Research on the Design Model of High-School Mathematics Homework under the "Double Reduction"

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Abstract. This paper focuses on the design of high - school mathematics homework in the context of the "Double Reduction" policy. Through questionnaires and interviews with mathematics teachers and students in a high school in Wuhan, it deeply explores the current situation of high - school mathematics homework design and completion, as well as students' needs. Based on the SOLO taxonomy theory, a high - school mathematics homework design model is constructed. Students are divided into three levels, A, B, and C, according to their abilities. Homework design is carried out from three aspects: objectives, structure (including question structure, question quantity, and difficulty structure), and content (scenario and question design). The aim is to achieve stratified teaching, reduce the burden and increase efficiency, and promote the all - round development of students. It also points out that students' ability levels are dynamically changing, and teachers need to continuously pay attention to and adjust the homework design.

Keywords: Double Reduction, High - school Mathematics, Homework Design, SOLO Taxonomy Theory, Stratified Teaching.

1 Introduction

In July 2021, the Ministry of Education of PRC promulgated the "Double Reduction" policy, clearly stating that "the total amount and duration of homework should be comprehensively reduced to alleviate the excessive homework burden on students". As an important part of teaching activities, homework is an activity that students carry out to complete their learning tasks. It has functions such as diagnosis, consolidation, and analysis of students' learning situations. It is not dispensable and cannot be reduced without limit. Mathematics is not only an important subject in the college entrance examination but also has the largest amount of homework among all subjects at the senior high school level.

Teacher Yan Shenghou[1] proposed the "Five Determinations" principle for high-quality homework design: determine the objectives according to the curriculum standards, focusing on precision; determine the structure according to the theme, focusing on rationality; determine the content according to the textbooks, focusing on

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correctness; determine the difficulty according to the students' learning situations, focusing on selectivity; determine the form according to the teaching, focusing on appropriateness.Teacher Zheng Xiaoting[2] advocated implementing the core mathematical literacy in the design of senior high school mathematics homework. Ma Jilei[3] suggested innovating the forms of homework, designing open-ended questions to enable students to learn independently and improve their enthusiasm. Based on the concept of deep learning, Wang Jiabo[4] proposed the implementation of "long-term homework", and Zhu Yunsheng[5] conducted research on the preview homework before senior high school mathematics classes from two aspects: self-exploration preview and spontaneous practice thinking. Zhou Chun[6] proposed stratified design, evaluation, and tutoring of homework according to the differences in students' levels.

Although there is no research on homework design under the "Double Reduction" policy abroad, many education experts have studied homework methods and strategies. The Soviet educator Kairov pointed out that homework is an organic part of teaching work, and its mission is to consolidate students' knowledge through independent work and to perfect students' skills and techniques[7]. Viktor Fedorovich Shatalov of the Soviet Union proposed in "Educational Random Notes" that assigning homework should be changed to recommending homework, which is divided into two types: required and optional[8]. Professor Turner, an education expert from the University of Pennsylvania in the United States, emphasized applying the knowledge learned in class to practice, exercising various skills, consolidating the learning effect, and cultivating creative thinking. He also included small inventions and creations in the category of homework[9]. Lee and Priutt defined four main types of homework: skill development, preparation, expansion, and integration[10].

Therefore, investigating the current situation of the design and evaluation of senior high school mathematics homework, studying senior high school mathematics homework based on the SOLO taxonomy theory, and designing basic and developmental homework that conforms to students' learning laws and characteristics and reflects the orientation of quality education have important theoretical and practical values for achieving stratified teaching, reducing the burden and increasing efficiency, enhancing students' enthusiasm, and promoting the all-round development of students.

2 Investigation and Analysis of Senior High School Mathematics Homework under the "Double Reduction"

The author conducted an investigation on all mathematics teachers and students of three grades in a senior high school in Wuhan through the compilation of questionnaires and interviews, aiming to understand the current situation of senior high school mathematics homework design, the completion of homework, and students' needs.

2.1 Students' Views on Mathematics Homework

The questionnaire for students is set with questions in the following four aspects: (1) students' basic information and learning levels; (2) students' attitudes towards

mathematics and homework; (3) the completion of students' mathematics homework; (4) students' views on the design, assignment, and evaluation of mathematics homework; (5) students' needs for homework design and evaluation. The questionnaire has a total of 22 questions for these five aspects, including 16 single-choice questions and 6 multiple-choice questions.

The survey results show that 67.09% of the students recognize the positive role of homework, and 89.24% of the students can complete mathematics homework carefully, but only 48.74% of the students can finish the homework within 60 minutes. Among the students who failed to complete the homework on time, 60.13% thought that there was too much homework, and 72.78% thought that the questions were too difficult; among the students who could not hand in their mathematics homework on time every day, 75.95% did not finish it. 56.33% of the students said that they needed to "look through their notes while doing homework". 48.73% of the students expected that "different standards should be used to evaluate students of different levels", 67.72% of the students thought that it was "necessary" to carry out stratified design of mathematics homework, and 81.64% of the students were willing to try and complete the stratified homework carefully. In the survey of the relevant factors that promote students to complete their homework actively, moderate homework difficulty, the sense of achievement, and appropriate homework quantity ranked the top three. The difficulty of homework has an important influence on students' completion of homework (see Fig. 1).

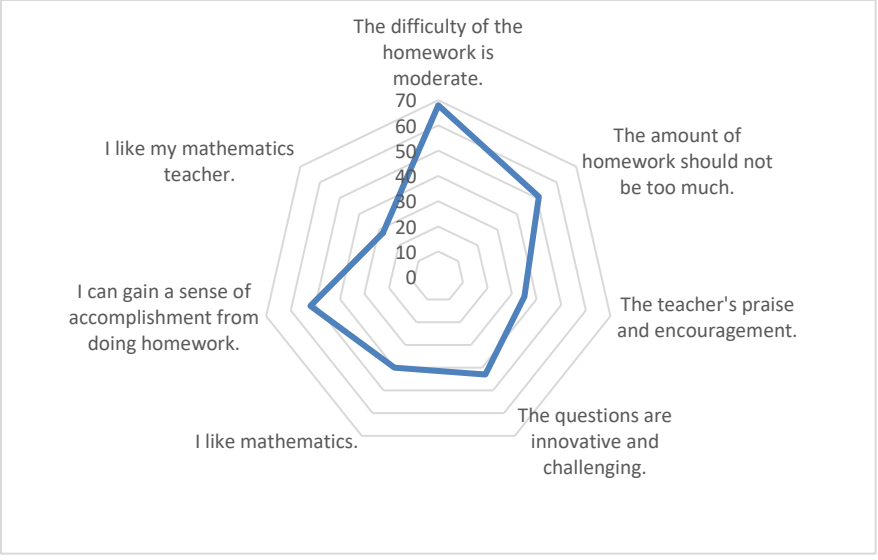

Fig. 1. Factors that Promote Students to Positively Complete Mathematics Homework.

2.2 Teachers' Views on Mathematics Homework

The questionnaire for teachers sets questions around the following five aspects: (1) The sources of materials for teachers to assign mathematics homework; (2) The ways teachers assign mathematics homework; (3) The types of mathematics homework teachers

assign and the functions of homework they attach importance to; (4) The ways teachers evaluate homework and tutor students; (5) Teachers' attitudes towards the stratified design and tutoring of homework. The questionnaire has a total of 12 questions for these five aspects, including 7 single - choice questions and 5 multiple - choice questions.

The survey results show that mathematics homework mainly comes from teaching - aid materials, followed by textbooks or workbooks, and a small number come from online resources or are self - designed and adapted by teachers. When designing mathematics homework, 92.31% of the teachers first consider "consolidating the foundation and enhancing students' ability to apply knowledge", and 53.85% of the teachers choose to target the college entrance examination. All teachers assign written homework, and only a few teachers in the first grade of senior high school assign oral homework, such as reciting formulas and definitions. In terms of homework design, teachers basically design unified homework for all students in a class. However, when there are large differences in the levels of the classes they teach, they will design different mathematics homework according to the class levels. Regarding whether it is necessary to carry out stratified design of students' homework, 46.15% of the teachers think it is not necessary, and only 15.38% of the teachers think it is "necessary". This phenomenon is quite different from what the author expected. In the interviews with teachers, most teachers believe that "although stratified homework can teach students in accordance with their aptitudes to a certain extent, it may make students feel differentiated, generate a resistant mentality, and increase the workload of teachers". But when the author informed the teachers of the data on students' views on stratified homework, all teachers believed that students' needs were very important and all said that "even if it increases the workload compared with traditional homework, they are still willing to try stratified homework" to help students improve their academic performance.

3 The Design Model of High - School Mathematics Homework under the "Double Reduction" Policy

After students enter senior high school from junior high school, with the deepening of high - school mathematics knowledge and the increase in ability requirements, the enthusiasm of some students for learning mathematics drops sharply. Influenced by the long - term exam - oriented education, teachers often design consolidation - type homework corresponding to the college entrance examination questions, and even adopt the "drill - and - kill" method. In 2021, the Ministry of Education issued the "Double Reduction" policy, requiring homework to "reduce the burden and increase efficiency", which requires teachers to improve their homework - design capabilities. Based on the aforementioned investigations and analyses, this study constructs a high - school mathematics homework design model by applying the SOLO taxonomy theory, as shown in Figure 2.

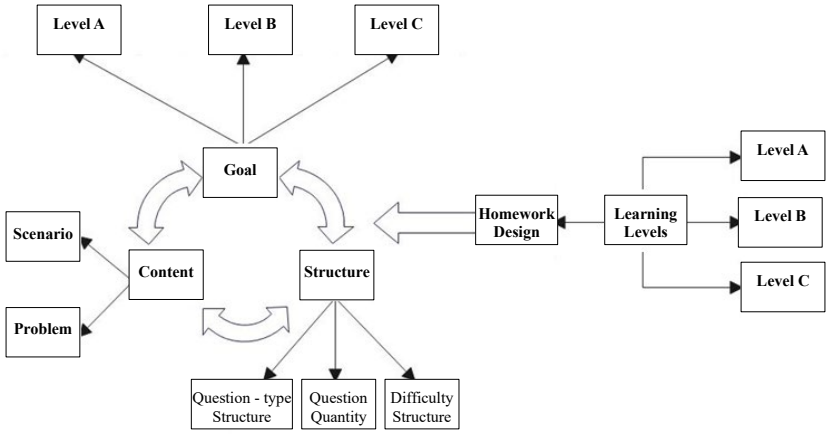

Fig. 2. The Design Model of Senior High School Mathematics Homework.

The 2017 edition (revised in 2020) of the High - School Mathematics Curriculum Standards proposes the basic concepts of "everything for the development of every student" and "different people achieve different developments in mathematics". As an important part of teaching activities, homework should better reflect the basic concepts of the curriculum standards. These concepts point out the direction for the design of high - school mathematics homework. According to the high - school mathematics curriculum standards, the basic elements of homework design include objectives, content, and structure. Among them, the objective is the core of homework, guiding the direction of content and structure; the content is the main carrier of the homework design objective and also the specific manifestation of the homework design structure; the structure is the framework of homework, which can reflect the connections of various parts of the content to achieve the objective. The three are closely linked, complement each other, and influence each other.

3.1 Division of Student Levels

Each student has different acceptance, cognitive, and learning abilities. Since there are hierarchical differences in students' ability levels, homework assignment can also adopt a stratified approach. According to the SOLO taxonomy theory, students' learning outcomes are divided into five levels from low to high: pre - structural, single - point structural, multi - point structural, relational structural, and extended abstract structural[11]. First, based on students' ability levels, we roughly divide students into three grades: Students with strong learning abilities and a good foundation are at level A. They can integrate other knowledge for abstract assumptions and comprehensive application; students with medium learning abilities who can basically understand knowledge are at level B; students with poor learning abilities and a weak foundation are at level C and basically cannot understand and solve problems.

3.2 Establishment of Objectives

For the three levels of learning abilities, A, B, and C, the objectives of homework design should also be different. Teachers should fully consider the zone of proximal development of each student. As Vygotsky said, "Teaching should precede development." Focusing on the zone of proximal development of students, strive to transform the potential development level into the actual development level and create a new zone of proximal development for students. For students with a high - level A learning ability, they can be cultivated according to the objectives of understanding, applying knowledge, and migrating and innovating, and their level is required to be slightly higher than the college entrance examination level; for students with a medium - level B learning ability, they are required to understand the learned knowledge, memorize it on the basis of understanding, and possess certain comprehensive application abilities; for students with a poor - level C foundation, they are required to understand and memorize some basic knowledge and basically meet the basic knowledge examination standards of the college entrance examination.

3.3 Design of Structure

The design of the homework structure needs to be closely related to the objectives, give full play to the comprehensive functions of each part of the homework content, and also take into account the differences in students' ability levels. This requires overall design from three aspects: question structure, question quantity, and difficulty structure.

Question Structure. The question - type structure should be appropriately rich. In this survey, among the types of homework designed by teachers, multiple - choice questions, fill - in - the - blank questions, and solution questions account for a relatively large proportion, with solution questions accounting for the largest proportion. Each question type has unique value in examining the mathematical discipline literacy and promotes the improvement of students' ability levels. Due to the differences in students' ability levels and the different target requirements for students, the homework design structure needs to be closely linked to the objectives. Among the common question types in high - school mathematics homework, relatively speaking, multiple - choice questions are relatively simple, fill - in - the - blank questions are slightly more difficult, and solution questions are more difficult.

The question - type structure of homework can be designed according to students' ability levels and target requirements. For students with a high - level A learning ability, according to the training objectives, it is recommended that multiple - choice questions account for 60% - 65%, fill - in - the - blank questions account for 20% - 25%, and solution questions account for a slightly larger proportion, 10% - 15%; for students with a medium - level B learning ability, it is recommended that multiple - choice questions account for 75% - 80%, fill - in - the - blank questions account for 15% - 20%, and solution questions account for about 5%; for students with a low - level C learning ability, it is recommended that multiple - choice questions account for 90% - 95%, fill

- in - the - blank questions account for 5% - 10%, and there is no requirement for solution questions for the time being.

Question Quantity. The question quantity should be appropriate, aiming for fewer but better - quality questions. The "Double Reduction" policy requires homework to "reduce the burden and increase efficiency". In this survey, the time for students to complete mathematics homework is mainly concentrated in 30 - 60 minutes and 60 - 90 minutes. 59.49% of the students think that 30 - 60 minutes of mathematics homework per day is more reasonable. 64.56% of the students cannot complete mathematics homework on time every day, and "too much homework" accounts for 60.13% of the reasons for not being able to complete it on time; 53.8% of the students cannot hand in mathematics homework on time every day, and "not finished" accounts for 75.95% of the reasons for not being able to hand it in on time. The design of the quantity of mathematics homework should be appropriate, and the homework time should be controlled within 30 - 60 minutes. It is recommended to control the number of questions at about 10 - 12. However, for students at level B and level C, the same number of questions means a relatively large workload and requires more time to complete. Therefore, it is recommended that the number of questions for students with a medium - level B learning ability be about 8 - 10, and the number of questions for students with a poor - level C foundation and low - level learning ability be about 5 - 7.

Difficulty Structure. The difficulty structure should be conducive to bringing out students' true levels. Students should be given some questions that are "just within reach with a little effort", which can slightly improve their existing ability levels and promote their development. If the "one - size - fits - all" approach is adopted, requiring all students to complete the homework according to the same standard, it may be convenient for teachers, but it is difficult to ensure that every student can gain something. Students' levels vary. If the questions are too difficult, students with a poor foundation may spend a long time or even be unable to solve them, thus hitting their self - confidence and losing their interest in learning; if the questions are too easy, students with strong learning abilities will feel that it is inefficient repetitive work, and their thinking and exploration levels will not be exercised.

It is recommended to distinguish the difficulty of homework design for students at the three levels of A, B, and C. For students with a high - level A learning ability and a good foundation, assign some reproduced questions of more difficult problems in class. These questions can be comprehensive questions combined with previous knowledge or open - ended and exploratory questions; for students with a medium - level B learning ability, assign questions of medium difficulty, including reproduced original questions (which can be completed through imitation), and can also include variations of the original questions or questions that have been paved the way in class but not specifically explained; for students with a poor - level C foundation and low - level ability, assign questions of low difficulty, which can be reproduced original questions, or questions with changed expressions or slightly modified but basically unchanged, and can be completed through imitation.

3.4 Design of Content

The homework content is the main carrier of the homework objective and also the specific manifestation of the composition of the homework structure. The content design should be carried out specifically according to the structure framework, closely following the objective requirements, and designing scenarios and questions.

Scenarios. The scenarios should be real and valuable. Under the guidance of the core mathematical literacy, using real - world backgrounds and real feelings as the materials for homework design, guide students to connect knowledge and flexibly and comprehensively apply the learned knowledge to solve practical problems in real life. Let students dare to face and understand real mathematical scenarios in the process of experiencing and applying mathematical knowledge to solve life problems, guide students to use mathematical concepts and methods to think and solve problems in the process of solving problems, and understand the essence of the discipline and educational value in real mathematical situations.

Questions. The questions should revolve around the mathematical curriculum content and point to the academic quality standards. When setting questions, choosing appropriate question scenarios is an important carrier for examining the core mathematical discipline literacy. The question design should revolve around the specific mathematical curriculum content to cultivate students' disciplinary qualities such as mathematical abstraction, logical reasoning, intuitive imagination, mathematical modeling, mathematical operation, and data analysis. When designing questions, the cognitive levels of students should be considered, and the questions should progress layer by layer and be closely linked. According to the content requirements of the new curriculum standards, guide students to use the learned mathematical knowledge to analyze and solve mathematical problems in real - world production and life.

4 Conclusion

The high - school mathematics homework design model constructed based on the SOLO taxonomy theory divides students into three levels, A, B, and C, according to their ability levels, and designs homework from three aspects: objectives, structure, and content. However, students are developing individuals with potential abilities, and their levels are not fixed. The students at the three levels of A, B, and C are dynamically mobile and may rise or fall to other levels after a period of learning. Therefore, teachers should always pay attention to students' learning states to make timely adjustments.

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