What is the known quantity? What are the unknowns? (Understanding) 2. How to solve this problem? What strategy did you adopt to solve the problem? (Analysis) 3. Write your solution. (solving) 4. Is it right to do so? Can you ask another question similar to example (2) based on the situation in example (1)? And answer the question. 5. Combine these two division formulas and tell us what they mean respectively. What kind of operation do you think division is? Do you know the name of each part of division? Group presentation: Group presentation: Randomly select a group of presentations with the class optimization master. (If you select a group that has already been reported, select it again) Activity 3: Explore the relationship between the parts of multiplication and division. (8 minutes) In the previous study, we have understood the meaning of multiplication and division, discuss the relationship between the various parts of multiplication and division within the group, and complete the following tasks: 1. The relationship between the parts of multiplication? 2. The relationship between the parts of division? 3. A one-sentence summary of the relationship between multiplication and division? Group presentation: Randomly select a group of presentations with the class optimization master. (If you select a group that has already been reported, select it again) 4) Knowledge consolidation and gamification teaching (5 minutes)

<table>
<tr><td></td><td>Teachers design a competition game, the content is the meaning of multiplication and division and the relationship between each part, choose the option you think is correct, two groups will compete, the group with the highest score wins. (The class optimization master randomly selected two groups to play the game)
5) Evaluation and Reflection (3 minutes)
Teachers guide students to evaluate and reflect. Students can evaluate their own performance in this study, what knowledge they have learned in this lesson, and find out their shortcomings and areas for improvement. At the same time, teachers can adjust and optimize teaching methods and contents according to students' performance and feedback to better meet students' learning needs.</td></tr>
<tr><td>Homework assignment</td><td>Fundamental question:


1. How are the following questions calculated? Why?
(1) Snails can crawl 5m per hour, how many meters can they crawl in 6 hours?
(2) An elephant weighs 5600kg, which is exactly eight times the weight of a cow. How many kilograms does the cow weigh?
2. Fill in ( ) with the appropriate number.
Extension question:
The New Year is coming, my mother sent a total of 248 yuan of red envelopes in the wechat group, which is exactly 4 times the number of red envelopes sent by Aunt Liu in the wechat group, how much money did Aunt Liu send in the wechat group?
Promotion question:</td></tr>
</table>

	The Mid-Autumn Festival is coming, Seinfeld, Gao Qi to Tang Jun home to visit. After Tang's mother took out 17 mooncakes and divided them evenly among the three of them, there were two left. What do they each get?
Learning evaluation	1. Observe classroom activities and give appropriate verbal comments, encouragement or criticism according to students' classroom performance. 2. Observe the situation of group cooperative learning, such as students' learning behavior and enthusiasm for participating in activities. Use class optimization master to record student performance. 3. Students' performance in completing the group cooperative learning activity list and reporting problems.
Teaching materials	1. The game activity is made using the Shivo whiteboard 5 software, a total of 16 questions, of which 10 questions are correct, 6 questions are wrong, the 16 questions are randomly assigned to two students, two people answer at the same time, the number of correct answers wins. The game video is as follows: Game activity.mp4 2. vase  Picture source: https: //www. item. jd. com/25934905817. html 3. The origin of addition, subtraction, multiplication and division French mathematician Xu Kai in 1484 written "arithmetic three", the use of some writing symbols, such as D to indicate addition, with M to indicate subtraction these two symbols first appeared in the German

	mathematician Wiedermann written "commercial speed calculation", he used "+" to indicate excess, with "-" to indicate insufficient. In 1514, Hecker of the Netherlands was the first to use "+" for addition and "one" for subtraction. In 1544, the German mathematician Stiefel formally used "+" and "one" to represent addition and subtraction in Integer arithmetic, and these two symbols gradually came to be recognized as true arithmetic symbols. The symbol "x" for multiplication was invented by the English mathematician Alfred Altred who introduced it in his 1631 book The Keys of Mathematics. It is said to be derived from the addition sign +, because multiplication is derived from the addition of the same numbers. Later, Leibniz thought that "x" was easily confused with "X" and suggested using ". " Multiplication sign, so, ". " It was also recognized. The division symbol "÷" was first used by Varys in England and was later popularized in the UK. The original meaning of division is division, and the middle horizontal line of the symbol "÷" separates the upper and lower parts, symbolically indicating "division". At this point, the four operational symbols were produced, and they were far from being universally adopted by all countries at that time. Source of information: https: //wenku. baidu. com/view/60b45e0174232f60ddccda38376baf1ffd4fe37f. html?_wkts_=1691339664653&bdQuery=%E5%8A%A0%E5%87%8F%E4%B9%98%E9%99%A4%E7%9A%84%E7%94%B1%E6%9D%A5 4. Reference materials: (1). Primary Mathematics Grade 4 Volume 2 (RJ). Editor-in-chief: Zhijian Du. Web site: http: //press. njnu. edu. cn; (2). Primary school lesson plan and homework design. Editor-in-chief: Xie Guping. Publishing House: Xinjiang Youth Publishing House. 5. Student cooperative learning activity list

	Activity 1: There are three flowers in each vase. How many flowers are there in the four vases? How do you understand the question? What is the known quantity? What are the unknowns? (Understanding) How to solve this problem? (Analysis) Write your solution. (Solution) Compare the addition formula with the multiplication formula. Which formula is easier? What kind of operation is multiplication? Do you know the names of the parts of multiplication? Can you give an example of a time when multiplication was used in your life? Activity 2: There are 12 flowers, every 3 bottles inserted, how many bottles can be inserted? Communication within the group, how do you understand the question? What is the known quantity? What are the unknowns? (Understanding) How to solve this problem? What strategy did you adopt to solve the problem? (Analysis) Write your solution. Is it right to do so? Can you ask another question similar to example (2) based on the situation in example (1)? And answer the question. Combine these two division formulas and tell us what they mean respectively. What kind of operation do you think division is? Do you know the name of each part of division? Activity 3: In the previous study, we have understood the meaning of multiplication and division, discuss the relationship between the various parts of multiplication and division within the group, and complete the following tasks: The relationship between the parts of multiplication? The relationship between the parts of division?

<table>
<tr><td></td><td colspan="3">A one-sentence summary of the relationship between multiplication and division?</td></tr>
<tr><td colspan="2">Lesson plan 3</td><td>1 Class period</td><td>Duration: 40 minutes</td></tr>
<tr><td>Topic of content</td><td colspan="3">24-point calculation technique</td></tr>
<tr><td>Learning content</td><td colspan="3">1. 24 point game rules
2. Understanding the meaning of addition, subtraction, multiplication and division
3. Addition, subtraction, multiplication and division algorithm</td></tr>
<tr><td>Learning objectives</td><td colspan="3">1. Understand the 24-point game rules.
2. Proficient in addition, subtraction, multiplication and division.</td></tr>
<tr><td>Teaching method</td><td colspan="3">Cooperative learning, Gamification teaching</td></tr>
<tr><td>Teaching process</td><td colspan="3">1) Introduce games to stimulate interest
1. Initial introduction of calculation rules (3 minutes)
Teacher: The teacher brought cards today. Do you often play cards? What kind of games do you play with poker? Would you like to play a poker game with your teacher?
Students: (Attracted the interest of the students through the poker game, the students are very much looking forward to the next game session)
Teacher: The name of the game is "24 o 'clock". Follow the teacher to understand the rules of the game.
The rules of the game are as follows: given four natural numbers, by "+", "-", "×", "÷" operation, you can swap the positions of the numbers, you can add parentheses at will, but specify that each number is used exactly once, so that the final number is 24. Let me first give an example: the teacher out a card 8, you can take out a card from your own hand, with addition, subtraction, multiplication, division random combination, and the teacher in the hand of this card to calculate 24?</td></tr>
</table>

	Student: I'll give you 3, 3 x 8=24. Teacher: How did you come up with 3? Student: I think about the multiplication table we always memorize, 3×8=24. Teacher: If I play 9, 9 and which number, I get 24? Student: I give 15 because 15+9=24. Teacher: Very good. When we can't pass the multiplication tables, can we try to consider addition, subtraction or division? 2. Discuss rules and deepen understanding (2 minutes) Student activities: Students discuss the rules of the game with each other, talk about each other's understanding of the rules of the game, and encourage students to come up with some game methods. Summary: First use the multiplication table, no formula can no longer use multiplication, use addition, subtraction or division. 2) Clarify the rules of the game and stimulate enthusiasm (3 minutes) 1. The class is divided into 8 groups, in each link of the activities, each group sent a student to the podium, in each deck of playing cards (excluding large, small Wang) in the extraction of four cards, the four numbers represented by these four cards according to the requirements in the specified time to calculate (four numbers can only be used once, you can use brackets), each operation result must be 24. You get 10 points for A correct answer, no points for a wrong answer or no answer (note: A, J, Q, and K represent the numbers 1, 11, 12, and 13, respectively). 2. In the game, the team members must abide by the discipline, do not shout, otherwise deduct the team score. 3. If the four cards drawn by the team cannot calculate 24, they can give up and draw four cards again, but they can only give up twice per round. 4, at the end of the game, the team with the leading score will be rewarded, and the team with the trailing score will perform for everyone.

	3) Carry out games and practice exploration Teacher: I believe you have figured out the gameplay and some skills now, would you like to challenge and see who is better? Let's play in groups. 1. First Leg (10 minutes) Teacher: Last week when we carried out the division of numbers, some students reflected that they were not happy to win the championship. This time, we will see which group can win. Today we will divide into four groups and play three games. In the first game, each team had four questions, 10 points for correct answers and 0 points for wrong or no answers. At this time, students have just started to calculate for a long time, mainly because they are not familiar with the mixed operation. After the calculation of four questions in each group, they will find that each group's thinking time is getting shorter and shorter, and they have a more and more thorough understanding of the rules of the game. Teacher: After this round of competition, are you more familiar with the arithmetic of integers? Do you remember the question that didn't work out "24 points" just now? Teacher-student interaction: In this process, the teacher should answer the questions that the students cannot calculate, let the students reflect on them, and summarize their skills. 2. Second Leg (8 minutes) Teacher: Now we begin to answer, each group of players can participate, the teacher said four cards, everyone began to consider, who first think out can immediately stand up and answer. Each question is still 10 points for correct answers and 5 points for incorrect answers. (1)1, 2, 4, 6; (2) 1, 2, 5, 6; (3) 1, 4, 6, 9 Student: (Everyone is more excited at this time, and wants to show

	themselves in this link and win glory for the group.) In this process, the most intense, many groups of students actively raise their hands, but there are also calculation errors, there will be chagrin, members of the group will abandon, at this time the teacher to stop this behavior, encourage him to participate in the next calculation. Student: In this round of the competition, you made less and less mistakes, and the answer speed is getting faster and faster. I feel that your oral arithmetic ability has been further improved. Interaction between teachers and students: In this process, the teacher should answer the questions that the students cannot calculate in this part, so that the students can reflect and summarize their skills. 3. Third round decider (8 minutes) In this link, the teacher took out the three boxes that have been prepared, the box has prepared cards in advance, each four cards constitute a classic calculation of 24 points (each box is not the same difficulty), respectively, 10 points (questions: 3, 3, 5, 9), 15 points (questions: 2, 3, 5, 5), 20 points (questions: 2, 3, 7, 9). The choice is made by the group representative. At this time, the points of each group are not the same, the backward group wants to choose the highest score can turn the defeat into a victory, and the team with a high score also wants to choose the most difficult box, so that it can win the championship with an absolute advantage. (In this section, each group chose the most difficult box, which also reflects the students' competitive character.) Students: Students actively participate in the final part of the competition. Interaction between teachers and students: After the end of the third part, the teacher answers the questions that the students cannot calculate in this part, so that the students can reflect and summarize their skills.

	4) Exchange of experience and summary (3 minutes) Teacher: Students, life contains a lot of mathematics, often see playing cards, today has become our learning tools, a class time is short, you may not be satisfied, you can often play in the future, I believe that soon you will become a master of computing. What have you learned from a lesson? Student: (Student talking about his gains) Teacher: Would you like to continue playing "24 o 'clock"? Teach this method to your family when you get home, and let them calculate it in a poker game. Can be a group of four people, each person issued a card, with these four cards to calculate 24 points, each card can only be used once, if it can not be calculated, each person takes back their own card, and issue a new one. Who first calculate the 24 points who will win once, you can collect the remaining three cards as their own, and finally who has more cards, who is the group of 24 points of the calculation of small expert. Go home and play this game with your family or friends. 5) Evaluation and Reflection (4 minutes) The teacher guides the students to evaluate and reflect. Students can evaluate their own performance in this study, what knowledge they have learned in this lesson, and find out their shortcomings and areas for improvement. At the same time, teachers can adjust and optimize teaching methods and contents according to students' performance and feedback to better meet students' learning needs.
Homework assignment	Fundamental question: (suitable for students with learning difficulties and intermediate students) Calculate 24 points: the rules of the game are: given four natural numbers, through the "+", "-", "×", "÷" operation, you can exchange the position of the number, you can add parentheses at will, but each number is used exactly once, so that the final number is 24.

	(1) 1, 1, 5, 6 (2) 4, 5, 8, 9 (3) 2, 2, 6, 8 Promotion question: (for top students) Calculate 24 points: the rules of the game are: given four natural numbers, through the "+", "-", "×", "÷" operation, you can exchange the position of the number, you can add parentheses at will, but each number is used exactly once, so that the final number is 24. (1) 1, 8, 12, 12 (2) 3, 6, 10, 11 (3) 2, 4, 6, 12
Learning evaluation	1. Observe classroom activities and give appropriate verbal comments, encouragement or criticism according to students' classroom performance. 2. Observe the situation of group cooperative learning, such as students' learning behavior and enthusiasm for participating in activities. Use class optimization master to record student performance. 3. Students' performance in completing the group cooperative learning activity list and reporting problems.
Teaching materials	1. The origin of the 24-point game https: //wenku. baidu. com/view/3af1bdd8adaad1f34693daef5ef7ba0d4a736d08. html?_wkts_=1691678216154&bdQuery=24%E7%82%B9%E6%B8%B8%E6%88%8F%E7%94%B1%E6%9D%A5 2. Primary school math Olympiad fun problem - 24 points exercises https: //baijiahao. baidu. com/s?id=1739494028341952781&wfr=spider&for=pc 3. Student cooperative learning activity list 24-point game rules: The rules of the game are as follows: given four natural numbers, through the "+", "-", "×", "÷" operation, you can exchange the positions of the numbers, you can add parentheses at will, but specify that each number is used exactly once, so that the final number is 24.

	First Leg (10 min.) Each group has four questions, 10 points for correct answers and 0 points for incorrect or no answers. 2. 3. 4. Second Leg (8 min.) Now we begin to answer, each group of players can participate, the teacher said four cards, everyone began to consider, who first think out can immediately stand up and answer. Each question is still 10 points for correct answers and 5 points for incorrect answers. (1)1, 2, 4, 6; (2) 1, 2, 5, 6; (3) 1, 4, 6, 9 Third round decider (8 minutes) The teacher took out the three boxes that have been prepared, which have cards prepared in advance, each four cards constitute a classic calculation of 24 points (each box is not the same difficulty), respectively, 10 points (questions: 3, 3, 5, 9), 15 points (questions: 2, 3, 5, 5), 20 points (questions: 2, 3, 7, 9). The choice is made by the group representative.

Lesson plan 4	1 Class period	Duration: 40 minutes

Topic of content	Relationship among unit price, quantity and total price
Learning content	1. The meaning of unit price, quantity and total price 2. The quantitative relationship between unit price, quantity and total price
Learning objectives	1. Understand the meaning of "unit price, quantity, total price". 2. Know "unit price x quantity = total price", and can deduce the other two quantity relations of unit price, quantity and total price. 3. Can use this set of relationships to solve some simple practical problems in life.
Teaching method	Cooperative learning, gamification teaching 1. Use gamification teaching method to review old knowledge.

	Teachers can first review the knowledge of addition and subtraction through a small game, such as the "quick calculation" game, which allows students to quickly answer some simple addition and subtraction questions. Then the teacher can introduce a new concept: "Today we are going to study the quantitative relationship between unit price, quantity and total price, which is very common in our daily life. 2. Create real situations, ask questions, and use cooperative learning to solve problems. A teacher can create a shopping situation: "Suppose you and your mother go to the supermarket and see that the unit price of apples is 10 yuan per kilogram, and you are going to buy 4 kilograms." So, how much do you have to pay?" Through this context, students are guided to understand the concepts of unit price, quantity and total price. Use cooperative learning method to improve students' problem-solving skills from four aspects: understanding, analyzing, solving and reflectin4. 3. Gamification teaching strengthens knowledge In the final stage of the course, the teacher can design a "shopping master" game. The rules of the game are: students are divided into several groups, and each group simulates the scene of shopping in a supermarket. They need to calculate the total price of various goods based on the given unit price and quantity, and compare which group can calculate quickly and accurately. This game can not only consolidate students' knowledge of unit price, quantity and total price, but also cultivate their calculation ability and competitive consciousness. Note: Incentives (Use game elements such as points and MEDALS to motivate students) Throughout the teaching process, teachers can use game elements such as points and MEDALS to motivate students to actively participate in learning and discussion. For example, students who answer questions correctly can get some points. The winning team in the "Shopper" game

	can get the "Shopper" trophy and so on. These rewards can serve as recognition and encouragement for their learning achievements, increasing their motivation and engagement in learning.
Teaching process	1)Introduction and review: (3 minutes) The teacher can first review the knowledge of addition and subtraction learned before through a small game. At the beginning of class, the teacher will design a "quick calculation" game, for example, let the students quickly answer some simple addition and subtraction questions. Then the teacher introduced a new concept: "Today we are going to study the quantitative relationship between unit price, quantity and total price, which is very common in our daily life. " 2)Situation creation and question raising (5 minutes) Today's lesson, love supermarket teacher Lu want to take you to go shopping? Show picture 1 (Picture source is shown in teaching materials section.) The scene is the school's nearest small supermarket. Let's hurry in! Show picture 2 (Picture source is shown in teaching materials section): Wow, there are so many commodities in the supermarket, complete varieties, dazzling eyes, it is really dizzying! Hey, what are those little yellow labels? Show picture 3: What do the numbers on it mean? Show picture 4: What do the numbers on it mean? Show picture 5: Sometimes, the price of the goods is also expressed in this way, do you know what this means? Materials section. The scene is the school's nearest small supermarket. Let's hurry in! 3)Cooperative inquiry and problem solving Activity 1: Understanding the meaning of "unit price, quantity, total price" (10 minutes)

	Show unit price, quantity and total price definition: the price of each item, called unit price; How much you buy is called quantity; A common amount of money is called the total price. Cooperate to complete tasks: 1. Read the definition of unit price, quantity and total price together, talk about your understanding of these three concepts in the group, and observe the meaning of each item in the receipt. What is the price, quantity and total price of each item? Can you give an example of what each item is? The group shows the results of cooperative learning, and uses the master of class management optimization to give points to the group with good performance 2. I asked the students to investigate the prices of some commodities yesterday. Do you know the unit price of any commodities? To give you two examples. Activity 2: Exploring the relationship between unit price, quantity and total price (14 minutes) Show test questions: (1)A basketball is 80 yuan, how much does it cost to buy three? (2)A kilogram of apples is 10 yuan. How much is it to buy 4 kilograms? Cooperate to accomplish tasks 1. What the two questions have in common: 2. Knowing the unit price and quantity of the product, how to find the total price? 3. If you know the total price and quantity to determine the unit price how to establish the quantity relationship? If you know the total price and the unit price to find the quantity how do you establish the quantity relationship? . 4. It cost 240 yuan to buy three basketballs. How much is each

	basketball? Can you name the known and the unknown in this problem? The group shows the results of cooperative learning, and uses the master of class management optimization to give points to the group with good performance 4) Knowledge consolidation and gamification teaching (5 minutes) The teacher designed a "shopping master" game. The rules of the game are: students are divided into several groups, and each group simulates the scene of shopping in a supermarket. They need to calculate the total price of various goods based on the given unit price and quantity, and compare which group can calculate quickly and accurately. 5) Evaluation and Reflection (3 minutes) The teacher guides the students to evaluate and reflect. Students can evaluate their own performance in this study, what knowledge they have learned in this lesson, and find out their shortcomings and areas for improvement. At the same time, teachers can adjust and optimize teaching methods and contents according to students' performance and feedback to better meet students' learning needs.
Homework assignment	Fundamental question: Say it and do the math (1) Orange juice is 4 yuan per bottle, how many yuan in a case of 12 bottles? Question known ( ) and ( ), unknown ( ) quantity relation ( ) (2) Each box of orange juice 40 yuan, 200 yuan can buy how many boxes? Question known ( ) and ( ), unknown ( ) quantity relation ( ) (3)200 yuan can buy 5 cases of orange juice, how much is each case of juice? Question known ( ) and ( ), unknown ( ) quantity relation ( ) Extension question:

	What kind of question can be filled according to the following conditions? (1) 4 towels 12 yuan, ? (2) A pair of sneakers 16 yuan, buy 3 pairs, ? (3) A set of sweatshirt 28 yuan, with 56 yuan , ? Promotion question: The school carries out the activities of reading Chinese classics, and needs to purchase 308 copies of the Book of Songs. Know each "book of Songs" 42 yuan, please calculate, Mr. Wang with 12000 yuan enough?
Learning evaluation	1. Observe classroom activities and give appropriate verbal comments, encouragement or criticism according to students' classroom performance. 2. Observe the situation of group cooperative learning, such as students' learning behavior and enthusiasm for participating in activities. Use class optimization master to record student performance. 3. Students' performance in completing the group cooperative learning activity list and reporting problems.
Teaching materials	1. Picture source: Picture 1:  Picture source: https: //www. xiangmu. com/xm/wanguoyuan/ Picture 2:

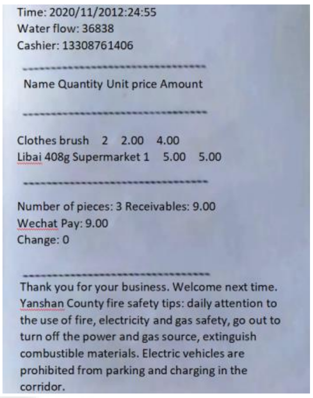
Picture source: http: //www. dianping. com/photos/902295601

Picture 3:

Picture source: https: //detail. 1688. com/offer/596220355503. html

Picture 4:

Picture source: http: //www. dianping. com/photos/902295601



Time: 2020/11/2012:24:55
Water flow: 36838
Cashier: 13308761406

Name Quantity Unit price Amount

Clothes brush 2 2.00 4.00
Libai 408g Supermarket 1 5.00 5.00

Number of pieces: 3 Receivables: 9.00
Wechat Pay: 9.00
Change: 0

Thank you for your business. Welcome next time. Yanshan County fire safety tips: daily attention to the use of fire, electricity and gas safety, go out to turn off the power and gas source, extinguish combustible materials. Electric vehicles are prohibited from parking and charging in the corridor.

Picture 5:

Picture source: https: //www. sohu. com/a/434085087_120210023

2. Reference material:

(1). Fourth Grade Math Volume 2 (RJ). Editor-in-chief: Zhijian Du. Web site: http: //press. njnu. edu. cn

(2). Elementary school lesson plan and homework design. Editor-in-chief: Xie Guping. Publishing House: Xinjiang Youth Publishing House.

3. Student cooperative learning activity list

Activity 1: Understanding the meaning of "unit price, quantity, total price" (5 minutes)

1. Read the definition of unit price, quantity and total price together, talk about your understanding of these three concepts in the group, and observe the meaning of each item in the receipt. What is the price, quantity and total price of each item? Can you give an example of what each item is?

Each item in the receipt refers to:

Their unit price is respectively:

The quantities are:

The quantities are:

2. I asked the students to investigate the prices of some commodities yesterday. Do you know the unit price of any commodities? To give two examples

	Example , Activity 2: Explore the relationship between unit price, quantity and total price (15 minutes) (1) One basketball is 80 yuan, how much is it to buy three? A kilogram of apples is 10 yuan. How much is it to buy 4 kilograms? (1) One basketball is 80 yuan, how much is it to buy three? A kilogram of apples is 10 yuan. How much is it to buy 4 kilograms? 1. What the two questions have in common: 2. Knowing the unit price and quantity of the product, how to find the total price? 3. If you know the total price and quantity to determine the unit price how to establish the quantity relationship? If you know the total price and the unit price to find the quantity how do you establish the quantity relationship? 4. It cost 240 yuan to buy three basketballs. How much is each basketball? Known quantity: Known quantity Solution		
Lesson plan 5		2 Class period	Duration: 80 minutes
Topic of content	Promotion activity		
Learning content	Promotional activities "Full reduction activity" "buy and get free activity"		
Learning objectives	1. Understand promotional activities such as "Full discount" and "buy and get free". 2. Be able to calculate the current price of goods according to the original price and preferential method.		

Teaching method	Problem-Based Learning, Cooperative learning, gamification teaching 1.Use Problem-Based Learning to design questions, create real situations, The teacher described a shopping scene: "On the weekend, you and your mother went to the supermarket to shop and saw that the supermarket was having a 'full 100 minus 20' and 'buy one get one free' promotion. So how much do we actually have to pay in these promotions? How many goods can you get? Choose which promotion saves the most money "through these questions, guide students into the new course of learning. Put forward full reduction activities and buy a few free several practical problems, hierarchical design, from simple to complex. 2. Use cooperative learning method to improve students' problem-solving skills from four aspects: understanding, analyzing, solving and reflecting on problems 3. Gamification teaching strengthens knowledge In the final stage of the course, the teacher designs a game of "supermarket Big winner". The rules of the game are: students are divided into several groups, and each group simulates the scene of shopping in a supermarket. They need to make a reasonable shopping plan based on the given budget and commodity prices, as well as the promotion activities of the supermarket, and use the calculation method learned to calculate the total expenditure and the number of goods obtained. In the end, the group that can buy the most goods within the budget becomes the "supermarket winner." This game can not only consolidate students' knowledge of "full reduction" and "buy and give", but also cultivate their financial awareness and competitive consciousness. Note: Incentives (Use game elements such as points and MEDALS to motivate students) Throughout the teaching process, teachers can use game elements such

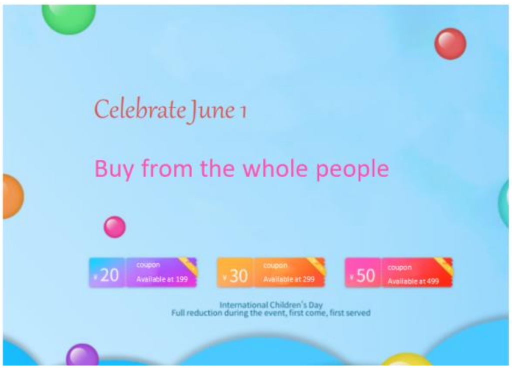
	as points, MEDALS, etc. to motivate students to actively participate in learning and discussion. For example, students who answer questions correctly can get some points. The winning team in the "Supermarket Big Winner" game can get the "Supermarket Big Winner" trophy and so on. These rewards serve as recognition and encouragement for their learning achievements.
Teaching process	1) Situation creation, problem introduction (6 minutes) Students, yesterday we let you know about the promotion of knowledge, do you know what is a promotion? What promotions did you learn about? Student: Student speaks Teacher: Students, promotional activities, as the name implies, are behavioral activities such as lowering prices or giving gifts in order to promote the sales of certain goods or services, which can promote sales, improve performance and increase revenue in a short period of time. June 1 Children's Day is coming, major shopping malls, playgrounds, bookstores and other places have carried out promotional activities, and the teacher to have a look! Show 5 pictures of promotional activities (The pictures are shown in the teaching materials) By looking at the pictures and real life, can you say what promotional activities? Say what you understand about these promotions. Student: Free on full, discount on full, reduced on full, lower the original price... Teacher: Students know a lot. How much do we actually have to pay in these promotions? How many goods can you get? Research these promotions with your teacher today! 2) Cooperative inquiry and problem solving Activity 1: "Full of less activity" (12 minutes) Example (1) : The supermarket held the anniversary celebration, special promotional activities: purchase over 200 yuan less 50 yuan, purchase

	over 500 yuan less 150 yuan. If Lele wants to buy a set of toys whose original price is 410 yuan, how much does he need to spend? Understanding question: How do you understand the difference between $200 and $50 and $500 and $150? What discount can Happy use for the toys she wants to buy? Tell me why? Analyze the problem: Talk to the group about how you would like to solve the problem. Problem solving: Write out your ideas mathematically. Reflect on your results to make sure they are correct. If Lele wants to buy a set of toys with an original price of 800 yuan, how much should she pay? Activity 2: "Buy and Get Free Activity" (12 minutes) Example (2) : In the supermarket, the price of A type of toothbrush is 13.5 yuan for 5, B type of toothbrush is 17.50 yuan for "buy 5 and get 2 free", which toothbrush is cheaper? How much cheaper per unit? 1. Understanding the question: How do you understand "buy 5, get 2 free"? What are the known and unknown quantities in this problem? 2. Analyze the problem: What can we do to solve the problem? What is it? What relationships are we going to use? How to solve this problem? 3. Problem solving: Write out your ideas mathematically. 4. Reflect on your results to make sure they are correct. Example (3) : Binbin went to the supermarket to buy a mineral water, the original price of 2.4 yuan per bottle, now carry out promotional activities, buy 4 get 1 free, Binbin bought 20 bottles of mineral water, how much money did he spend? (12 minutes) Understanding questions: How do you understand "buy 4 get 1 free"? What are the known and unknown quantities in this problem? Analysis question: Binbin bought 20 bottles, how many bottles do you actually need to pay? Why is that? Tell me what you think.

	Problem solving: Write out your ideas mathematically. Reflect on your results to make sure they are correct. Example (4) : The bookstore sells books, buy a set of books 46 yuan, buy two sets of books 75 yuan. Xiao Ming has 430 yuan, how many sets of books can you buy? (12 minutes) Understanding the question: What is known in the test? What are the requirements? 2. Analysis question: If you buy two sets of two sets, how much money does each set need? Do you buy two sets of two? Or do you buy them one by one? Why? Tell me how you want to solve this question. 3. Problem solving: Write out your ideas mathematically. 4. Reflect on your results to make sure they are correct. 3) Present results and evaluation (16 minutes) Group presentation: Class optimization Master App randomly select some groups to report. Outcome Presentation: Each group selects a representative to present their solution and exploration process to the whole class. This facilitates mutual learning and inspiration among students. Evaluation and Feedback: Teachers and students jointly evaluate the solutions presented by each group and provide constructive feedback. Evaluation criteria can include aspects such as the innovation, practicality, and logic of the solutions. 4) Summary and reflection (6 minutes) Teacher Summary: The teacher summarizes the entire problem-solving process, emphasizing the strengths demonstrated by the students during the exploration process as well as areas that require improvement. Student Reflection: Students are encouraged to engage in personal and group reflection, contemplating their own performance during the problem-solving process and how they can improve and enhance their

	skills in the future. 5) Knowledge consolidation and gamification teaching (4 minutes) In the final stage of the course, the teacher designs a game of "supermarket Big winner". The rules of the game are: students are divided into several groups, and each group simulates the scene of shopping in a supermarket. They need to make a reasonable shopping plan based on the given budget and commodity prices, as well as the promotion activities of the supermarket, and use the calculation method learned to calculate the total expenditure and the number of goods obtained. In the end, the group that can buy the most goods within the budget becomes the "supermarket winner." This game can not only consolidate students' knowledge of "full reduction" and "buy and give", but also cultivate their financial awareness and competitive consciousness.
Homework assignment	Fundamental question: 1.The supermarket held the anniversary celebration, and launched special promotions: If you buy 400 yuan less than 50 yuan, 800 yuan less than 100 yuan, if Lele wants to buy a set of toys with an original price of 700 yuan, how much does he need to spend? 2. A bunch of flowers 35 yuan to buy 5 bunches of flowers to send 2 bunches of incognito to buy 5 bunches of each bunches of flowers How much cheaper? Extension question: Huadu Primary school fourth grade 8 teachers led 172 students to the field of autumn outing each person to bring a bottle of mineral water, mineral water in the supermarket 2 yuan bottle, and buy 5 to get 1, if the collective to buy, as long as pay how much money can be? Promotion question: Beverage promotion: Sales method 1 1 bottle 10 yuan/bottle

	Sales method 2 1 box (2 bottles)18/ box Sales Method 3 1 box (8 bottles)60 yuan/box Mom took 200 yuan to buy drinks, how many bottles can you buy at most?
Learning evaluation	1. Observe classroom activities and give appropriate verbal comments, encouragement or criticism according to students' classroom performance. 2. Observe the situation of group cooperative learning, such as students' learning behavior and enthusiasm for participating in activities. Use class optimization master to record student performance. 3. Students' performance in completing the group cooperative learning activity list and reporting problems.
Teaching materials	1. Fourth Grade Math Volume 2 (RJ). Editor-in-chief: Zhijian Du. Web site: http: //press. njnu. edu. cn 2. Elementary school lesson plan and homework design. Editor-in-chief: Xie Guping. Publishing House: Xinjiang Youth Publishing House. 3. https: //max. book118. com/html/2023/0627/5142241300010233. shtm 4. https: //wenku. baidu. com/view/684f46444b2fb4daa58da0116c175f0e7cd1192c. html?_wkts_=1691896592578&bdQuery=%E6%BB%A1%E5%87%8F%E6%B4%BB%E5%8A%A8%E6%95%99%E5%AD%A6%E8%AE%BE%E8%AE%A1%E5%AD%A6%E7%94%9F%E5%88%86%E6%9E%90 5. picture source



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6. Student cooperative learning activity list

Activity 1: "Full of less activity" (15 minutes)

Example (1) : The supermarket held the anniversary celebration, special promotional activities: purchase over 200 yuan less 50 yuan, purchase over 500 yuan less 150 yuan. If Lele wants to buy a set of toys whose original price is 410 yuan, how much does he need to spend?

Understanding question: How do you understand the $50 deduction over $200 and the $150 deduction over $500? What discount can Happy use for the toys she wants to buy? Tell me why?

Analyze the problem: Talk to the group about how you would like to solve the problem.

Problem solving: Write out your ideas mathematically.

Reflect on your results to make sure they are correct. If Lele wants to buy a set of toys with an original price of 800 yuan, how much should she pay?

Activity 2: "Buy and Get Free Activity" (15 minutes) Example question (2) : In the supermarket, the price of A type of toothbrush is 13. 5 yuan for 5, B type of toothbrush is 17. 50 yuan for "buy 5 and get 2 free", which toothbrush is cheaper? How much cheaper per unit?

Understanding the question: How do you understand "buy 5, get 2 free"?

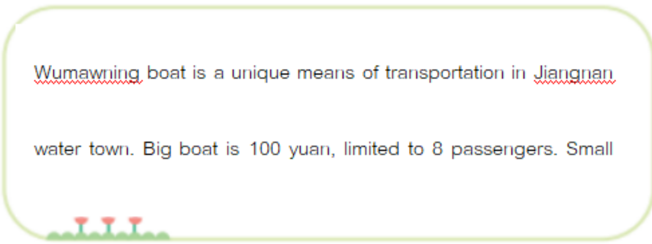
<table>
<tr><td></td><td colspan="2">What are the known and unknown quantities in this problem?
Analyze the problem: What can we do to solve the problem? What is it?
What relationships are we going to use? How to solve this problem?
Problem solving: Write out your ideas mathematically.
Reflect on your results to make sure they are correct.
Example (3) : Binbin went to the supermarket to buy a mineral water, the original price of 2. 4 yuan per bottle, now carry out promotional activities, buy 4 get 1 free, Binbin bought 20 bottles of mineral water, how much money did he spend? (15 minutes)
Understanding questions: How do you understand "buy 4 get 1 free"?
What are the known and unknown quantities in this problem?
Analysis question: Binbin bought 20 bottles, how many bottles do you actually need to pay? Why is that? Tell me what you think.
Problem solving: Write out your ideas mathematically.
Reflect on your results to make sure they are correct.
Example (4) : The bookstore sells books, buy a set of books 46 yuan, buy two sets of books 75 yuan. Xiao Ming has 430 yuan, how many sets of books can you buy? (15 minutes)
1. Understanding the question: What is known in the test? What are the requirements?
2. Analysis question: If you buy two sets of two sets, how much money does each set need? Do you buy two sets of two? Or do you buy them one by one? Why? Tell me how you want to solve this question.
3. Problem solving: Write out your ideas mathematically.
4. Reflect on your results to make sure they are correct.</td></tr>
<tr><td>Lesson plan 6</td><td>1 Class period</td><td>Duration: 40 minutes</td></tr>
<tr><td>Topic of content</td><td colspan="2">Chartering problem</td></tr>
<tr><td>Learning</td><td colspan="2">1. The application of the relationship between price, quantity and total</td></tr>
</table>

content	price quantity 2. The method of solving the problem by making gradual adjustments based on the hypothesis results.
Learning objectives	1. Master the basic method of making gradual adjustments based on assumptions first. 2. Able to apply the learned knowledge to solve the cost problem of common "charter plan".
Teaching method	Problem-Based Learning, Cooperative learning, gamification teaching 1. Use Problem-Based Learning to design questions, create real situations. The teacher described a real boat rental scenario: "The school organized a spring trip and needed to rent some boats. Each boat can seat 4 people and the rent is 24 yuan per boat. Each boat can seat 6 people, and the rent is 30 yuan per boat. There are 40 students in our class. How many boats do we need to rent? How much will it cost?" Through this question, students are guided into the study of new lessons. Use cooperative learning method to improve students' problem-solving skills from four aspects: understanding, analyzing, solving and reflecting on problems. 3. Gamification teaching strengthens knowledge In the final stage of the course, the teacher designed a "Spring Trip charter boat Grand Challenge" game. The rules of the game are: the students are divided into several groups, and each group simulates the scenario of renting a boat for a spring outing. They need to make a reasonable charter plan according to the given number of students and the rental and capacity of the boat, and use the calculation method learned to calculate the total rent and whether the number of people can meet the demand. In the end, the team that can come up with the most economical and satisfying charter plan will be the winner of the "Spring

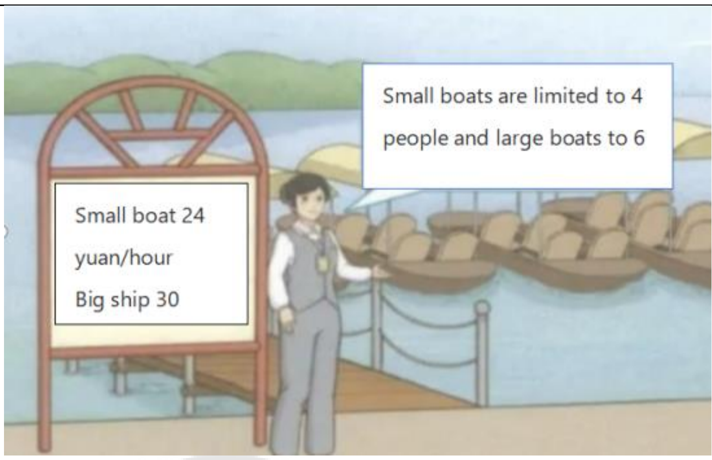
	Vacation Charter Challenge". This game can not only consolidate students' knowledge of chartering problems, but also cultivate their financial awareness and competitive consciousness. Note: Incentives (Use game elements such as points and MEDALS to motivate students) Throughout the teaching process, teachers can use game elements such as points, MEDALS, etc. to motivate students to actively participate in learning and discussion. For example, students who answer questions correctly can get some points. The winning team in the "Spring Tour Charter Challenge" game can get the "Spring Tour Little Master" trophy and so on. These rewards serve as recognition and encouragement for their learning achievements.
Teaching process	1) Create a situation and introduce a problem (3 minutes) 1. Play children's favorite entertainment program "Open the door", test students' listening, see who is the fastest response? (Play the song accompaniment) presuppose: Student: "Let's paddle together". 2. The students guessed correctly. "Let's paddle together" is a popular song in our teacher's childhood. It has been popular for decades. Do you know what this song is about? presuppose: Student: “North Sea boating”. 3. Let’s imagine, how pleasant it is to go boating on the river with the gentle wind and the rising sun, the willows like greenery, light oars! Spring is here, do you want a spring outing? Students think about it, if we want to organize a spring outing recently, what cost problems will we encounter? Students are free to talk about the cost of car rental, meals, tickets to scenic spots, and recreational items. 4.My favorite recreational item is rowing. Let us first study the issue of

	chartering fees today, the blackboard topic: "Chartering Issues" 5. What do we need to know first? Student: How many charging schemes are there? What are the fees for each plan? 6. Let's have a look at the plan of chartering a boat in a scenic area. Present the problem situation: Talk to each other in groups 7. What questions would you ask? Give credit to students who ask valuable questions. (Class management master small program bonus points) 2) Defining and analyzing the problem (5 minutes) 1. Present the question: If there are 32 students in our class who want to play boating for 1 hour, how can we buy tickets more cost-effectively? What conditions do you need to solve this problem? Preset: Students may answer many questions, such as how much does it cost per person to rent a big boat? How much does it cost per person to rent a boat? Is it cheaper for us to rent a big boat or a smaller boat? Do we all charter small boats or all big boats? Or can small boats and big boats be rented together? Give praise to students who raise valuable questions (you can use the class optimization master app to add points) Encourage students who do not meet the requirements, and point out the reasons for the non-compliance 2. Students cooperate, communicate and discuss the most economical plan for chartering a boat. Preset question: Can you calculate how much each ship costs per person? Choose again. You can try both small boats or both big boats to see which is more economical, and then adjust. Assuming that if you use a big boat, how much will it cost?

	Assuming how much would it cost to use a small boat? No matter what kind of boat you rent, is the boat you rented full? Wouldn't it be more economical to adjust it without a full adjustment? 3)Explore and solve problems (17minitues) 1. Organize the solution to the problem and try to solve the problem according to the solution Teacher looks around to maintain discipline and helps students answer questions 2. Group report and display the results Since there are too many groups to report one by one, 2 groups are randomly selected for reporting with the help of the Class Optimization Master APP, and extra points are given to the groups that perform well. Other groups that did not report can question the reporting group and give extra points for praise. 3. Work in groups and fill out the study sheet 4. Summary process and formation method 4)Present results and evaluation(8 minutes) Group presentation: Class optimization Master App randomly select some groups to report. Outcome Presentation: Each group selects a representative to present their solution and exploration process to the whole class. This facilitates mutual learning and inspiration among students. Evaluation and Feedback: Teachers and students jointly evaluate the solutions presented by each group and provide constructive feedback. Evaluation criteria can include aspects such as the innovation, practicality, and logic of the solutions. 5)Summary and reflection(3 minutes) Teacher Summary: The teacher summarizes the entire problem-solving process, emphasizing the strengths demonstrated by the students during

	the exploration process as well as areas that require improvement. Student Reflection: Students are encouraged to engage in personal and group reflection, contemplating their own performance during the problem-solving process and how they can improve and enhance their skills in the future. Consolidation and promotion (8 minutes) In the final stage of the course, the teacher designed a "Spring Trip charter boat Grand Challenge" game. The rules of the game are: the students are divided into several groups, and each group simulates the scenario of renting a boat for a spring outing. They need to make a reasonable charter plan according to the given number of students and the rental and capacity of the boat, and use the calculation method learned to calculate the total rent and whether the number of people can meet the demand. In the end, the team that can come up with the most economical and satisfying charter plan will be the winner of the "Spring Vacation Charter Challenge". This game can not only consolidate students' knowledge of chartering problems, but also cultivate their financial awareness and competitive consciousness.
Homework assignment	Fundamental question: Xincheng Primary School organized fourth-grade students to study in  Jiangnan water towns. (1) There are 42 students in Class 1 Grade 4. What is the cheapest way to rent a boat? How much is the rent? (2) There are 47 teachers and students in Class 3 Grade 4. How to rent a

	Option 1 Adult ticket :180 yuan/person Child ticket: 60 yuan/person Option 1 Adult ticket :180 yuan/person Child ticket: 60 yuan/person boat most cost-effectively? How much is the rent? Extension question: Sunshine Travel Agency launched the "Taishan one day tour" of two How to buy tickets for 6 adults and 4 children? (2) Adults 4, children 6, how to buy tickets? Promotion question:  The teachers and students of class 4 (1) went to the Botanical garden to sketch. There are 35 students and 5 teachers leading the team. What is the cheapest way to buy tickets? What is the minimum cost?
Learning evaluation	1. Observe classroom activities and give appropriate verbal comments, encouragement or criticism according to students' classroom performance. 2. Observe the situation of group cooperative learning, such as students' learning behavior and enthusiasm for participating in activities. Use class optimization master to record student performance. 3. Students' performance in completing the group cooperative learning activity list and reporting problems.
Teaching materials	1. Fourth Grade Math Volume 2 (RJ). Editor-in-chief: Zhijian Du. Web site: http: //press. njnu. edu. cn

<table>
<tr><td></td><td colspan="2">

2. Elementary school lesson plan and homework design. Editor-in-chief: Xie Guping. Publishing House: Xinjiang Youth Publishing House.
3. Student cooperative learning activity list
1. Present the question: If there are 32 students in our class who want to play boating for 1 hour, how can we buy tickets more cost-effectively? What conditions do you need to solve this problem?
2. Students cooperate, communicate and discuss the most economical plan for chartering a boat.
3. Try to solve the problem according to the solution
Teacher looks around to maintain discipline and helps students answer questions
4. Group report and review problem</td></tr>
<tr><td>Lesson plan 7</td><td>2 Class period</td><td>Duration: 80 minutes</td></tr>
<tr><td>Topic of content</td><td colspan="2">The circumference of a rectangle and a square</td></tr>
<tr><td>Learning content</td><td colspan="2">1. Meaning of circumference
2. Derivation method of circumference formula of rectangle and square
3. Apply the knowledge about the circumference of rectangular and square lines to solve practical problems in life.</td></tr>
</table>

Learning objectives	1. Understand what girth means 2. Master the derivation method of circumference formula of rectangle and square 3. Can flexibly apply the knowledge about the circumference of rectangular and square lines to solve practical problems in life.
Teaching method	Cooperative learning, gamification teaching 1. Use gamification teaching method to review old knowledge. The teacher designed a "floor tile puzzle" game, by asking students to use different shapes and sizes of floor tile models to do the puzzle, and guide them to observe the size of the space occupied by different floor tiles. Then ask the question, "What is the difference in the size of the space occupied by these tiles?" Thus leads to the concept of area. 2. Create real situations, ask questions, and use cooperative learning to solve problems. The teacher showed a real life scene: "Xiao Ming's new house needs to be renovated, and his mother wants him to help calculate how much it will cost to lay the floor tiles. What information would you need to know to help him solve this problem?" Through this question, students are guided into the study of new lessons. Use cooperative learning method to improve students' problem-solving skills from four aspects: understanding, analyzing, solving and reflecting on problems 3. Gamification teaching strengthens knowledge In the final stage of the course, the teacher designs a game of "floor tile designer". The rules of the game are: students are divided into several groups, each group uses different shapes and sizes of floor tile models to design a beautiful floor pattern, and calculate the total area and number of floor tiles required. Then compare the creativity of each group's design scheme and the accuracy of the calculation. This game can not only consolidate students' area knowledge, but also cultivate their design

	ability and aesthetic awareness. Note: Incentives (Use game elements such as points and MEDALS to motivate students) Throughout the teaching process, teachers can use game elements such as points, MEDALS, etc. to motivate students to actively participate in learning and discussion. For example, students who answer questions correctly can get some points. Teams that perform well in the "FIoor Tile Designer" game can be awarded "Excellent Designer" MEDALS and so on. These rewards serve as recognition and encouragement for their learning achievements.
Teaching process	1) Introduction and review: (3 minutes) The teacher designed a "graph kingdom" game, by asking students to play different graphic roles, in the form of questions or contests to review the characteristics of rectangles and squares previously learned. The game is designed to stimulate students' memories of what they have learned before and to lay the foundation for new lessons. 2) Situation creation and question raising (5 minutes) (Show two cards: one rectangle, one square) Teacher: The birthday of two of my teacher's friends is coming up and the teacher wants to make two cards for them, one is rectangular and the other is square, but he doesn't think the cards are pretty enough, so I want to make the week of the two cards decorated with ribbons (show the week with my hand). Can you guess which card needs the longer ribbon? Which card needs a shorter ribbon? (Design intention: Guide students to think and stimulate their desire to explore through practical problems). Students say what they think. Teacher: In fact, we want to compare the "length of two cards need ribbons", that is, to compare the "length of two cards for a week" (teacher demonstration refers to a week), now let's point to the circumference of a

	card. The students "point" the circumference of the two cards with their hands under the guidance of the teacher. Teacher: Very good. Just now the students have made their own guesses when comparing the two cards. Please compare the difference between the rope measurement method and the ruler method. Student: The rope measurement method is simple and quick, and can be compared without calculation. The ruler measurement method is troublesome and needs to be calculated, but it can specifically calculate who is longer than who. Teacher: What the students said is very good. Now let's verify it together. Is it right or wrong? 3) Cooperative inquiry and problem solving Activity 1: Explore the circumference formula of a rectangle. (20 minutes) One rectangular and square card per person Collaborate on the following questions: 1. Measure the length and width of the rectangle and record it. 2. What is the circumference of the rectangle? Report and exchange, combined with students' answers on the board: The circumference of a rectangle = length + length + length + length = length x 2+ width x 2 =(length + width) x 2 1. Measure the length and width of the rectangle and record it. 2. What is the circumference of the rectangle? Report and exchange, combined with students' answers on the board: The circumference of a rectangle = length + length + length + length = length x 2+ width x 2 =(length + width) x 2 (1) Measure the side length of the square and record it.

	(2) What is the circumference of the square? Report and exchange, combined with students' answers on the board: The circumference of the square = side + side + side + side = side length x 4 Which of these two methods do you prefer? Why? Teachers and students summed up the formula of circumference of a square = side length ×2 Activity 2: A rectangular flower bed is 5 meters long and 3 meters wide. What is the circumference of this flower bed in meters? (16 minutes) Cooperation completed: 1. Say what you understand about the question in the group, and write what you know and what you don't know. 2. How does the analysis solve this problem? 3. Write out the resolution process. 4. Talk about whether this is the right thing to do. Group report (Class optimization Master APP randomly selected a group of reports) Activity 3: A square tablecloth (like the picture on the right), to sew lace around it, the length of the lace is how many decimeters? (16 minutes) 1. Say what you understand about the question in the group, and write what you know and what you don't know. 2. How does the analysis solve this problem? 3. Write out the resolution process, 4. Talk about whether this is the right thing to do. Group report (Class optimization Master APP randomly selected a group of reports) 4) Knowledge consolidation and gamification teaching (15 minutes) In the final stage of the course, the teacher designs a game of "supermarket Big winner". The rules of the game are: students are divided

	into several groups, and each group simulates the scene of shopping in a supermarket. They need to make a reasonable shopping plan based on the given budget and commodity prices, as well as the promotion activities of the supermarket, and use the calculation method learned to calculate the total expenditure and the number of goods obtained. In the end, the group that can buy the most goods within the budget becomes the "supermarket winner. " This game can not only consolidate students' knowledge of "full reduction" and "buy and give", but also cultivate their financial awareness and competitive consciousness. 5) Evaluation and Reflection (3 minutes) The teacher guides the students to evaluate and reflect. Students can evaluate their own performance in this study, what knowledge they have learned in this lesson, and find out their shortcomings and areas for improvement. At the same time, teachers can adjust and optimize teaching methods and contents according to students' performance and feedback to better meet students' learning needs.
Homework assignment	Fundamental question: 1. The basketball court is 28 meters long and 15 meters wide. What is the circumference of the basketball court in meters?  2. Take a piece of wire 36 cm long and form a square exactly. How many centimeters are the sides of the square? Extension question: A rectangular vegetable patch, 9 meters long and 6 meters wide. How many meters is it around here? If it's against a wall, how many meters is it at least? Promotion question:

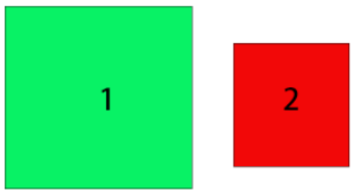
	A piece of iron wire can be made into a rectangle 28 centimeters long and 12 centimeters wide. If it is made into a square, what is the side length of the square? 1. Fourth Grade Math Volume 2 (RJ). Editor-in-chief: Zhijian Du. Web site: http: //press. njnu. edu. cn 2. Elementary school lesson plan and homework design. Editor-in-chief: Xie Guping. Publishing House: Xinjiang Youth Publishing House.
Learning evaluation	1. Observe classroom activities and give appropriate verbal comments, encouragement or criticism according to students' classroom performance. 2. Observe the situation of group cooperative learning, such as students' learning behavior and enthusiasm for participating in activities. Use class optimization master to record student performance. 3. Students' performance in completing the group cooperative learning activity list and reporting problems.
Teaching materials	Student cooperative learning activity list Activity 1: Explore the circumference formula of a rectangle. (20 minutes) Each person is given a rectangular and square card 1. Measure the length and width of the rectangle and record it. Length of rectangle = width of rectangle = . 2. What is the circumference of the rectangle? Summary of methods: Summarize the formula for the circumference of the rectangle: . Activity 2: Explore the circumference formula of a rectangle. (15 minutes) We have accounted for the circumference of the rectangle, so how should we calculate the circumference of the square? 1. Measure the sides of the square and record them. The side length of the square = .

<table>
<tr><td></td><td colspan="2">2. What is the circumference of the square?
Summary of methods:
Summarize the formula for the circumference of the square .</td></tr>
<tr><td>Lesson plan 8</td><td>1 Class period</td><td>Duration: 40 minutes</td></tr>
<tr><td>Topic of content</td><td colspan="2">Cognitive area</td></tr>
<tr><td>Learning content</td><td colspan="2">1. Meaning of area
2. Area of the plane figure
3. Compare the area size of the plane graphics</td></tr>
<tr><td>Learning objectives</td><td colspan="2">1. Understand the meaning of area.
2. Know the area of the plane figure.
3. Compare the area of the figure.</td></tr>
<tr><td>Teaching method</td><td colspan="2">Cooperative learning, gamification teaching
1. Use gamification teaching method to review old knowledge.
Before class, the teacher designed a "graphic puzzle" game, by allowing students to use different shapes and sizes of graphic cards to puzzle, and guide them to observe the size of the space occupied by different graphics. Then ask the question, "What is the difference in the size of the space occupied by these shapes?" Thus leads to the concept of area.
2. Create real situations, ask questions, and use cooperative learning to solve problems. The teacher showed a real life scene: "Xiao Ming's family wants to buy a new carpet and needs to know the area of the floor of the room. So how do we calculate the floor area of the room?" Through this question, students are guided into the study of new lessons. Use cooperative learning method to improve students' problem-solving skills from four aspects: understanding, analyzing, solving and reflecting on problems
3. Gamification teaching strengthens knowledge
At the end of the course, the teacher designs a game called "Little</td></tr>
</table>

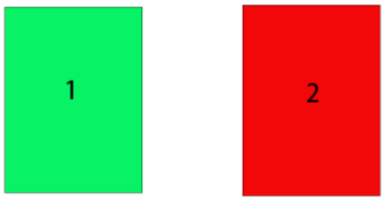
	Surveyor". The rules of the game are: students are divided into several groups, and each group uses measuring tools (such as ruler, tape measure, etc.) to measure the surface area of different objects in the classroom, such as tables, Windows, etc. The accuracy and efficiency of each group's measurement results were then compared. This game can not only consolidate students' area knowledge, but also cultivate their practical operation ability and competitive consciousness. Note: Incentives (Use game elements such as points and MEDALS to motivate students) Throughout the teaching process, teachers can use game elements such as points, MEDALS, etc. to motivate students to actively participate in learning and discussion. For example, students who answer questions correctly can get some points. The team that performs well in the "Little Surveyor" game can get the "Excellent Surveyor" medal and so on. These rewards serve as recognition and encouragement for their learning achievements.
Teaching process	1) Introduction and review: (3 minutes) The teacher designs a "graphic jigsaw" game by asking students to use graphics cards of different shapes and sizes to do the puzzle, and guiding them to observe the size of the space occupied by different graphics. Then ask the question, "What is the difference in the size of the space occupied by these shapes?" Thus leads to the concept of area. 2) Situation creation and question raising (5 minutes) The teacher showed a real life scene: "Xiao Ming's family wants to buy a new carpet and needs to know the area of the floor of the room. So how do we calculate the floor area of the room?" Through this question, students are guided into the study of new lessons. 3) Cooperative inquiry and problem solving. Activity 1: Sense the area of the surface of the object. (6 minutes)

	Teacher: Touch the cover of the textbook and the top of the desk and talk about your feelings Student: The cover of the textbook can be touched quickly, but the top of the desk can be touched more slowly Teacher: That is to say, the size of the textbook cover is different from the size of the desk. The size of the textbook cover is the area of the textbook cover, and the size of the desk top is the area of the desk top. Can you tell me about the area of surfaces on other objects like the teacher said? Communication and discussion within the group, with examples (3 can be used) Teachers and students summarize the concept of area, the size of the surface of the object is called the area of the surface of the object. Activity 2. Perceive the area of the enclosed figure. (6 minutes) "Drawing Competition" : the rules of the game: each group sends a representative to draw the shape of the graph you have learned on the blackboard and fill it with color, and the number of graphs drawn within the specified time wins. (Note: unpainted does not count) (Class Optimization Master APP randomly selected 2 groups to participate in the competition) The end of the game will still cause students to question the fairness of the game, and the questioning will cause students to think that the closed graphics have sizes. Summary: The size of a closed figure is its area. Activity 3. Compare the size of the graphic area. (6 minutes)

Show three sets of graphics:



The first group



The second group

The third group

Teacher: Whose area is larger in the first group? In what way can we compare?

Student: The area of 1 is large, you can use the observation method

Teacher: Whose area is larger in the second group? In what way can we compare?

Student: The area of 2 is large, you can use the overlap method

Teacher: Whose area is larger in the third group? In what way can we compare?

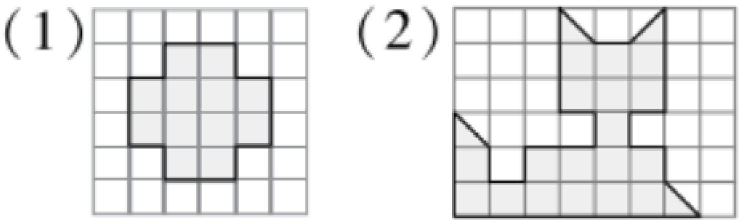
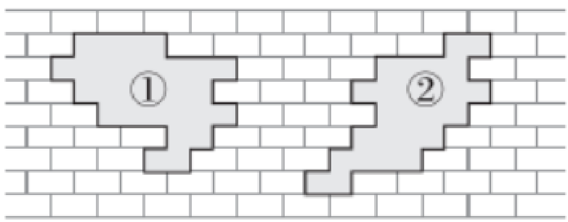
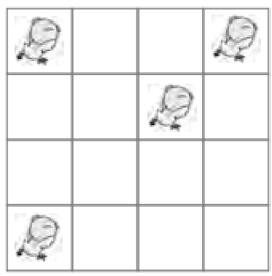
Student: The length of number 1 is longer than number 2, the width of number 1 is shorter than number 2, and neither observation nor overlap will work.

The teacher handed out the third set of graphics and asked the group to work together.

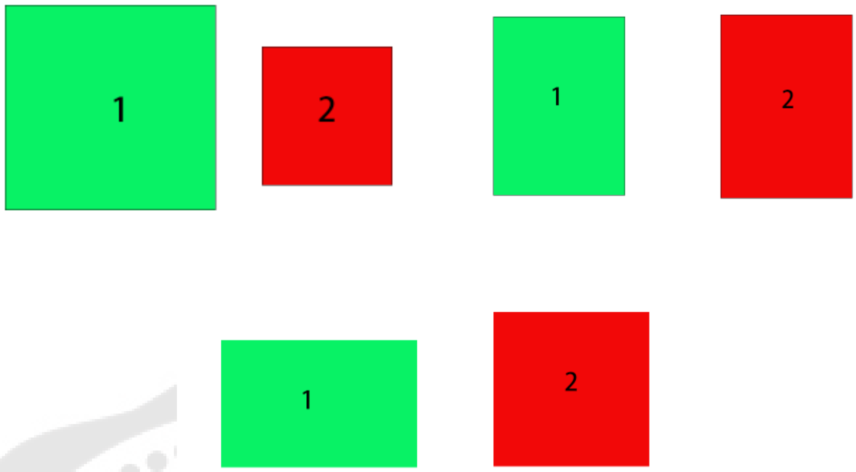
Group cooperation requirements: (Provide materials: small circle, small triangle, small square, small rectangle, transparent square paper.)

(1) You can think of your own ideas, or you can use the materials provided by the teacher.

	(2) After coming up with a method, the group leader leads everyone to explore other methods. (3) After the operation, talk about the conclusions reached in the group. Group presentation results (one group randomly selected by Class Optimization Master APP) Activity 4: Feel the same area, graphics are not necessarily the same "Pasting graphics" competition: The rules of the game, with four of the same small square stickers pasted different shapes, pasted more shapes the team wins. (3 minutes) Group discussion What did you find? Activity 5. Feel the same area, graphics are not necessarily the same. (6 minutes) "Pasting graphics" competition: The rules of the game, with four of the same small square stickers pasted different shapes, pasted more shapes the team wins. Group discussion What did you find? 4) Knowledge consolidation and gamification teaching (5 minutes) At the end of the course, the teacher designs a game called "Little Surveyor". The rules of the game are: students are divided into several groups, and each group uses measuring tools (such as ruler, tape measure, etc.) to measure the surface area of different objects in the classroom, such as tables, Windows, etc. The accuracy and efficiency of each group's measurement results were then compared. This game can not only consolidate students' area knowledge, but also cultivate their practical operation ability and competitive consciousness. 5) Evaluation and Reflection (3 minutes) The teacher guides the students to evaluate and reflect. Students can evaluate their own performance in this study, what knowledge they have learned in this lesson, and find out their shortcomings and areas for

	improvement. At the same time, teachers can adjust and optimize teaching methods and contents according to students' performance and feedback to better meet students' learning needs.
Homework assignment	Fundamental question: 1. In the figure below, each represents 1cm2. What are the areas of the following figures?  ( )cm2 ( )cm2 2. Below are four figures in an equilateral network. Are the areas of the four figures equal? What do you think? The shortest circumference is ( ) Extension question: Below is a broken wall. Compare, which of these two wall holes is bigger?  Promotion question:  There is a vacant lot in front of the mother chicken's house (pictured), which is divided into four pieces of the same size and shape to build a house for each child. Do you know how it's divided? (Do not change the position of the chicken, score one point on the graph)

Learning evaluation	1. Observe classroom activities and give appropriate verbal comments, encouragement or criticism according to students' classroom performance. 2. Observe the situation of group cooperative learning, such as students' learning behavior and enthusiasm for participating in activities. Use class optimization master to record student performance. 3. Students' performance in completing the group cooperative learning activity list and reporting problems.
Teaching materials	1. Reference materials: (1). Primary Mathematics Grade 4 Volume 2 (RJ). Editor-in-chief: Zhijian Du. Web site: http: //press. njnu. edu. cn; (2). Primary school lesson plan and homework design. Editor-in-chief: Xie Guping. Publishing House: Xinjiang Youth Publishing House. 2. Student cooperative learning activity list Activity 1: Sense the area of the surface of the object. 1. Touch the cover of your textbook or the top of your desk and talk about your feelings 2. The size of the textbook cover is the area of the textbook cover, and the size of the desk top is the area of the desk top. Can you say the area of surfaces on other objects like this? Examples (3 are enough) To summarize the concept of area: . Activity 2: Perceive the area of the enclosed figure "Drawing Competition" : the rules of the game: each group sends a representative to draw the shape of the graph you have learned on the blackboard and fill it with color, and the number of graphs drawn within the specified time wins. (Note: unpainted does not count) 1. Do you think the game is fair? Summary: Area of closed graph: . Activity 3: compare the size of the graphic area Show three sets of

<table>
<tr><td></td><td colspan="2">graphics:


Who has the biggest area in the first group? In what way can we compare?
Who has the biggest area in the second group? In what way can we compare?
Who has the largest area in the third group? In what way can we compare?
Materials provided: small circle, small triangle, small square, small rectangle, transparent square paper.
Activity 4: Feel the same area, graphics are not necessarily the same
"Pasting graphics" competition: The rules of the game, with four of the same small square stickers pasted different shapes, pasted more shapes the team wins. (3 minutes)
What did you find out about it? .</td></tr>
<tr><td>Lesson plan 9</td><td>2 Class period</td><td>Duration: 80 minutes</td></tr>
<tr><td>Topic of content</td><td colspan="2">Area of rectangle and square</td></tr>
<tr><td>Learning content</td><td colspan="2">1. The meaning of area
2. Area formula derivation method of rectangle and square</td></tr>
</table>

	3. Apply the knowledge about the area of rectangular and square rows to solve practical problems in life.
Learning objectives	1. Understand what girth means 2. Master the derivation method of circumference formula of rectangle and square 3. Can flexibly apply the knowledge about the circumference of rectangular and square lines to solve practical problems in life.
Teaching method	Cooperative learning, gamification teaching 1. Use gamification teaching method to review old knowledge. The teacher designed a "graphic Lianlianlian" game, by allowing students to pair rectangles and squares and other graphics, review the graphic knowledge learned before. Then ask the question, "Which of these figures is easy to calculate?" Why?" Thus leads to the calculation method of rectangular and square area. 2. Create real situations, ask questions, and use cooperative learning to solve problems. The teacher showed a real life scene: "The school is preparing to lay floor tiles on the playground and needs to calculate how many floor tiles are needed. If the tiles are square or rectangular, how do we calculate the area of the tiles we need?" Through this question, students are guided into the study of new lessons.Use cooperative learning method to improve students' problem-solving skills from four aspects: understanding, analyzing, solving and reflecting on problems 3. Gamification teaching strengthens knowledge At the end of the course, the teacher designs a "wall designer" game. The rules of the game are: students are divided into several groups, and each group simulates the design of a classroom wall. They need to calculate the area of the wall according to the given length and width (or side length), using the calculation method they have learned, and compare the difference in the area of the wall under different design schemes. This

	game can not only consolidate students' area knowledge, but also cultivate their design ability and competitive consciousness Note: Incentives (Use game elements such as points and MEDALS to motivate students) Throughout the teaching process, teachers can use game elements such as points, MEDALS, etc. to motivate students to actively participate in learning and discussion. For example, students who answer questions correctly can get some points. The winning team in the "Wall Designer" game can win the "Excellent Designer" trophy and so on. These rewards serve as recognition and encouragement for their learning achievements..
Teaching process	1) Introduction and review: (4 minutes) The teacher designed a "graphic Lianlianlian" game, by allowing students to pair rectangles and squares and other graphics, review the graphic knowledge learned before. And then you play cartoons. (Animation content: Peppa Pig moved to a new house, mother pig asked pig and George to paint the wall: "Children, you go to the new house to paint the wall. " Two little pigs to paint the wall, after a while, mother pig came: "Tired, you who brush more ah?" "I have more, I have more. " "No, no, it's me!" Paige and George have an argument.) Teacher: Who did the most brushing? We watch Peppa Pig paint a rectangle (rectangle) and George pig paint a square (square). Can you think of any way to compare? 2) Situation creation and question raising (5 minutes) The teacher showed a real life scene: "The school is preparing to lay floor tiles on the playground and needs to calculate how many floor tiles are needed. If the tiles are square or rectangular, how do we calculate the area of the tiles we need?" Through this question, students are guided into the study of new lessons.

3) Cooperative inquiry and problem solving

Activity 1: Explore the area formula of the rectangle (25 minutes).

Cooperate to accomplish tasks

According to the groups assigned before class, each group was given a plate, several square cards with sides of 1 cm, an envelope (containing two kinds of rectangular cardstock), and several square stickers with sides of 1 cm.

Would you please use a ruler to measure the side length of the square? (1 cm)

1. Please use these small squares to create a rectangle (there is no limit to the number). Please enter the relevant data in the table below for the students who set up the table first.

NO.	Length (cm)	Width (cm)	Number of 1cm2 squares	Area (1cm2)
1				
2				
3				
4				
5				

What you found?

Class Optimization Master APP randomly selected a group to show.

2. Take out a rectangular cardstock in the envelope, measure its length and width, paste it with a square sticker, and find its area.

Class Optimization Master APP randomly selected a group to show. If there are different groups than the presentation group, they can present their methods. (Pasted all over or just one row or column)

3. Take out another kind of rectangular cardstock in the envelope and measure its length and width. Can you work out its area without the help

	of small square lines? How do you verify that your results are correct? 4. Class Optimization Master APP randomly selected a group of display. 5. Summarize the rectangular area formula. Activity 2: Explore the area formula of a square (10 minutes). 1. Make a large square with a small square and write down its side length and area. 2. Pull out the square cardstock inside the envelope, measure the side length of the cardstock, calculate the area of the square cardstock, and verify that your calculation is correct. 3. Summarize the area of the square. Talk about the connection between rectangular and square area formulas. Class Optimization Master APP randomly selected a group to show. Activity 3: Practical Application (18 min.) (1) A rectangular fish pond, 28 meters long and 15 meters wide. What is the area of the fish pond? Cooperation completed: 1. Say what you understand about the question in the group, and write what you know and what you don't know. 2. How does the analysis solve this problem? 3. Write out the resolution process. 4. Talk about whether this is the right thing to do. Group report (Class optimization Master APP randomly selected a group of reports) (2) There is a square lotus pond in the garden. Its circumference is 64 meters and its area is how many square meters? 1. Say what you understand about the question in the group, and write what you know and what you don't know. 2. How does the analysis solve this problem? 3. Write out the resolution process,

	4. Talk about whether this is the right thing to do. Group report (Class optimization Master APP randomly selected a group of reports) 4) Knowledge consolidation and gamification teaching (15 minutes) At the end of the course, the teacher designs a "wall designer" game. The rules of the game are: students are divided into several groups, and each group simulates the design of a classroom wall. They need to calculate the area of the wall according to the given length and width (or side length), using the calculation method they have learned, and compare the difference in the area of the wall under different design schemes. This game can not only consolidate students' area knowledge, but also cultivate their design ability and competitive consciousness. 5) Evaluation and Reflection (3 minutes) The teacher guides the students to evaluate and reflect. Students can evaluate their own performance in this study, what knowledge they have learned in this lesson, and find out their shortcomings and areas for improvement. At the same time, teachers can adjust and optimize teaching methods and contents according to students' performance and feedback to better meet students' learning needs.
Homework assignment	Fundamental question: 1. The length of a rectangular flower bed is 16 meters and the width is 10 meters. How many square meters is the area of tulips planted in this flower bed? 2. Take a piece of wire 36 cm long and form a square exactly. How many centimeters are the sides of the square? Extension question: A square, the side length of 28 meters, delimit 28 meters long, 12 meters wide rectangular land to grow tomatoes, the rest of the kind of cabbage kind of cabbage how many square meters?

	Promotion question: A square, the side length of 28 meters, delimit 28 meters long, 12 meters wide rectangular land to grow tomatoes, the rest of the kind of cabbage kind of cabbage how many square meters?
Learning evaluation	1. Observe classroom activities and give appropriate verbal comments, encouragement or criticism according to students' classroom performance. 2. Observe the situation of group cooperative learning, such as students' learning behavior and enthusiasm for participating in activities. Use class optimization master to record student performance. 3. Students' performance in completing the group cooperative learning activity list and reporting problems.

<table>
<tr>
<td>Teaching materials</td>
<td>
1. Reference material:
(1). The cartoon is based on Peppa Pig,
https: //www. iqiyi. com/v_182xqeve678. html
(2). Fourth Grade Math Volume 2 (RJ). Editor-in-chief: Zhijian Du. Web site: http: //press. njnu. edu. cn
(3). Elementary school lesson plan and homework design. Editor-in-chief: Xie Guping. Publishing House: Xinjiang Youth Publishing House.
(3). https: //wenku. baidu. com/view/17ba77205afb770bf78a6529647d27284b7337a8?aggId=29f48a68753231126edb6f1aff00bed5b9f373cb&fr=catalogMain_text_ernie_recall_backup_new%3Awk_recommend_main3&_wkts_=1691600908245&bdQuery=%E9%95%BF%E6%96%B9%E5%BD%A2%E5%92%8C%E6%AD%A3%E6%96%B9%E5%BD%A2%E7%9A%84%E9%9D%A2%E7%A7%AF%E5%AE%9E%E9%99%85%E5%BA%94%E7%94%A8
(4). https: //wenku. baidu. com/view/9c5b62013f1ec5da50e2524de518964bcf84d2f9. html?_wkts_=1691602618976&bdQuery=%E9%95%BF%E6%96%B9%E5%BD%A2%E5%92%8C%E6%AD%A3%E6%96%B9%E5%BD%A2%E9%9D%A2%E7%A7%AF%E8%AF%95%E9%A2%98
2. Student cooperative learning activity list
Activity 1: Explore the area formula of the rectangle (25 minutes).
Would you please use a ruler to measure the side length of the small square? (   ).
1. Please use these small squares to create a rectangle (there is no limit to the number). Please enter the relevant data in the table below for the students who set up the table first.
<table>
<tr><td>NO.</td><td>Length (cm)</td><td>Width (cm)</td><td>Number of 1cm2 squares</td><td>Area (1cm2)</td></tr>
<tr><td>1</td><td></td><td></td><td></td><td></td></tr>
</table>
</td>
</tr>
</table>

	2				
	3				
	4				
	5				

What you found : . .

2. Take out a rectangular cardstock in the envelope, measure its length and width, paste it with a square sticker, and find its area.

3. Take out another kind of rectangular cardstock in the envelope and measure its length and width. Can you work out its area without the help of small square lines? How do you verify that your results are correct?

Summarize the area of the rectangle by the formula = .

Activity 2: Explore the area formula of a square (10 minutes).

1. Make a large square with a small square and write down its side length and area.

2. Pull out the square cardstock inside the envelope, measure the side length of the cardstock, calculate the area of the square cardstock, and verify that your calculation is correct.

3. Sum up the square area formula = .

Activity 3: Practical Application (16 min.)

(1) A rectangular fish pond, 28 meters long and 15 meters wide. What is the area of the fish pond?

1. Say what you understand about the question in the group, and write what you know and what you don't know.

2. How does the analysis solve this problem?

3. Write out the resolution process.

4. Talk about whether this is the right thing to do.

(2) There is a square lotus pond in the garden. Its circumference is 64 meters and its area is how many square meters?

1. Say what you understand about the question in the group, and write

	what you know and what you don't know. 2. How does the analysis solve this problem? 3. Write out the resolution process. 4. Talk about whether this is the right thing to do.

Lesson plan 10	1 Class period	Duration: 40 minutes

Topic of content	Floor tile problem
Learning content	Use area related knowledge to solve practical problems.
Learning objectives	Can use area related knowledge to solve practical problems in life.
Teaching method	Problem-Based Learning, Cooperative learning 1. Use Problem-Based Learning to design questions, create real

	situations, and explore independently The teacher showed a real life scene: "Xiao Ming's new house needs to be renovated, and his mother wants him to help calculate how much it will cost to lay the floor tiles. What information would you need to know to help him solve this problem?" Through this question, students are guided into the study of new lessons. 2. Use cooperative learning method to improve students' problem-solving skills from four aspects: understanding, analyzing, solving and reflecting on problems。 3. Gamification teaching strengthens knowledge n the final stage of the course, the teacher designs a game of "floor tile designer". The rules of the game are: students are divided into several groups, each group uses different shapes and sizes of floor tile models to design a beautiful floor pattern, and calculate the total area and number of floor tiles required. Then compare the creativity of each group's design scheme and the accuracy of the calculation. This game can not only consolidate students' area knowledge, but also cultivate their design ability and aesthetic awareness. Note: Incentives (Use game elements such as points and MEDALS to motivate students) Throughout the teaching process, teachers can use game elements such as points, MEDALS, etc. to motivate students to actively participate in learning and discussion. For example, students who answer questions correctly can get some points. Teams that perform well in the "Floor Tile Designer" game can be awarded "Excellent Designer" MEDALS and so on. These rewards serve as recognition and encouragement for their learning achievements.
Teaching process	1)Create the situation, introduce the problem. (3 minutes) Teacher: Xiao Ming's family has bought a new house and is going to

	decorate it recently. His mother wants him to help calculate how much it will cost to lay the floor tiles. What information would you need to know to help him solve this problem? Student: The size of the house, the specifications of the tiles bought, the price of each tile... Teacher: What the students said is very good. Today, we will first help Xiaoming's mother calculate how many floor tiles she needs to buy. Blackboard topic: Paving tile problem 2) Explore new knowledge. (15 minutes) Activity 1: The floor of Xiaoming's living room is rectangular, 6 meters long and 3 meters wide. How many tiles will be used to cover the floor of this living room with square tiles with sides of 3 decimeters? 1.Understand the problem: What mathematical information can you learn from the problem? 2.Analyze the problem: What can we do to solve the problem? What is it? Are there any other algorithms? Exchange ideas within the group. 3.Problem solving: Express your ideas mathematically? 4.Reflect on the question: Is the answer correct? Tell me what you think. Activity 2: Xiao Ming's kitchen floor is 3 meters long and 2 meters wide. How many square tiles are needed for the kitchen floor with an area of 4 decimeters square? 1.Understand the problem: What mathematical information can you learn from the problem? 2.Analyze the problem: What can we do to solve the problem? What is it? Are there any other algorithms? Exchange ideas within the group. 3.Problem solving: Express your ideas mathematically? 4. Reflect on the question: Is the answer correct? Tell me what you think. Group presentation 3) Present results and evaluation (10 minutes)

	Group presentation: Class optimization Master App randomly select some groups to report. Outcome Presentation: Each group selects a representative to present their solution and exploration process to the whole class. This facilitates mutual learning and inspiration among students. Evaluation and Feedback: Teachers and students jointly evaluate the solutions presented by each group and provide constructive feedback. Evaluation criteria can include aspects such as the innovation, practicality, and logic of the solutions. 4) Summary and reflection (5 minutes) Teacher Summary: The teacher summarizes the entire problem-solving process, emphasizing the strengths demonstrated by the students during the exploration process as well as areas that require improvement. Student Reflection: Students are encouraged to engage in personal and group reflection, contemplating their own performance during the problem-solving process and how they can improve and enhance their skills in the future. 5) Knowledge consolidation and gamification teaching (10 minutes) At the end of the course, the teacher designs a "wall designer" game. The rules of the game are: students are divided into several groups, and each group simulates the design of a classroom wall. They need to calculate the area of the wall according to the given length and width (or side length), using the calculation method they have learned, and compare the difference in the area of the wall under different design schemes. This game can not only consolidate students' area knowledge, but also cultivate their design ability and competitive consciousness.

Homework assignment	Fundamental question: The stadium needs to be equipped with a large screen measuring 8 meters long and 3 meters wide. The large display is composed of several small displays with an area of 4 square decimeters. How many small displays are used to install the large display? Extension question: Plant protection UAV, also known as unmanned aerial vehicle, is an unmanned aircraft used for agriculture and forestry plant protection operations, which can be sprayed through ground remote control or navigation flight control, and can spray chemicals. A plant protection drone in a pesticide spraying operation, flying 5 meters per second, spraying width of 3 meters, how many square meters can the plant protection drone spray in a minute? Promotion question: There is a rectangular playground that is 150 meters long and 5 times as long as wide. (1) If the artificial square lawn with a side length of 3 decimeters is used to pave, how many pieces of such lawn are needed? (2) If this kind of lawn is 22 yuan per piece, how much will it cost?
Learning evaluation	1. Observe classroom activities and give appropriate verbal comments, encouragement or criticism according to students' classroom performance. 2. Observe the situation of group cooperative learning, such as students' learning behavior and enthusiasm for participating in activities. Use class optimization master to record student performance. 3. Students' performance in completing the group cooperative learning activity list and reporting problems.
Teaching materials	1. Reference material: (1). Fourth Grade Math Volume 2 (RJ). Editor-in-chief: Zhijian Du. Web site: http: //press. njnu. edu. cn

	(2). Elementary school lesson plan and homework design. Editor-in-chief: Xie Guping. Publishing House: Xinjiang Youth Publishing House. (3). https: //wenku. baidu. com/view/684f46444b2fb4daa58da0116c175f0e7cd1192c. html?_wkts_=1691896592578&bdQuery=%E6%BB%A1%E5%87%8F%E6%B4%BB%E5%8A%A8%E6%95%99%E5%AD%A6%E8%AE%BE%E8%AE%A1%E5%AD%A6%E7%94%9F%E5%88%86%E6%9E%90 2. Student cooperative learning activity list Activity 1: The floor of Xiaoming's living room is rectangular, 6 meters long and 3 meters wide. How many tiles will be used to cover the floor of this living room with square tiles with sides of 3 decimeters? Understand the problem: What mathematical information can you learn from the problem? Analyze the problem: What can we do to solve the problem? What is it? Are there any other algorithms? Exchange ideas within the group. Problem solving: Express your ideas mathematically? Reflect on the question: Is the answer correct? Tell me what you think. Activity 2: Xiao Ming's kitchen floor is 3 meters long and 2 meters wide. How many square tiles are needed for the kitchen floor with an area of 4 decimeters square? Understand the problem: What mathematical information can you learn from the problem? Analyze the problem: What can we do to solve the problem? What is it? Are there any other algorithms? Exchange ideas within the group. Problem solving: Express your ideas mathematically? Reflect on the question: Is the answer correct? Tell me what you think. Group presentation (Class Optimization Master APP randomly selected a group of presentations)

Lesson plan 11	1 Class period	Duration: 40 minutes

Topic of content	Average
Learning content	1. The meaning of average. 2. Method of average. 3. The use of averages in life.
Learning objectives	1. Understand the meaning of averages. 2. Master averages. 3. Ability to use averages to solve practical problems in life.
Teaching method	Cooperative learning, gamification teaching 1. Use gamification teaching method to review old knowledge. Before class, the teacher designed a "guess the number" game, allowing students to review the addition, subtraction, multiplication and division operations learned before by guessing an unknown number. After the game, the teacher led the students to think: "If we want to know the overall level of a set of numbers, what method should be used to represent it?" This leads to the concept of average. 2. Create real situations, ask questions, and use cooperative learning to solve problems. The teacher showed a real life scene: "The school held a math contest. There were four classes participating, and each class had a different result. How can we compare the overall level of the four classes?" Through this question, students are guided to think about the practical meaning and application of the average. Use cooperative learning method to improve students' problem-solving skills from four aspects: understanding, analyzing, solving and reflecting on problems. 3. Gamification teaching strengthens knowledge At the end of the course, the teacher designs a game called the Average Challenge. The rules of the game are: students are divided into several groups, and each group uses a calculator or pen and paper to calculate

	the average of a given number and submit an answer within a specified time. Then the calculation speed and accuracy of each group were compared. This game can not only consolidate students' knowledge of averages, but also cultivate their calculation skills and competitive consciousness. Note: Incentives (Use game elements such as points and MEDALS to motivate students) Throughout the teaching process, teachers can use game elements such as points, MEDALS, etc. to motivate students to actively participate in learning and discussion. For example, students who answer questions correctly can get some points. Teams that perform well in the "Average Challenge" game can get the "Average Little Master" medal and so on. These rewards serve as recognition and encouragement for their learning achievements.
Teaching process	1) Gamified import (3 minutes) Students have learned how to average two numbers before, and use the game Space Wobble to recall how to average two numbers. Under the guidance of the teacher, the students opened the game interface of "Space Touch Ball", the teacher timed the time, the students began to play the game, and awarded to the students who scored the highest and took the shortest time in each group. Teacher: It seems that the students have mastered the average of two numbers. Do you know the use of the average in life? Can you average many numbers? Let us know more about it today! 2) Situation creation and question raising (5 minutes) The teacher showed a real life scene: "The school held a math contest. There were four classes participating, and each class had a different result. How can we compare the overall level of the four classes?" Through this question, students are guided to think about the practical

	meaning and application of the average. 3) Cooperative inquiry and problem solving. Activity 1: Understand the meaning of the average and "move more to make up less" method to find the average. (8 minutes) Show 3 chalk boxes, box 1 has 9 pieces of chalk, box 2 has 5 pieces of chalk, box 3 has 7 pieces of chalk, I want to ask the students to help, how to make 3 chalk boxes in the same amount of chalk? Although students have not learned to find the average of many numbers, it is easy to work out that 7 pieces of chalk can be put in each pencil box, just take 2 pieces of chalk out of box 1 and put them in box 2. When the students finish the operation, the teacher will ask: now there are 7 pieces of chalk in each box, what is the number of 7? Student: Seven is the average of three numbers: nine, five, and seven. Teacher: Like this, move the chalk from more pencil boxes to less pencil boxes so that there is the same amount of chalk in each pencil box. This method is called the "move more to make up less" method, and the equal number obtained is called the average of these numbers. Activity 2: Calculating the average. (8 minutes) Finish game: The first level "transfer more to compensate less" method to find the average of 8, 12, and 14. The second level, "transfer more to compensate less" method, finds the average of the four numbers 7, 9, 10, and 14. The third "transfer more to compensate less" method finds the average of 5, 6, 10, 14 and 15. Talk to each other in a group about how it feels to beat the game? Observe the relationship between the total number, number and average of the first level, the second level and the third level? What conclusions would you draw? (Total ÷ number = average)

Boys' team	
Name	Number of shuttlecock kicks
Wang Xiaofei	19
Liu Dong	15
Li Lei	16
Semin	20
Minsun Qi	15

Girls' team	
Name	Number of shuttlecock kicks
Yang Yu	18
Zeng Shihan	20
Li Ling	19
Zhang Qian	19

Activity 3. Practical application of averages. (8 minutes)

Show the problem situation: Class 4, Group 4 boys and girls have a key kicking match. Let's take a look at their match.

Which team has the better result?

Communicate and discuss within the group, cooperate to complete the task

1. How do you understand the question? What is the known quantity? What are the unknowns? (Understanding)

2. How to solve this problem? What quantitative relationships do you use? What strategy did you adopt to solve the problem? (Analysis)

3. Write your solution. (solve)

4. Is it right? Tell me what you think? (Reflection after resolution)

Group presentation:

Use the class optimization master to randomly select a group of presentations.

4) Knowledge consolidation and gamification teaching (5 minutes)

At the end of the course, the teacher designs a game of "picking fruit". In order to consolidate the knowledge of this lesson, under the guidance of the teacher, students practice finding the average of many numbers by playing the game "Picking Fruit". During the game, the teacher should

	inspect the students and help them solve the problems encountered in the game in time. 5) Evaluation and Reflection (3 minutes) The teacher guides the students to evaluate and reflect. Students can evaluate their own performance in this study, what knowledge they have learned in this lesson, and find out their shortcomings and areas for improvement. At the same time, teachers can adjust and optimize teaching methods and contents according to students' performance and feedback to better meet students' learning needs.
Homework assignment	Fundamental question: 1. According to statistics, garbage classification can reduce the amount of domestic garbage produced per capita by more than half, so that garbage can be better disposed of harmlessly, so as to better protect the earth environment. Before the World Environmental Protection Day in 2021, Aimin Primary School organized students from grades 1 to 6 to participate in garbage sorting activities, recycling 64 kg of waste in the first week, 56 kg of waste in the second week, and 60 kg of waste in the third week. How many kilograms of waste are recycled per week on average? How many kilograms of waste are recycled per grade on average? 2 Choose one or the other (1) The average weight of Xiao Ming, Xiao Qiang, Xiao Jun and Xiao Zhi is 43 kg, of which the sum of the weight of Xiao Ming and Xiao Qiang is 90 kg, the weight of Xiao Zhi is 38 kg, and the weight of Xiao Jun is () kg. A. 38 B. 44 C. 42 (2) The following statement is correct (). A. The school customizes uniforms for students according to their average height B. In a math test, the average score of Group 1 of Xiao Lin was 92, and

<table>
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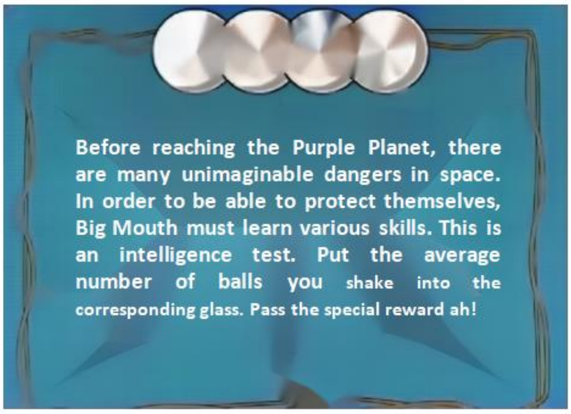
the average score of Group 2 of Xiao Fang was 90. Xiao Lin's score was not necessarily higher than Xiao Fang's
c. The average water depth of a river is 1. 2m, and a 150 cm tall Xiaoqiang will not be dangerous to swim in the river
Extension question:
<table>
<tr><th>Week</th><th>Mon</th><th>Tue</th><th>Wed</th><th>Thu</th><th>Fri</th><th>Sat</th><th>Sun</th></tr>
<tr><td>Sales volume/case</td><td>14</td><td>16</td><td>18</td><td>17</td><td>22</td><td>22</td><td>24</td></tr>
</table>
The sales of green tea in supermarkets last week are as follows:
(1) How many boxes of green tea are sold on average every day?
(2) How many boxes of green tea should the supermarket prepare each day for the next week? (The answer is not unique, reasonable)
Promotion question:
Mingming a few times before the average score of the math test is 86 points, this time to test 100 points, in order to increase the average score to 88 points, this is the number of tests?
</td>
</tr>
<tr>
<td>Learning evaluation</td>
<td>
1. Observe classroom activities and give appropriate verbal comments, encouragement or criticism according to students' classroom performance.
2. Observe the situation of group cooperative learning, such as students' learning behavior and enthusiasm for participating in activities. Use class optimization master to record student performance.
3. Students' performance in completing the group cooperative learning activity list and reporting problems.
</td>
</tr>
<tr>
<td>Teaching materials</td>
<td>
1. "Space Wobble" game rules: Before reaching the purple planet, encounter many unimaginable dangers in space. In order to be able to protect themselves, Big Mouth must learn various skills. This is an intelligence test. Put the average number of balls you shake into the
</td>
</tr>
</table>

corresponding glass. Pass the special reward ah!



A screenshot of the rules of the Space Teeter game

2. "Picking Fruit" game rules: First add the numbers displayed under the three trees to find the average. Then, according to the calculated results, use one of the four apples corresponding to the bottom, and then click with the mouse. Note, however, that the number below the Apple clicked must be the average of the three numbers given above!

Game main interface diagram

3. Reference materials:

(1). Primary Mathematics Grade 4 Volume 2 (RJ). Editor-in-chief: Zhijian Du. Web site: http: //press. njnu. edu. cn;

(2). Primary school lesson plan and homework design. Editor-in-chief: Xie Guping. Publishing House: Xinjiang Youth Publishing House.

4. Student cooperative learning activity list

	Activity 1: Understand the meaning of the average and "move more to make up less" method to find the average. Show 3 chalk boxes, box 1 has 9 pieces of chalk, box 2 has 5 pieces of chalk, box 3 has 7 pieces of chalk, How do you get the same amount of chalk in three pencil cases? Activity 2: Calculating the average. Finish game: The first level "transfer more to compensate less" method to find the average of 8, 12, and 14. The second level, "transfer more to compensate less" method, finds the average of the four numbers 7, 9, 10, and 14. The third "transfer more to compensate less" method finds the average of 5, 6, 10, 14 and 15. Observe the relationship between the total number, number and average of the first level, the second level and the third level? What conclusions would you draw? (Total ÷ number = average) Activity 3: Practical application of averages The boys and girls in Class 4, Group 4 have a key kicking match. Let's

Boys' team	
Name	Number of shuttlecock kicks
Wang Xiaofei	19
Liu Dong	15
Li Lei	16
Semin	20
Minsun Qi	15

Girls' team	
Name	Number of shuttlecock kicks
Yang Yu	18
Zeng Shihan	20
Li Ling	19
Zhang Qian	19

have a look at their match.

	Which team has the better result? 1. How do you understand the question? What is the known quantity? What are the unknowns? (Understanding) 2. How to solve this problem? What quantitative relationships do you use? What strategy did you adopt to solve the problem? (Analysis) 3. Write your solution. (solve) 4. Is it right? Tell me what you think? (Reflection after resolution)		
Lesson plan 12		1 Class period	Duration: 40 minutes
Topic of content	Compound bar chart		
Learning content	1. Characteristics of the compound bar chart 2. Drawing method of compound bar statistical chart 3. Application of compound bar chart in daily life		
Learning objectives	1. Know the characteristics of multiple bar charts. 2. Multiple bar charts will be drawn. 3. Flexible application of compound bar charts to solve practical problems in life.		
Teaching method	Cooperative learning, gamification teaching 1. Use gamification teaching method to review old knowledge. Before class, the teacher designed a "data guess" game, by showing some simple single bar statistics charts, let students guess the data represented by these statistics charts. After the game, the teacher guided the students to review the relevant knowledge of the single bar chart, which laid the foundation for learning the double bar chart. 2. Create real situations, ask questions, and use cooperative learning to solve problems. The teacher shows a real life scene: "Urban life scene and rural life scene" show the urban and rural population statistics table. To get students thinking about how can we intuitively compare the situation of		

	urban and rural populations?" . Through this question, students are guided to think about the practical application of double bar statistical charts. Use cooperative learning method to improve students' problem-solving skills from four aspects: understanding, analyzing, solving and reflecting on problems. 3. Gamification teaching strengthens knowledge At the end of the course, the teacher designs a game called "Double Bar Chart Contest." The rules of the game are: students are divided into several groups, each group uses the given data to draw a double bar chart, and submit the work within the specified time. The accuracy and aesthetics of the statistical plots drawn by the groups were then compared. This game can not only consolidate students' knowledge of compound bar chart, but also cultivate their practical ability and competitive consciousness. Note: Incentives (Use game elements such as points and MEDALS to motivate students) Throughout the teaching process, teachers can use game elements such as points, MEDALS, etc. to motivate students to actively participate in learning and discussion. For example, students who answer questions correctly can get some points. The team that performs well in the "Double Bar Statistical Chart Competition" game can get the medal of "Statistics Little Master" and so on. These rewards serve as recognition and encouragement for their learning achievements.
Teaching process	1) Introduction and review. (3 minutes) The teacher designed a "data guess" game, by showing some simple single bar statistics charts, let the students guess the data represented by these statistics charts. After the game, the teacher guided the students to review the relevant knowledge of the single bar chart, which laid the foundation for learning the double bar chart.

Urban and Rural \ Count \ Year	1980	1990	2000	2010
Urban	21	27	35	46
Rural	58	54	49	43

2) Situation creation and question raising (5 minutes)

Presentation of courseware: urban pictures and rural pictures (pictures are shown in the teaching materials section)

Teacher: Students, please observe these two pictures. What places do they show?

Student: The first picture is of a town and the second picture is of a country.

Teacher: You have observed very carefully. Now the urban construction in our country is getting better and better, and the countryside is not bad either. Don't believe me, look! This is the urban and rural population statistics table of a certain region (courseware) :

Urban and rural population statistics table in a certain area

3) Cooperative inquiry and problem solving.

Teacher: What information can you get from this statistical table?

After independent thinking, the students report by name.

Teacher: Well done, class! With so much information from this table, is there a graph that I can see at a glance how the population of a town or country is changing?

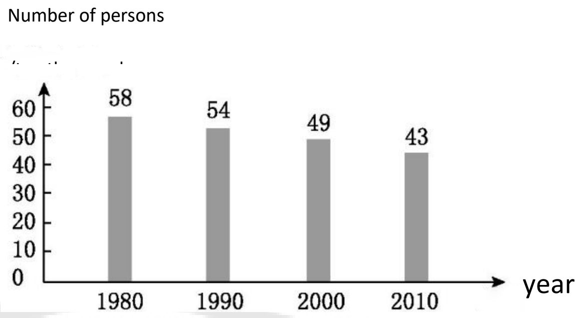
Sheng (after thinking): Yes, we can draw a bar chart.

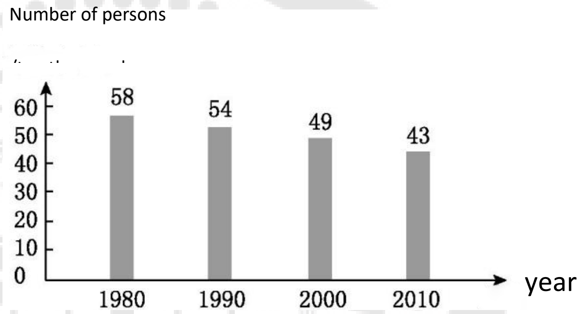
Teacher: Please do it! Cities and villages are free to choose one way to draw bar charts.

Organize students to display their works by projection after completing them independently.

Each teacher chooses a statistical map to show, and presents courseware while displaying students' works.

Statistical table on the urban and rural population of a region





Activity 1: Please observe, what are the similarities and differences between these two statistical charts? (6 minutes)

Cooperate, exchange and discuss, and show the results of the group (two groups are randomly selected to report)

(Similarities: The year on the horizontal axis is the same; They each have the same number of people on the vertical axis.

Difference: One counts the urban population of an area, the other counts the rural population of an area)

Activity 2: Since they have something in common, can we combine these two bar charts into one statistical chart? (6 minutes)

How do you synthesize a statistical graph?

Group communication, group debriefing. (Class optimization Master APP randomly selected a group to show.)

(1) Change the name of this statistical map to "Urban and rural Population

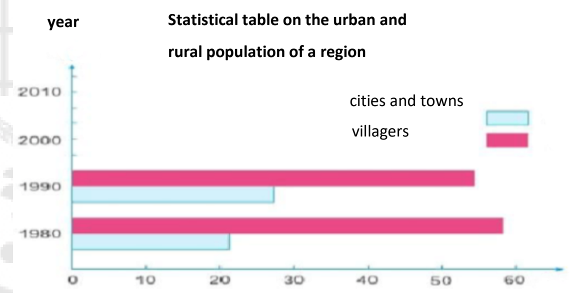
map of a region". 2: The vertical axis of the statistical chart does not need to be modified, and two scales are drawn on the horizontal axis each year, respectively representing the town and the country. 3: The width of each scale is equal, and the spacing between each year is equal. 4: At the top right of the chart, draw a small straight bar in different colors to show the population of the town and the country.

Knowledge links: The small straight bars that distinguish between towns and villages are called legends in a compound bar chart, and we can use different colors to represent different categories.

Organize the students to independently complete the statistical chart on the paper card of longitudinal compound bar chart, and display the students' works.

Activity 3: Answer the questions according to the bar chart (6 minutes)

(1) Which year has the largest urban population?Which year is the least?



Number of persons/ten thousand

(2) Which year has the largest rural population? Which year is the least?

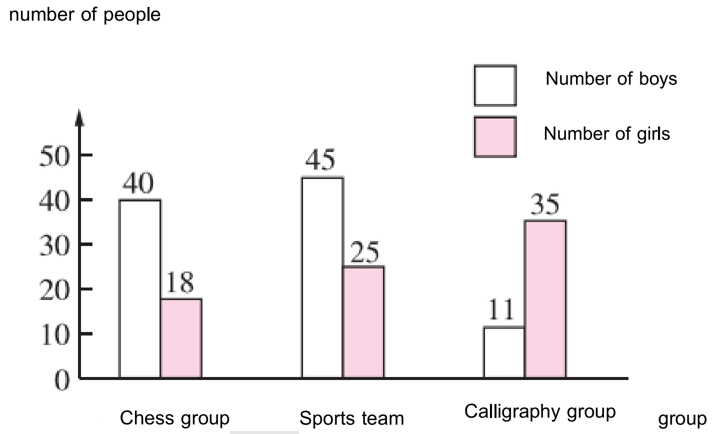
(3) Which year has the largest total urban and rural population? Which year is the least?

(4) What other information can you get? (Write two lines)

Group communication, group debriefing.

Activity 4: Show the horizontal compound bar chart: (Note: The compound bar chart can also be drawn like this, called the horizontal bar chart.) (6 minutes)

	(1) What is the difference with the statistical chart above? Cooperation and communication, group discussion (a group is randomly selected for presentation.) Organize the students to independently complete the statistical chart on the paper card of longitudinal compound bar chart, and display the students' works. 4) Knowledge consolidation and gamification teaching (5 minutes) At the end of the course, the teacher designs a game called "Double Bar Chart Contest. " The rules of the game are: students are divided into several groups, each group uses the given data to draw a double bar chart, and submit the work within the specified time. The accuracy and aesthetics of the statistical plots drawn by the groups were then compared. This game can not only consolidate students' knowledge of compound bar chart, but also cultivate their practical ability and competitive consciousness. 5) Evaluation and Reflection (3 minutes) The teacher guides the students to evaluate and reflect. Students can evaluate their own performance in this study, what knowledge they have learned in this lesson, and find out their shortcomings and areas for improvement. At the same time, teachers can adjust and optimize teaching methods and contents according to students' performance and feedback to better meet students' learning needs.
Homework assignment	Fundamental question

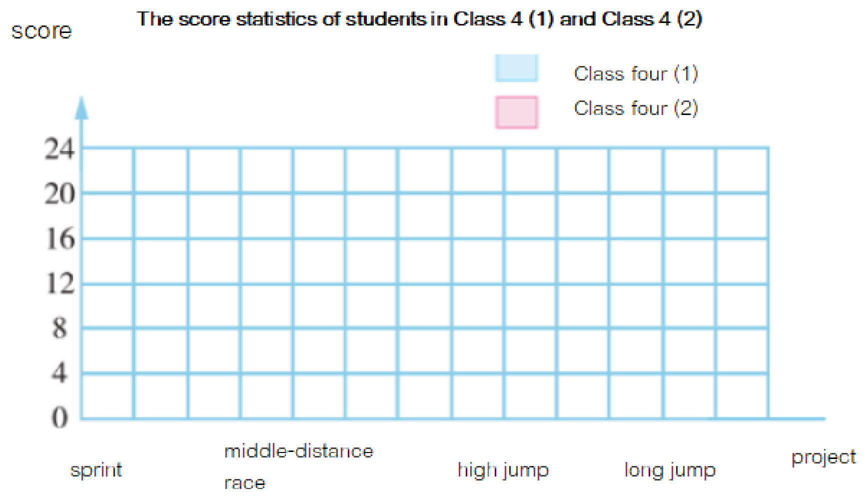
	 Fill in the blank according to the statistical chart of the number of male and female students in the extra-curricular interest group of Mingde Primary School There are ( ) people in the chess group, and ( ) people in the above interest groups. (2)( ) The number of boys in the group is the largest, and ( ) the number of girls in the group is the smallest. (3) There are ( ) people in each group on average, and there are ( ) girls in each group on average. (4) There is the smallest difference between the number of male and female students in the group Extension question: During the school sports meeting, Cong Cong recorded the scores of students in Class 4 (1) and Class 4 (2). Class 4 (1) : Sprint 15 points, middle distance running 8 points, high jump 12 points, long jump 9 points Class 4 (2) : Sprint 20 points, middle distance running 15 points, high jump 4 points, long jump 11 points (1)Organize the records of Congcong in the following statistical table,

	and calculate the total score of the two classes respectively, and fill in the table.

	Sprint	Middle-distance race	High jump	Long jump	Total
Class four (1)					
Class four (2)					

(2)Complete the statistical chart according to the statistical table

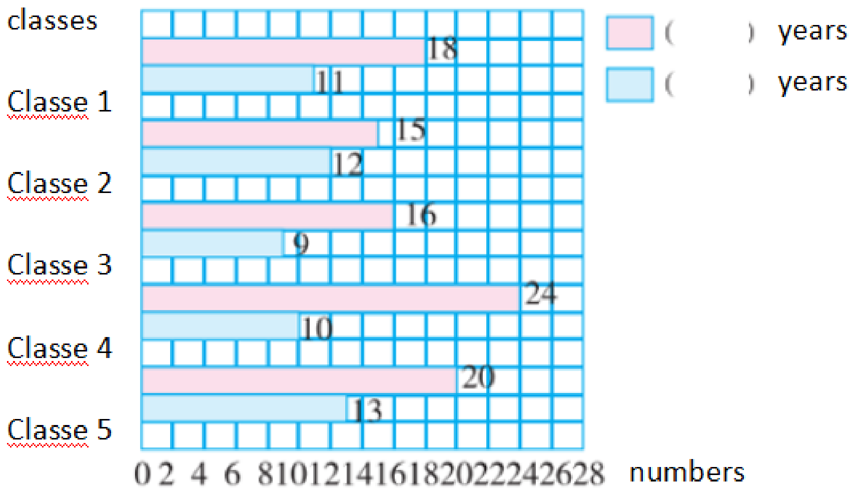
(3) Which items did Class 4 (2) do better than Class 4 (1)?



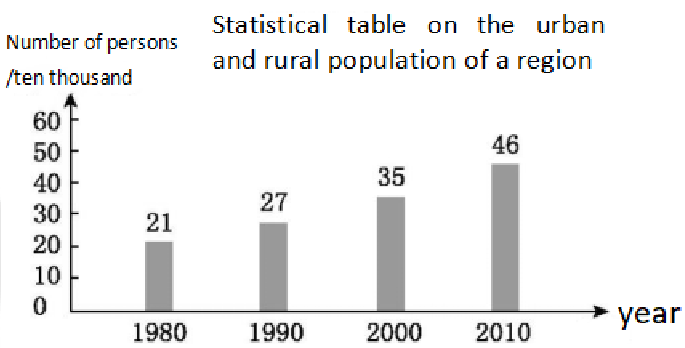
(4) What other math questions can you ask and answer?

Promotion question:

Answer the questions according to the statistical graph on the right

	Sea City Elementary School 2020-2021 **Myopia Counts by Class, Grade 4**  (1) The number of myopia in each class of Grade four in 2020 is less than that in 2021. Please complete the legend in the upper right corner of the statistical chart according to this information. (2) The largest increase in myopia in fourth grade from 2020 to 2021 is in class (). (3) In 2020, there are () myopic students in the fourth grade of Haicheng Primary School, with an average of () myopic students per class. (4) By reading the statistics chart, what do you want to say to the fourth grade students in Haicheng Primary School?
Learning evaluation	1. Observe classroom activities and give appropriate verbal comments, encouragement or criticism according to students' classroom performance. 2. Observe the situation of group cooperative learning, such as students' learning behavior and enthusiasm for participating in activities. Use class optimization master to record student performance. 3. Students' performance in completing the group cooperative learning activity list and reporting problems.
Teaching	1. Reference materials:

materials	(1). Primary Mathematics Grade 4 Volume 2 (RJ). Editor-in-chief: Zhijian Du. Web site: http: //press. njnu. edu. cn; (2). Primary school lesson plan and homework design. Editor-in-chief: Xie Guping. Publishing House: Xinjiang Youth Publishing House. Student cooperative learning activity list 2. Student cooperative learning activity list Activity 1: Please observe, what are the similarities and differences between these two statistical charts?



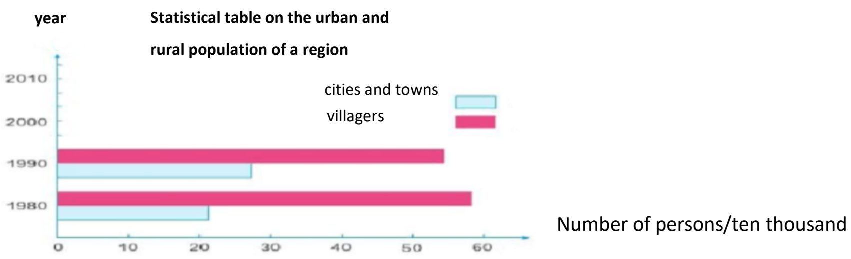
Activity 2: Since they have something in common, can we combine these two bar charts into one statistical chart? How do you synthesize a statistical graph?

Knowledge link: A small straight bar used to distinguish between town and country in a compound bar chart

Activity 3: Answer the questions according to the bar chart

(1) Which year has the largest urban population? Which year is the least?

(2) Which year has the largest rural population? Which year is the least?



(3) Which year has the largest total urban and rural population? Which year is the least?

	(4) What other information can you get? (Write two lines) Activity 4: Show the horizontal compound bar chart: (Note: The compound bar chart can also be drawn like this, called the horizontal bar chart.) What's the difference with the chart above?	
Lesson plan 13	1 Class period	Duration: 40 minutes
Topic of content	Possibility	
Learning content	1.Experience certain events and uncertain events; 2.Feel the possibility is high or low 3.Use the list method to judge the possibility.	
Learning objectives	1.Knowing that some events occur with certainty and others with uncertainty; 2.Learn to judge the likelihood of events in your life. 3.Use the knowledge to solve simple problems in life.	
Teaching method	Cooperative learning, Gamification teaching	
Teaching process	1)Game import, introduce new knowledge (5 minutes) Take a black chess piece from each of the three boxes shown below. How do you describe the event So review the "impossible, possible, certain" learned in the third grade. So... In this lesson, continue to explore the possibilities and see what new things students can gain. 2. Chess game Why don't we play a little game together first? The game is called "Touch the pieces." The rules of the game are like this: the teacher here has a box of chess pieces, a group of boys, a group of girls, respectively choose one	

	Each delegate takes turns touching the pieces from the box and putting them back, each male or female touching five times. Touch the number of white chess more, the girl wins; If you hit black more times, the boys win. (The teacher asked the students to select a boy and a girl representative and a scorekeeper respectively, and then started the game. The "Touch the pieces" game instructions are shown in the teaching materials section) 3. Game summary (1) At the end of the game, the girls won by an absolute advantage, we congratulate the girl group first. The teacher wants Ask the boys if there's anything they want to say about this? (The boy will then suggest that the box may be white There are more chess than black, so it's not fair to play.) (2) The teacher put 8 white and 2 black pieces in the box, leading to the possibility of touching the black pieces .Smaller than the one that touched the white. In life, only fair things can make everyone satisfied, and the game must be fair. 2)In-depth learning, comprehensive training (8 minutes) 1. Connect with life and ask questions (1) In life, there are many examples of the use of fairness principles. For example, before a football game, the two sides flip a coin The manner in which the choice of kick-off or venue is determined; In, for example, Olympic table tennis, the first set is served Draw lots to decide. At the end of each game, the two sides change courts. It can be seen that the principle of fairness in real life The utility is very wide. (2) Just now, we used the score to show the possibility of two outcomes in the game of "coin toss", and found Now these two possibilities are equal in magnitude. So, in the actual coin

	toss, there are heads and tails Does it really have to happen the same number of times? If the teacher asks the students to flip a coin 10 times, they guess What are the possible outcomes? (3) The probability of both sides appearing is equal, and the number of occurrences must be equal? Now let's play one "Coin toss" small game, we personally take a look at the number of positive and negative appear is the same. 2. Explore and solve problems (1) "Coin toss" game rules (2) The result of a coin toss is represented by a fraction There are only two: heads and tails. So the probability of heads is 1/2, and the probability of tails is 1/2 Sex is also 1/2, both outcomes are equally likely, so it's fair. It can be seen that although the probability of both sides is 1/2 through calculation, it has been operated in practice In the process, it is not necessarily guaranteed that the number of positive and negative occurrences is exactly equal, and there may be more positive or negative occurrences A lot of situations. Some students rolled exactly 5 heads and 5 tails; Some students have more heads than tails; Some students have more tails than heads. Why does this happen? 3. Analyze the results, summarize and reflect The courseware shows a statistical table of the number of coin flips by mathematicians Experimenter Throw count Heads up number of times The number of times tails face up DeMorgan 2048 1061 987 Buffon 4040 2048 1992

	Fehrer 10000 4979 5021 Pearson 24000 12012 11988 Romanovsky 80640 40173 40467 Although both players are equally likely to win, a fair game also involves a certain amount of chance. classmates If we look at the records of coin tosses played by mathematicians throughout history, we can see that as the number of games has increased, Heads and tails are going to be more and more similar. So, we can come to a conclusion: swim The result of the play is not equal, because we do not play enough times, with the increasing number of games, win or lose Closer and closer. 3)Apply the score, indicating the possibility (12 minutes) 1. Create a situation (1) During the break, Xiao Ming and Xiao Hua are going to play chess. But they were modest in deciding who would go first Jean, can you figure out a way for them to decide who goes first? (2) A student mentioned that you can roll dice to decide who goes first. This is a very good method, Xiaoxiao students also thought of this method, let's see how she did it. (Post the method of smile, "the number of points is greater than 3, Xiao Ming goes first; If the count is less than 3, Xiao Hua will go first.") 2. Ask a question The students use their brains to think about it, is the method of smiling fair? If it's not fair, you can come up with a modification How? To make it fair? 3. Summary and reflection The key to judging whether a game is fair is to look at their likelihood. The

	possibility is high, the chance to win more; The possibility is small, the chance to lose is more; A game is fair only when the possibilities are equal and the chances of winning or losing are equal Flat. 4)Apply the ability to develop (8 minutes). 1. Class, do you often watch the weather forecast? If you say there's a 60% chance of rain today, you do it Prepare for what? 2. The students have played the game of "Big Wheel of Fortune" in the street. Now, teacher, there are three types Big turntable, students use their brains to answer the questions raised in the form. (The turntable table is shown in the teaching materials section) (1) If you are the boss and you choose the ( ) wheel, the probability of winning is ( ) (expressed in points) (2) If you are a customer and you choose the ( ) turntable, the probability of winning is () (expressed in points) (3) If you choose the pick ( ) wheel from a fair and impartial perspective, the probability of winning is ( ). (expressed in fractions) 5) Summary promotion(4 minutes) Students, in this lesson, we start from the games around us and know the "possibility". Not only learned such as How to use a score to represent the probability of an event, learn how to judge whether an event is fair, and And I also understand that even if it is a fair game, it will win or lose in the actual game due to various factors. I hope the students can use the knowledge learned today in the future life and entertainment, OK?

	6)Student self-evaluation and mutual evaluation. (4 minutes) Students fill in the self-evaluation form, mutual evaluation form.
Homework assignment	Fundamental question: 1. Each of the three boxes below contains 6 balls that are identical except for the color. Touch one ball from each of the three boxes and connect the result with the corresponding box. 2. Fill in the blanks with "maybe," "impossible," or "definitely. (1) The vehicle passes a junction and ( ) meets a red light (2) A triangle ( ) is formed by three lines. (3) An infinite decimal is larger than a finite decimal. (4) Two parallel lines ( ) intersect. Extension question: Use the three cards below to make a swing. If the three digits placed are singular, Liang Liang wins: The three digits placed are even numbers, Xiao Ming wins. Think about it, who has the best chance of winning? Is that fair? Promotion question: Lucky draw (open question). (Fill in the turntable as shown in the picture as required) (1) Drawing (2) Drawing (1). Lucky draw for students participating in games and performances. The most likely to draw a Post-it note, the second most likely to draw a ruler, and the least likely to draw a pencil case. (2). Draw the lucky prize. The most likely to draw nothing, the less likely to draw "100,000 Why", the least likely to draw the "four Great novels".
Learning evaluation	1. Observe classroom activities and give appropriate verbal comments, encouragement or criticism according to students' classroom performance.

	2. Observe the situation of group cooperative learning, such as students' learning behavior and enthusiasm for participating in activities. Use class optimization master to record student performance. 3. Students' performance in completing the group cooperative learning activity list and reporting problems. 4. Students' self-evaluation and mutual evaluation.	
Lesson plan 14	1 Class period	Duration: 40 minutes
Topic of content	Household budget	
Learning content	1. Review the concept of mean and its calculation method. 2. Learn and understand what a compound chart is and how it presents data. 3. Analyze and solve practical problems in household budget by means of averages and multiple charts.	
Learning objectives	1. Students can accurately calculate the average of a given data set. 2. Students are able to create and interpret multiple statistical graphs. 3. Students are able to make preliminary planning and analysis of household budgets using averages and multiple charts. 4. Enhance students' problem-solving skills, collaborative skills and critical thinking.	
Teaching method	Gamification teaching, Cooperative learning Gamification: Review of mean knowledge through fun game activities. Problem-Based Learning: Create real situations and guide students to self-inquiry. Cooperative method: Work in groups to solve problems together. Gamification incentives: points, MEDALS, etc.	
Teaching process	1)Introduction and review: (8 minutes) Game introduction: "Average Solitaire" small game, quick question-and-answer form to review the concept of average.	

	Bonus points: Students who answer correctly get points. 2)Situation creation and question raising (12 minutes) Create a situation: Imagine that each student's family needs to make a budget plan for one month. Ask the question: How do you determine the average cost of each budget? How to visually display budget allocation? 3)Cooperative inquiry and problem solving (12 minutes) Self-inquiry: Students work in groups to try planning a household budget using a duplex chart template. Group work: Discuss, analyze and solve problems, teachers tour and guide. Share and exchange: Each group presents a duplex chart and explains the basis for budget allocation. 4) Knowledge consolidation and gamification teaching (5 minutes) Gamification exercise: "Little budget Master" challenge to consolidate knowledge by answering questions. Instant feedback: The correct answer and analysis are displayed after each level, and the points are added up. 5) Evaluation and Reflection (3 minutes) The teacher guides the students to evaluate and reflect. Students can evaluate their own performance in this study, what knowledge they have learned in this lesson, and find out their shortcomings and areas for improvement. At the same time, teachers can adjust and optimize teaching methods and contents according to students' performance and feedback to better meet students' learning needs.
Homework assignment	Fundamental question: Students go home and work with their families to create a real household budget and draw a duplex statistical map. Promotion question:

	Reflection journal: Record your feelings, problems, and solutions during the budgeting process.
Learning evaluation	1. Observe classroom activities and give appropriate verbal comments, encouragement or criticism according to students' classroom performance. 2. Observe the situation of group cooperative learning, such as students' learning behavior and enthusiasm for participating in activities. Use class optimization master to record student performance. 3. Students' performance in completing the group cooperative learning activity list and reporting problems.
Teaching materials	1. Reference material: (1). Fourth Grade Math Volume 2 (RJ). Editor-in-chief: Zhijian Du. Web site: http: //press. njnu. edu. cn (2). Elementary school lesson plan and homework design. Editor-in-chief: Xie Guping. Publishing House: Xinjiang Youth Publishing House. 2. Average solitaire cards and duplex chart template. 3. Student cooperative learning activity list 1. Review the average concept and prepare to participate in the "average solitaire" game. 2. Discuss and determine the expenditure of the family budget in the group, and calculate the average cost of each item. 3. Create a household budget map using a duplex chart template and prepare to share it. 4. Challenge the "Budget little Master" game to consolidate what you have learned.

Lesson plan 15	2 Class period	Duration: 80 minutes

Topic of content	Nutrition lunch-rational combination
Learning content	1. Nutrients in common dishes 2. Some basic indicators of a nutritious lunch 3. Simple combinations 4. Simple statistical knowledge
Learning objectives	1. Understand the nutrients needed by humans and some basic indicators of a nutritious lunch. 2. Can comprehensively use simple arrangement and combination, statistics and other related knowledge to solve problems.
Teaching method	Problem-Based Learning; Cooperative learning method, Gamification 1. Use Problem-Based Learning to design questions, create real situations, and explore independently The teacher showed a real life scene: "The school cafeteria offers a variety of lunch options, but each lunch has a different nutritional composition. How do we choose a balanced lunch?" . Through this question, students are guided to think about how to make a reasonable nutritious lunch plan. 2 Use cooperative learning method to improve students' problem-solving skills from four aspects: understanding, analyzing, solving and reflecting on problems. 3. Gamification teaching strengthens knowledge At the end of the class, the teacher designs a "nutritious lunch contest" game. The rules of the game are: students are divided into groups, each group uses the given ingredients to create a nutritious lunch plan, and submit answers within a set time. They then compared whether the lunch plans developed by the groups met the criteria of nutritional balance and whether they met budget constraints. This game can not only consolidate students' knowledge of nutrition, but also cultivate their practical ability

	and sense of competition. Note: Incentives (Use game elements such as points and MEDALS to motivate students) Throughout the teaching process, teachers can use game elements such as points, MEDALS, etc. to motivate students to actively participate in learning and discussion. For example, students who answer questions correctly can get some points. The team that performs well in the "nutrition Lunch Competition" game can get the "Nutrition little Master" medal and so on. These rewards serve as recognition and encouragement for their learning achievements.
Teaching process	1)Create situations and introduce problems. (8 minutes) 1. Teacher: Class, the teacher would like to interview you. What kind of TV programs do you like to watch? Would you please name a TV program you like to watch? Students: Aerial photography of China, poetry Conference, big country, Sichuan flavor, etc. (Students speak freely) 2. Guess what kind of programs I like? The teacher likes a program called "Chinese Food". It is a program that introduces the food culture around the country. Let's have a look. 3. Play the short video "Chinese Food" (the video is shown in the teaching materials section). 4. Teacher: OK, that's it. Do you have anything to say? The student answered that 5. Teacher: Yes, you are greedy. In fact, we Chinese people have been paying special attention to food culture since ancient times, but also pay special attention to the nutrition of eating inside. Do you know what nutrients are in the dishes we usually eat? Student: Calories, fat, protein... Student: Sugar, water, protein, inorganic salt, dietary fiber...

	Teacher: That's good. In fact, there are many nutrients in every food. 6. Teacher: Today, we will focus on the two most important nutritional indicators for our primary school students to study "how to eat the most nutritious lunch". Present topic: Nutritious lunch 2)Carry out research around the problem 1. What is a "nutritious lunch"? (5 minutes) Teacher: A good lunch, in addition to meet the requirements of delicious, balanced nutrition is very important, students are growing body time, scientific diet is more important. Let's find out what the experts have to say. Nutrition experts: Children around the age of 10 should get no less than 2926 kilojoules of calories from each lunch, and no more than 50g of fat. Knowledge link: Heat refers to the ability of food to produce energy for the body. It is usually expressed in terms of calories (Cal) or joules (J), and what we usually call "calories" is generally calories. The higher the calories in the food you eat, the more energy you will have for your body. But too many calories can lead to excess energy, which can lead to obesity and other problems. Fat is an important nutrient that is mainly used to store energy, maintain body heat and protect internal organs. At the same time, fat also contains a variety of essential fatty acids, which are the key to maintaining normal physiological functions of the human body. However, too much fat intake can lead to health problems such as obesity and cardiovascular disease, so attention should be paid to controlling fat intake. Proteins are one of the basic building blocks of the human body, the basis for cell composition and function and the synthesis of many metabolites. Proteins are also important raw materials for the synthesis of enzymes, hormones and immune factors. Since the body cannot store

protein as well as fat and carbohydrates, it needs to be supplemented with enough protein every day. However, too much protein will increase the burden on the kidneys, so it is necessary to carry out appropriate intake according to personal conditions and the amount of exercise and other factors.

Students are asked to exchange and discuss expert advice and use mathematical conformance to express in addition to expert advice. (Heat $\geq$2926 kJ; Fat $\leq$50g)

2.Does the restaurant provide nutritious lunches? (10 minutes)

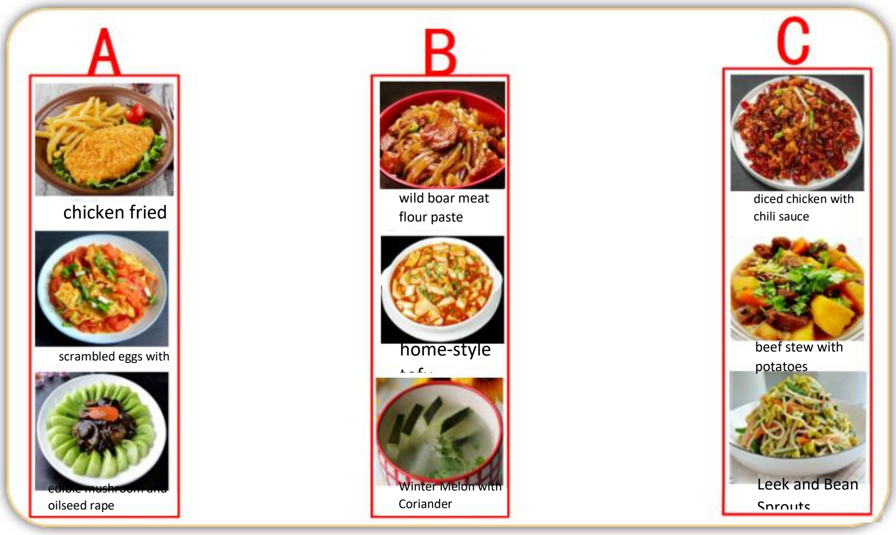
Information: Recipes of the Day:

Recipe Nutrition table:

Number	Dish name	Calories/kJ	Fat/g	Protein/g
1	chicken fried steak	1254	19	20
2	scrambled eggs with tomatoes	899	15	11
3	edible mushroom and oilseed rape	911	11	7

4	sweet and sour fish chunks	2112	18	14
5	home-style tofu	1020	16	13
6	Winter Melon with Coriander	954	7	1
7	Kung Pao Chicken	1033	18	7
8	beef stew with potatoes	1095	23	16
9	Stir-fried Bean Sprouts with Leek	497	12	3

Launch package:



Combined with expert advice, team cooperation, exchange and discuss whether the package plan is up to standard.

The group presented the results.

	3. How to make a nutritious lunch? (20 minutes) Teacher: Students, let's be nutrition experts together, choose 3 kinds of dishes, according to the advice of nutrition experts, for us to design a nutritious lunch. (1) Communication and discussion: What should we pay attention to when choosing a nutritious lunch? (2) Cooperate in design and fill in the form. Team report. Pick one team, and fill in until you can't match. 6. Choose a nutritious lunch that everyone likes? (10 minutes) The students are really amazing. We can make a total of 13 kinds of nutrition packages. In the following discussion session, please discuss with each group again. From these 13 kinds of packages, choose one of your group's favorite and send a representative to recommend it to our class. 7. Choose a nutritious lunch that everyone likes? (10 minutes) The students are really amazing. We can make a total of 13 kinds of nutrition packages. In the following discussion session, please discuss with each group again. From these 13 kinds of packages, choose one of your group's favorite and send a representative to recommend it to our class. Format: Our group recommends the ( ) package because ( ). 3)Statistical analysis and comprehensive application 1.Through the recommendation of each group of students, we have introduced 6 kinds of nutritious lunch sets. 2.1. Next, let's choose two students who are very good at counting to count the number of boys and girls who like each package. If the package is not your favorite, you don't have to raise your hand. Fourth, explore the extension Teacher: Students, today we configure ourselves to meet our taste, in line

	with our nutrition package, in fact, the number of children obesity in our country is more, we come to understand. The courseware shows the video "The harm of Childhood Obesity cannot be Ignored" (the video is displayed in the teaching materials section). Teacher: In fact, whether it is overweight or thin, it will do some harm to our body. The courseware shows the harm of fat and thin: fat people have too much body fat, which is easy to cause some diseases. Such as: hyperlipidemia, hypertension and so on. Overweight adolescents affect the growth and development of the body, affecting the development of intelligence, thin people have too little body fat, will appear malnutrition, memory loss and other symptoms. Being overweight or thin will affect the normal development of the human body, especially teenagers. 4) Present results and evaluation Group presentation: Class optimization Master App randomly select some groups to report. Outcome Presentation: Each group selects a representative to present their solution and exploration process to the whole class. This facilitates mutual learning and inspiration among students. Evaluation and Feedback: Teachers and students jointly evaluate the solutions presented by each group and provide constructive feedback. Evaluation criteria can include aspects such as the innovation, practicality, and logic of the solutions. 5) Summary and reflection Teacher Summary: The teacher summarizes the entire problem-solving process, emphasizing the strengths demonstrated by the students during the exploration process as well as areas that require improvement. Student Reflection: Students are encouraged to engage in personal and group reflection, contemplating their own performance during the

	problem-solving process and how they can improve and enhance their skills in the future. 6)Knowledge consolidation and gamification teaching At the end of the class, the teacher designs a "nutritious lunch contest" game. The rules of the game are: students are divided into groups, each group uses the given ingredients to create a nutritious lunch plan, and submit answers within a set time. They then compared whether the lunch plans developed by the groups met the criteria of nutritional balance and whether they met budget constraints. This game can not only consolidate students' knowledge of nutrition, but also cultivate their practical ability and sense of competition.
Homework assignment	Fundamental question: 1. Why do we need to eat a variety of different foods to stay healthy? Please share your opinion. Promotion question: 2. In daily life, how should we achieve a balanced diet and comprehensive nutrition? Please talk about your ideas based on your practical experience.
Learning evaluation	1. Observe classroom activities and give appropriate verbal comments, encouragement or criticism according to students' classroom performance. 2. Observe the situation of group cooperative learning, such as students' learning behavior and enthusiasm for participating in activities. Use class optimization master to record student performance. 3. Students' performance in completing the group cooperative learning activity list and reporting problems.
Teaching materials	1. Video "Chinese Food", source: https: //www. miguvideo. com/p/detail/668477899?channelId=CAAAB000902005900000000&pwId

	=85f718dd360f4b0c86b195931a57fdf4 2. The video "Childhood Obesity Is Too Big to Ignore" can be found at https: //www. iqiyi. com/v_e26u449exw. html 3. Student cooperative learning activity list 1. What is a "nutritious lunch"? (8 minutes) Nutrition experts: Children around the age of 10 should get no less than 2926 kilojoules of calories from each lunch, and no more than 50g of fat. Knowledge link: Heat refers to the ability of food to produce energy for the body. It is usually expressed in terms of calories (Cal) or joules (J), and what we usually call "calories" is generally calories. The higher the calories in the food you eat, the more energy you will have for your body. But too many calories can lead to excess energy, which can lead to obesity and other problems. Fat is an important nutrient that is mainly used to store energy, maintain body heat and protect internal organs. At the same time, fat also contains a variety of essential fatty acids, which are the key to maintaining normal physiological functions of the human body. However, too much fat intake can lead to health problems such as obesity and cardiovascular disease, so attention should be paid to controlling fat intake. Proteins are one of the basic building blocks of the human body, the basis for cell composition and function and the synthesis of many metabolites. Proteins are also important raw materials for the synthesis of enzymes, hormones and immune factors. Since the body cannot store protein as well as fat and carbohydrates, it needs to be supplemented with enough protein every day. However, too much protein will increase the burden on the kidneys, so it is necessary to carry out appropriate intake according to personal conditions and the amount of exercise and other factors.

Students are asked to exchange and discuss expert advice and use mathematical conformance to express in addition to expert advice.

2. Does the restaurant offer nutritious lunches? (10 minutes)

Set A:

Set B:

C Package:

3. How to make a nutritious lunch? (25 minutes)

Plan	Package number	Heat / kilocoke	Fat / gram
1			
2			
3			
4			

4. Choose a nutritious lunch that everyone likes? (15 minutes)

Our group recommends is the (   ) package.

Because:

VITA