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Research on the Design of Middle School Mathematics Homework Based on Project Based Learning

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Abstract: *Homework is not only a continuation of classroom learning, but also an important way for students to develop their thinking ability and humanistic literacy. With the introduction of the "double reduction" policy, project-based learning has become an important direction for the reform of middle school mathematics education. In this context, conducting research on project-based learning based design of middle school mathematics homework is of great significance for improving the current situation of "complex" homework in middle school mathematics. This study focuses on the project-based learning concept and mainly investigates the following two questions: (1) What should be the principles and processes for designing project-based homework in middle school mathematics? (2) How to carry out project-based homework design in middle school mathematics? To further optimize the design of middle school mathematics homework, a strategy for project-based homework design in middle school mathematics is proposed.*

Keywords: *Project-Based Learning; Middle School Mathematics Homework; Project Based Homework Design*

1. Preface

The Outline of Basic Education Curriculum Reform points out that through the study of mathematics basic courses, students can master basic knowledge, develop basic skills, cultivate strong interest in mathematics, develop good mathematical habits, and enhance their intellectual and ability levels. [1] How to keep homework? How to stay? This issue has become a focal point of debate among educators. The country has issued corresponding documents stipulating that written homework is not assigned to first and second grade students, and the average daily completion time of written homework for third to sixth grade students should not exceed 60 minutes. In junior high school, the average daily completion time of written homework should not exceed 90 minutes. [2] Although the country has introduced relevant policies, the author has found in the actual teaching process that there are still many frontline educators who adhere to traditional educational concepts, advocate the use of problem-solving skills, have excessive homework, mechanical and boring questions, and lack personalized design. Project Based Learning (PBL) originated from the American educator Dewey's advocacy of "learning by doing," and was developed from Kepler's design based teaching method. [3] Krayek believes that "project-based teaching" refers to teachers organizing, guiding, and carrying out teaching activities through driving questions, and students collaborating with each other in these activities, using new learning technologies to explore and solve problems, and developing and presenting results that represent problem-solving. [4] With the strong promotion of Chinese international students at Columbia University, the design teaching method entered China from the United States and went through five stages of development: the first stage (1914-1949), the localization process of design teaching method experienced ups and downs; The second stage (1950-1990) was the quiet period of designing teaching methods; The third stage (1990-2010) saw the emergence of curriculum activities with project-based learning elements; The fourth stage (2010 present) is the budding of project-based learning for cultivating literacy. [5]

Based on this, this article takes core literacy as the guide, actively responds to national policies, and organically integrates project-based learning and math homework. It explores the design path of math homework under project-based learning, ensuring that homework is less burdensome but not of lower quality. It not only consolidates basic knowledge but also enhances students' learning enthusiasm. In response to the current situation of math homework settings, the following research is conducted:

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Firstly, by consulting relevant materials and conducting research on the background of mathematics teaching, the research topic, background, and significance were determined. Secondly, the author establish the principles and implementation process for project-based homework design in junior high school mathematics. Then, based on the designed process, using middle school mathematics textbooks as the content basis for project selection, for example, in the "Comprehensive and Practical" section of the Beijing Normal University version of the seventh grade mathematics textbook, a project-based assignment is assigned - "Create a large uncovered rectangular box as much as possible". Finally, we will delve into effective design strategies for project-based assignments and summarize and reflect on them.

2. Design Model of Middle School Mathematics Homework Based on Project based Learning

2.1 Design Principles

(1) Subjectivity

The humanism represented by Maslow believes that education and teaching should focus on the wholeness, subjective experience, and internal growth needs of individuals, and attach importance to their autonomy. Students are the main body of mathematics learning, and they should fully participate in the learning process to achieve their inner growth. Teachers are the guides and mentors of students' growth, creating a good learning atmosphere and helping students achieve their inner growth. Homework plays a consolidating role in classroom knowledge. Homework is the continuation of classroom teaching. In the process of completing homework, students should not only repeatedly complete the homework assigned by the teacher, but also actively think. Therefore, the design of homework should pay attention to students' own development, cultivate their subjectivity, and enhance their ability for self-development and self-education. The implementation of homework not only requires attention to the development of students' knowledge and skills, but also to the application and improvement of their comprehensive abilities and qualities in other aspects. When designing project-based assignments, taking into account students' zone of proximal development, students can consolidate their knowledge, and collaborate in groups to complete the final presentation of the project.

(2) Authenticity

The important premise of project-based homework is the real task context, which provides an ideal environment for the development of students' various abilities, can provide students with richer and more authentic learning experiences, and help them more intuitively delve into the problem-solving process. Real situations can stimulate students' deep-seated motivation, force them to engage in critical thinking, and cultivate their core competencies. When setting up real task scenarios, teachers should be close to real social and professional issues, consider the social, cultural, historical, and economic backgrounds they are in, rather than fabricating them out of thin air. The design of project-based assignments should be carried out in real environments as much as possible, integrate into the real world as much as possible, solve problems with practical significance, and form results with practical significance.

(3) Collaboration

The design of project-based homework should reflect students' cooperation, and the design of project-based homework should not only stay at the level of teacher teaching, but also shift to the level of students' knowledge acquisition. In the implementation process of project-based learning homework design, teachers divide students into several groups with similar abilities. Teachers assign project-based homework to students, and students participate in the formulated plan. The participation process not only requires students to independently complete tasks, but also requires various forms of group cooperation and exploration to solve comprehensive problems. Students communicate during the group cooperation process, and work together towards the ultimate goal. Through group cooperation in learning, students' subjectivity is effectively ensured, their intrinsic interest in learning is stimulated, their sense of cooperation is cultivated, the quality of homework completion is improved, and it is conducive to the development of students' comprehensive literacy.

(4) Diversity

The diversity of homework can enhance students' interest in learning mathematics. Single and repetitive homework content can easily lead to students' boredom. Different forms of homework can provide students with freshness, attract their attention, and stimulate their curiosity. The theory of multiple intelligences points out that everyone has unique advantages and potentials in various intelligences, and diverse assignments can meet individual differences, providing students with diverse

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choices. Students at different levels can choose tasks that are suitable for themselves, meet the learning requirements of different students, and promote their development. Each student has different levels of knowledge, learning styles, and learning abilities, and the content, form, and difficulty of homework also need to be diverse. The design of homework must consider the individual differences of students and meet the choices of students with different abilities. The evaluation method must be evaluated from multiple perspectives. In multiple aspects such as students' independent exploration and achievement display, it cannot be limited to a single evaluation method. Multiple evaluation methods can evaluate students from different dimensions.

2.2 Design Process

After reviewing relevant literature on project-based learning, scholar Liu Jingfu proposed six steps in his research on project-based learning (PBL): "selecting projects - developing plans - exploring activities - creating works - exchanging results - evaluating activities". [6]These six steps are currently widely recognized as the project-based learning process, as shown in Figure 1.

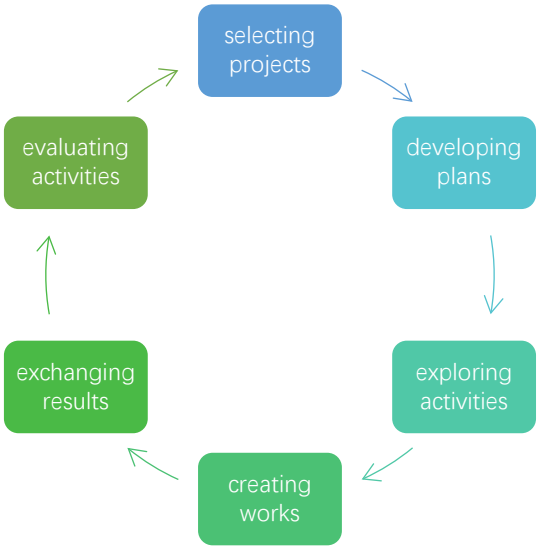

Figure 1: The operational process of project-based learning (PBL)

Compared to traditional assignments, project-based assignments have long-term development potential, emphasizing that students are in real situations and can solve real problems through research, social research, hands-on practice, and collaborative communication. While completing project-based assignments, students can effectively promote the development of various abilities such as data collection and logical thinking. Based on the project-based learning process of scholar Liu Jingfu, the author has obtained the following project-based homework design process(see Figure 2):

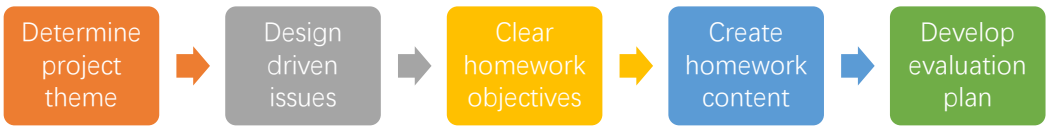

Figure 2: Flowchart for Designing Mathematics Project based Homework

2.3 Demonstration of project-based homework cases

2.3.1 Basis for Topic Selection

(1) Originating from textbooks

This project is mainly derived from the "Comprehensive and Practical" section of the seventh grade mathematics textbook published by Beijing Normal University. Making a box as large as possible without a lid is a practical lesson for operation. It requires students to comprehensively apply the knowledge, methods, and ideas they have learned, and use mathematical thinking to solve real-world problems. Through a series of exploratory learning activities such as analysis, conjecture, operation, reflection, and communication, students should explore how to make a large uncovered rectangular box as much as

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possible, and apply the results of the exploration to practice, forming project results, experiencing the connections and application value between knowledge, and developing core competencies.

(2) Explore the real situation

In ancient times, people used natural materials such as bamboo, wood, or stone to store food, jewelry, and other items. Boxes were used as containers, and in modern society, the production process of boxes has become very advanced. Different materials and designs meet the needs of various occasions. By studying the maximization of the volume of rectangular prisms, one can deepen their understanding of relevant knowledge, broaden their horizons, and make them realize the close relationship between mathematical knowledge and people's lives and production, thereby enhancing their interest in learning mathematics.

2.3.2 Design driven issues

A certain cardboard manufacturing company needs to produce specialized rectangular cardboard boxes for YTO Logistics Company, requiring the use of square cardboard to create the largest rectangular cardboard box in terms of volume, in order to accommodate more items. Assuming you are a designer for the cardboard box manufacturing company(see Figure 3):

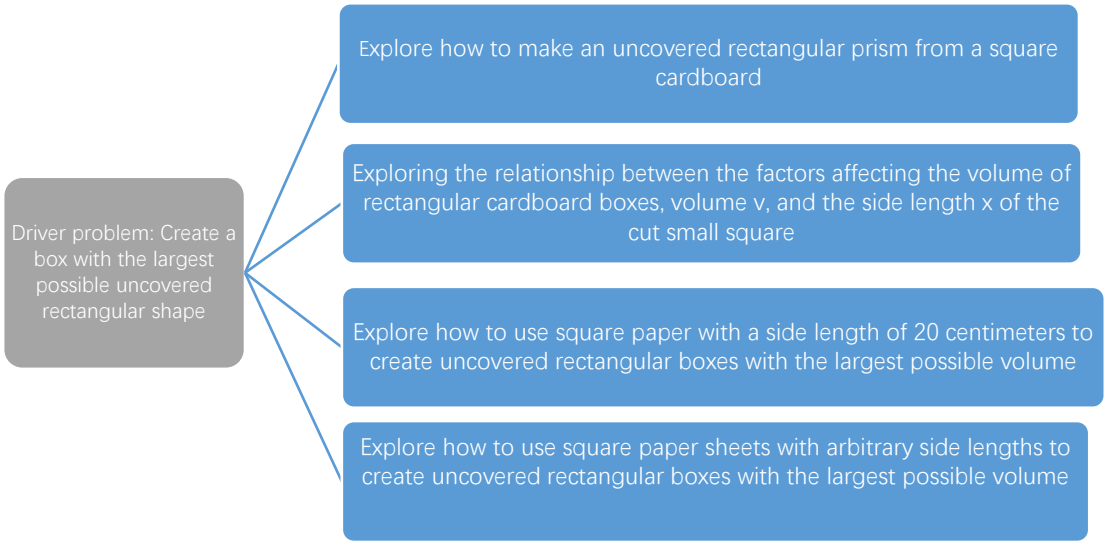

Figure 3 Distribution of Driver Problem Segmentation

2.3.3 Clarify homework objectives

(1)Students are able to understand the relevant properties of unfolding and folding graphics, as well as the value of representing numbers with letters;

(2)Students can analyze the factors that affect the volume of rectangular cardboard boxes and obtain the relationship between the volume V and the side length X of the cut small square;

(3) Students are able to use a 20 cm square piece of paper to create an uncovered rectangular box with the largest possible volume, and apply mathematical principles to analyze and use any square piece of paper to create an uncovered rectangular box with the largest possible volume.

2.3.4 Creating homework content

(1) Hands on

(a) Students draw an unfolded diagram of an uncovered rectangular prism.

(b) Students use a square piece of paper to make an uncovered rectangular prism.

(c) Students compare with the rectangular cardboard box made by your desk mate, who has a larger capacity?

(2) In depth study of controlling variables

(a) The relationship between the bottom area of a rectangular paper box and its height.

(b) The relationship between the side length of the cut small square and the height of the folded

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uncovered rectangular box.

(3) Select Model

For the length, width, and height of an uncovered rectangular box, assuming the height of the box is x cm, use x to represent the other two quantities. Students observe the implicit functional relationship between the height and volume of the rectangle, and write an analytical expression for x representing the volume v of the uncovered rectangular box.

(4) Solve the model

According to $v=x(20-2x)^2$, what is the appropriate value of x to maximize the volume of a rectangular prism? How did you do it? How to maximize the capacity of an uncovered rectangular box made of square paper with a side length of 10 cm to hold candies? What if the side length of a square is 30 cm?

(5) Interpreting the Model

If the side length of this square piece of paper is a, the height of the uncovered rectangular box folded is x cm, and the volume v of this uncovered rectangular box is equal to the algebraic formula containing a and x.Does the variation of v follow a regular pattern as x changes?

(6) Achievement Exhibition

Students create a research report titled 'Research Report on Creating a Large Unfaced Rectangular Storage Box' and present the group's research findings in PPT format.

2.3.5 Develop evaluation plan

Teachers create an evaluation plan table from three aspects, as shown in Table 1.

Table 1 Evaluation Plan Table

Create a large uncovered rectangular storage box as large as possible							
Group name:			Evaluator:			Evaluation time:	
Team members:							
Please mark a "√" in the area where you think the evaluated group has performed appropriately		Internal peer evaluation within the group			Teacher evaluation		
knowledge and skills	Know the relevant knowledge of unfolding and folding graphics						
	The process of making cardboard box models is standardized, and the data is correct						
mathematical thinking	Divide tasks with design						
	Being able to explain one's own thinking process						
research report	The reasoning process is rigorous, persuasive, and effective						
	Standardized format, complete steps						
brief summary:							

3. Optimization strategy for mathematics homework design based on project-based learning

How to optimize project-based assignments? Let project-based assignments take root and grow better, avoiding being mere formalities. Through investigation, it was found that frontline teachers have insufficient theoretical understanding on how to design project-based assignments. This article will explore effective design strategies for project-based homework from four aspects, in order to maximize the effectiveness of project-based homework.

3.1 Creating Rich and Realistic Scenarios

Dewey once said in "How We Think": "There is a lack of situations in schools that can stimulate students' thinking like real life outside of school." "Situation" refers to the events designed by teachers for the development of teaching activities. The lack of situation ignores the connection between students and real life, and students lose the thinking of situation. Learning only stays at simple mechanical repetition, unable to truly internalize knowledge, and learning becomes dull and boring. The purpose of creating situations is to connect students' learning with real life, giving students a process of exploration

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and growth. Real projects are the most influential projects for students, and teachers can create real situations related to students' interests, identities, and cultures. By meeting the requirements of the community or school, students can create valuable products to participate in practice.

3.2 Determine the homework objectives guided by core competencies

Homework not only consolidates classroom knowledge, but also serves as an important means of cultivating students' core competencies. Project based homework design can develop students' abilities and diagnose their level of literacy. Project based homework aims to develop reasoning ability, data concept, and modeling concept in core literacy. Teachers should choose project content that is consistent with the core literacy goals, combine course objectives, unit objectives, and class objectives, transform the relatively macro goals of core literacy into specific learning objectives, and cultivate students to observe the real world with a mathematical perspective and think about the real world with mathematical thinking. The development of students' core competencies cannot be separated from specific situations. Teachers must create challenging situations that are close to students' life experiences and cultivate their ability to solve practical problems. The design of project-based assignments must follow the path of "goal orientation concretization contextualization", first determining core competency goals, then transforming them into actionable specific goals, and finally integrating carefully designed contexts into the task.

3.3 Develop Performance Evaluation Metrics

The key to project-based homework evaluation lies in using good scales to distinguish levels. Traditional homework evaluation only focuses on students' scores, while project-based homework evaluation emphasizes the learning process of students. A good evaluation mechanism can exercise students' thinking ability, promote their deep thinking of knowledge, cultivate their core literacy ability, and enable them to continuously learn and complete their own growth in project tasks. The common types of evaluation scales include simple graded checklists and solo level gauges based on the depth of students' thinking. Good evaluation scales can have moderate discrimination, and students with different levels have obvious differences. Based on the results, feedback is provided to ultimately promote students' thinking in the project process, help them understand their own shortcomings, and make improvements. Teachers create an evaluation scale, first break down a large task into several small parts, evaluate each small part, and finally synthesize the results. Teachers set reasonable evaluation criteria around unit objectives, lesson objectives, and specific goals of project-based assignments, providing effective feedback to students and fully leveraging the evaluation role of assignments.

3.4 Establish a project-based homework support system

At present, it is urgent to enhance the understanding of project-based education concept among frontline educators and improve the training system of project-based education concept. Some teachers have cognitive barriers and implementation difficulties in the teaching process, which hinders the "landing" of project-based teaching. The education department should hold theoretical training meetings irregularly, excellent teachers should share theoretical knowledge of project-based homework, regularly hold project-based homework seminars, exchange experience in project-based homework design, and teachers should form a characteristic resource library of excellent cases to help teachers master relevant skills, provide inspiration and ideas for teachers, and provide reference and learning for frontline educators. The school actively coordinates various resources both inside and outside the school, provides multimedia tools, encourages teachers to lead students to museums, art galleries, and other external locations to participate in research, allowing students to learn and explore in real environments, and provides open project-based homework resources.

4. Conclusion

Based on the investigation of relevant data, this study found some problems in middle school mathematics homework. Based on the theory of project-based learning, the principles and process of homework design were proposed. With project-based learning as the basis, the assignment of homework in middle school mathematics was studied, and the following research conclusions were drawn:

Firstly, teachers should conduct in-depth research on the new mathematics curriculum standards, read relevant literature on project-based learning at home and abroad, and design principles and processes for middle school mathematics project-based homework based on the characteristics of project-based

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learning, in order to provide examples for future research in this area. Secondly, by understanding the current situation of middle school mathematics homework assignments, it was found that the amount of homework is relatively appropriate, but the types of homework assignments are relatively single. It was found that teachers rarely assign content related to project-based homework, but students are interested in project-based learning and are willing to try new forms of homework in order to generate new ideas and better exercise mathematical thinking in the process. Thirdly, this article has selected the "Comprehensive and Practical" section of the Mathematics textbook for Grade 7, Volume 1 of Beijing Normal University as the project theme for conducting project-based assignments. The project assignment "Creating a Large Unfaced Rectangular Box as Large as Possible" has been designed, which meets the requirements of the new curriculum standards for students and allows them to connect the knowledge they have learned with real-life situations, enhancing their initiative and creativity.

Project based assignments require teachers to balance unit and class objectives, rely on real-life situations, take task driven approaches as the main thread, and advance in the form of projects. The author will further strengthen theoretical learning, closely design more project-based assignments around real situations for educational experiments, track students' performance in all aspects, and actively implement core mathematical literacy.

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