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Promoting Deep Learning in Mathematics Education —Based on Understanding by Design Theory

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Abstract: *Education reform requires us to seek teaching methods that promote students' understanding and promote students' pleasant learning. The deepening of curriculum reform calls for deep learning and unit teaching. Under this background, it is very important to explore mathematics unit teaching design based on UbD theory. In order to improve students' learning efficiency and understand the meaning of knowledge, the UbD mathematics unit teaching model based on deep learning is constructed and the teaching strategy is given to provide reference for mathematics education.*

Keywords: *Deep learning; UbD theory; Mathematics teaching; Unit teaching*

1. Introduction

Deep learning has become the focus of researchers' research with the proposal of core literacy, and deep learning is an important way to achieve core literacy. The organization of mathematics unit teaching conforms to the trend of curriculum reform[1]. Understanding by Design (UbD) theory emphasizes understanding first, reverse teaching design, and regards understanding as the first task. The deepening of new curriculum calls for deep learning and unit teaching[2], and UbD theory can provide theoretical support for unit teaching design. In this context, it is particularly important to combine the theory with deep learning and unit instructional design to explore UbD mathematical unit instructional design based on deep learning.

UbD is short for Understanding by Design, which stands for Instructional Design in pursuit of Understanding, was proposed by American curriculum experts Grant Wiggins and Jay McTighe in 1998, also known as reverse instructional design. The model focuses on goal-oriented, large concepts and important performance tasks. It proposes three stages of reverse design, respectively are determining expected results, determining appropriate evaluation evidence, designing learning experiences and teaching. Teachers should first define the expected learning outcome, then consider how to determine the indicators of students' understanding of transfer, and finally consider how to carry out instructional design in order to achieve the expected learning outcome. A clear prioritization of content, big concepts, basic questions, six aspects of understanding and the WHERETO element of the teaching plan are key elements of UbD theory.

In 1976, American Ference Marton and Roger Saljo put forward the concepts of "deep learning" and "surface learning" for the first time, which opened the upsurge of deep learning exploration and research in the field of education. Deep learning is closely related to key words such as "challenge oriented", "active construction", "critical thinking", "knowledge transfer" and "evaluation and creation". In teaching, under the guidance of literacy oriented learning goals, students focus on guiding learning topics, actively participate and devote themselves to challenging learning tasks and activities, master basic knowledge and skills, experience basic ideas of disciplines, build knowledge structure, and understand and evaluate learning content and process. Students can use knowledge and methods to solve problems creatively, form positive internal learning motivation, advanced social emotions and correct values, and obtain healthy development and meaningful learning process. This paper defines deep learning as the process in which students take the initiative to participate in active construction and in the face of challenges under the guidance of teachers, make variations on the basis of understanding to adapt to new situations and apply knowledge, and develop their higher-order thinking. Unit teaching is characterized by system integration. The design of mathematics unit teaching should also follow the whole systematic thinking and give full play to the unique advantages of unit teaching in teaching. The core of UbD theory is

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understanding first and reverse design. Teachers should define the expected learning outcome firstly, then think about how to determine the indicators of student understanding transfer, and finally consider how to design instruction in order to achieve the expected learning outcome. Clear prioritization of content, big concepts, basic questions, six aspects of understanding and WHERETO elements in the teaching plan are the key elements of UbD theory.

2. Pattern Construction

According to UbD theory, combining unit instructional design and deep learning, the UbD mathematical unit instructional design process based on deep learning is constructed, as shown in Figure 1. UbD Mathematics unit teaching model based on deep learning, the first stage needs to clarify the expected learning results, including unit preliminary analysis and determining unit objectives. On the basis of the clear priority of knowledge, the unit theme is determined, the core task is clearly understood, the basic problem is divided, and the unit goal is determined. The second stage involves the identification of acceptable evidence, including evaluation of the unit. According to the six aspects of understanding, with the goal of implementing deep learning, evaluation criteria and methods are determined, and continuous evaluation and independent reflection are carried out. The third stage needs to plan the corresponding learning process and carry out the teaching design. With the WHERETO elements of the teaching plan, the teaching design aims to promote students' deep participation, including creating problem situations for the goal of facing challenges, independent inquiry for the goal of active construction, variable training for the goal of transfer and application, summary for the goal of information integration, reflection and application for the goal of creation and evaluation. In addition, critical thinking permeates these five links. The whole design process is dynamic and should be constantly improved to perfect the teaching.

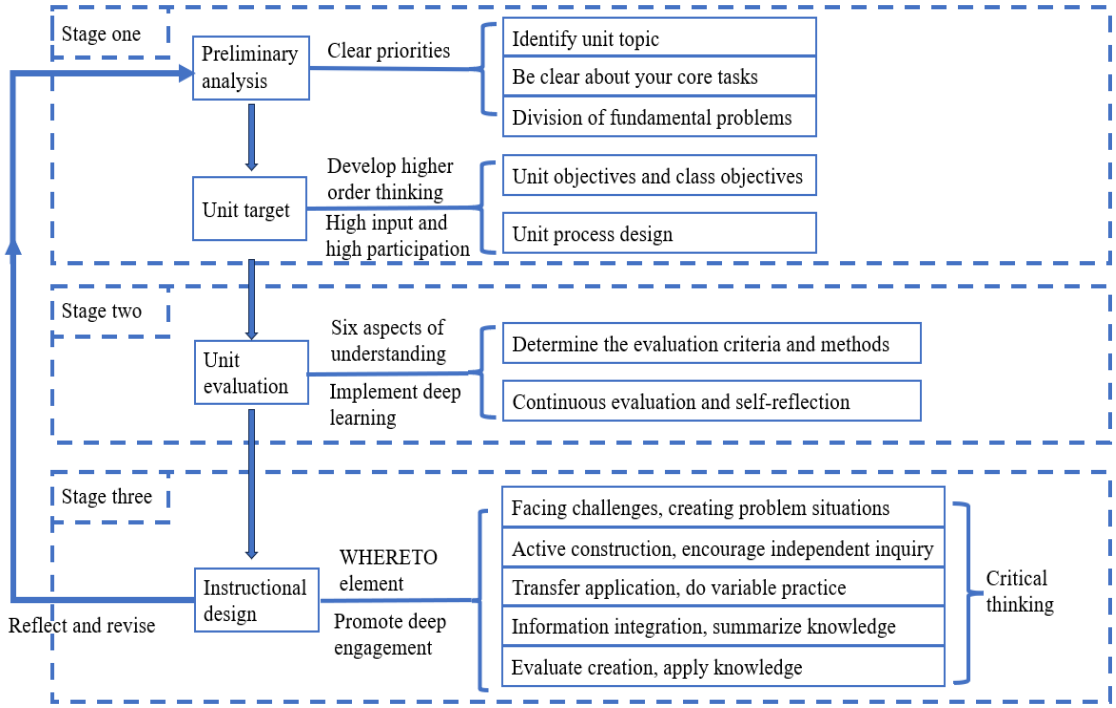

Figure 1: UbD mathematical unit teaching design model.

2.1. Clarify the expected learning outcomes

The steps in the first stage are mainly to analyze and determine the unit objectives in the early stage, and finally to clarify the expected learning results.

2.1.1. Determine the unit theme

Unit teaching design must determine the unit theme firstly, which is the basic work of unit. The subject of mathematics unit can be the subject class unit organized by the mathematical knowledge system, the method class unit organized by the mathematical thought method, the HPM class unit organized by the history of mathematics development, and the literacy class unit organized by the

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mathematical core literacy. Teachers should consider the current level of students according to the theory of the nearest development area when selecting the units.

2.1.2. Define big concepts and core tasks

As "a concept-driven discipline", mathematics is constructed by concepts and their relationships. According to the framework of knowledge prioritization given by UbD theory, teachers need to analyze the unit content, clarify the big concepts and core tasks in the unit, and identify which knowledge is important to master and complete, and which knowledge needs to be familiar with. Curriculum standards and textbooks are important reference materials for teachers to determine the priority of knowledge. By reading the curriculum objectives and contents in curriculum standards, teachers can determine the degree to which students need to master various kinds of knowledge, and the compilation of textbooks can also reflect the priority of knowledge.

2.1.3. Divide basic problems

"Basic questions are the door to understanding", basic questions are valuable, directed, and explorable questions based on big concepts. By clarifying one basic question after another, students can reach the teaching goal step by step, build the knowledge system, establish the connection between knowledge, and finally understand knowledge and develop higher-order thinking. The basic problem should be challenging, portable and directional. Teachers should analyze the gap between students' current level and the level they need to reach, set appropriate basic questions, and achieve learning advancement by solving basic questions one by one.

2.1.4. Determine the unit objective

After completing the preliminary analysis of the unit, the unit goal should be determined. Consistency, structure and development are the principles that should be followed in determining the unit goal. Teachers should analyze teaching materials, students, curriculum standards, unit key and difficult points, teaching methods and other elements to reflect the core content of curriculum standards and textbook requirements to promote the development of students' mathematical literacy. Unit design process is based on the analysis and decomposition of unit objectives, planning unit learning path, dividing class hours according to the actual situation and completing class hours design. The design unit process can be divided into two parts: overall design and lesson design. The overall design includes comprehensive teaching elements analysis, unit objective determination and analysis; Lesson period design is designed for students' learning activities to promote students' deep participation and ensure students' main position. Lesson design should conform to the idea of overall design, and accurately grasp the relationship between overall design and phased goals. Lesson design points to the landing of teaching practice, and the characteristics of deep learning process can be used as the basis for lesson design to guide the design of students' learning activities.

2.2. Determine the acceptable evidence

2.2.1. Determine the evaluation criteria and methods

Unit evaluation should formulate clear evaluation objectives and standards, select appropriate evaluation topics and methods, attach importance to the unity of process and result evaluation, the combination of self-evaluation and others evaluation, and pay attention to the timeliness and effectiveness of feedback. For students, setting clear evaluation goals and standards can help students understand what they have learned, what aspects they are lacking, which helps students to self-supervise and make timely adjustments. For teachers, formulating clear evaluation goals and standards can help teachers clarify teaching behaviors, understand students' learning process and mastery level, facilitate teachers to adjust and improve teaching in time. The formulation of evaluation objectives should be based on unit objectives and lesson objectives, appropriate evaluation methods and means should be chosen. Evaluation methods should be varied, which can be classroom observation, classroom questions, classroom exercises, after-class quizzes, teacher-student exchanges, student evaluation and academic tests. The evaluation should not only pay attention to the students' mastery of the "four basics", but also pay attention to the development of the students' "four abilities". Evaluation should be the unity of process and result evaluation, the continuous evaluation throughout the whole process of learning. Deep learning emphasizes the active participation of students. In the evaluation process, students can not only accept the evaluation of others as the evaluation object, but also have a clear judgment of themselves based on the evaluation of others, so as to achieve the unity of self-evaluation and other evaluation. At the same time, attention should be paid to the timeliness and effectiveness of evaluation feedback.

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2.2.2. Continuous evaluation and independent reflection

Through continuous evaluation, the teaching objectives can be continuously monitored in time, the problems of students' learning integration and the deficiencies of teachers' teaching can be found in time, and the adjustment and running-in can be made constantly. Reflection is indispensable and plays a unique role in mathematics education. Reflection is a kind of higher-order thinking ability, and timely reflection can help teachers and students find and adjust the problems in time, and promote the occurrence of deep learning. Teachers need to reflect on each other's aspects and reflect and review with critical thinking, which is an important means to achieve teachers' experience accumulation and professional growth. Reflection is also important for students. Teachers should guide students to learn to reflect. Through review and reflection, students can get a new understanding of the knowledge and methods that have been learned, which plays an important role in self-improvement. Through mathematics class, teachers should not only complete the task of imparting knowledge, but also "educate people" in the teaching process, and cultivate students' good moral character and habits such as learning to reflect. Knowledge may be forgotten for a long time, but good habits and learning methods can accompany students for a lifetime.

2.3. Plan the learning process accordingly

Considering that deep learning is ultimately implemented in the specific learning process, teachers should accurately grasp the characteristics of each learning stage that facilitates students' deep learning in the design of unit processes. According to the definition of the concept, the characteristics of deep learning process are further summarized as challenge-oriented, active construction, transfer application, information integration, evaluation and creation.

2.3.1. Facing challenges

Both the construction of new knowledge and the integration of knowledge in deep learning require the participation of students' previous knowledge. In teaching, teachers should guide students to conduct critical review based on knowledge experience, trigger cognitive conflicts and create challenging problem situations in order to find new problems and construct new knowledge. Create problem situations and design challenging learning tasks to attract students to explore deeply and maintain their interest in learning[3]. Meaningful and challenging learning tasks can arouse students' curiosity and competitiveness. Students overcome difficulties and experience success in a challenging environment. In order to achieve this, question setting is very important. Good questions can stimulate students' enthusiasm and desire for inquiry, attract students to actively participate in and explore, grasp the essence of mathematics, experience success, and develop the core quality of mathematics.

2.3.2. Active construction

Mathematics is problem-driven, so teaching mathematics must also be problem-driven. To construct new knowledge links, teachers can set up question chains and guide students to think positively and explore actively through connecting basic questions, so as to achieve advanced learning and develop higher-order thinking. In the process of active construction we can accumulate the experience of mathematical activities and construct our own knowledge[4]. This point coincides with Freydenthal's "re-creation" theory and constructivism theory. Mathematics education should strive to improve students' ability to apply the knowledge to solve practical problems, compile appropriate mathematical problems, and use problems to drive mathematics learning. Questions and answers between teachers and students, inquiry learning, cooperative learning and other forms often run through the whole process of problem solving. Mathematics teaching of problem solving plays an irreplaceable role in emotional communication between teachers and students, cultivating students' sense of teamwork, and better adapting to social life.

2.3.3. Migrate applications

Deep learning not only requires students to be able to use existing knowledge to solve problems, but also to be able to transfer applications. Teachers should guide students to deeply understand the problem, critically analyze the key elements in the problem, find the knowledge content associated with it, form the basic idea of problem solving, so as to solve the problem. Deep learning not only emphasizes the mastery of knowledge, but also emphasizes the integration and application of knowledge to new situations. After solving problems, it is also necessary to guide students to expand and change the problems, provide students with new problem situations, guide students to transfer knowledge to other problem situations, achieve the internalization and deepening of knowledge and skills with the change

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of problems and the transfer and application of knowledge.

2.3.4. Information integration

Deep learning requires students to form a knowledge system and incorporate new knowledge into the original knowledge system. By summarizing summaries, teachers organize students to review knowledge and methods, appropriately infiltrate the subsequent knowledge related to them. In the process of forming the system, teachers can help students sort it out in the form of program block diagrams or tables. In addition, it is necessary to popularize the multiple applications of these knowledge in practical life for students as much as possible. Through the integration of various knowledge and information, the cognitive structure of students is reconstructed and their understanding of the meaning of knowledge is deepened.

2.3.5. Evaluation and creation

Through reflection students can clarify their own learning situation and remind students to focus on learning goals, constantly adjust and promote deep understanding[5]. Through strategic guidance students can find a suitable rhythm and continuously engage in learning. The forms and subjects of evaluation should be diverse, and the realization of learning goals can be more comprehensively understood through multi-dimensional and three-dimensional evaluation. Encourage students to actively apply what they have learned, exert their subjective initiative, and cultivate their creative ability.

UbD mathematics unit teaching design based on deep learning is dynamic development, and it should be tested, adjusted and improved continuously in practice. In the teaching process, teachers should also think positively, be good at reflection, take students as the base, and constantly improve education and teaching.

3. Conclusions

Promote students' learning based on reverse teaching design. Result-oriented, change the design order. With the help of UbD theory, mathematics unit teaching design provides a new idea for mathematics unit teaching design. This kind of teaching design not only promotes students' understanding of knowledge, but also improves students' ability to solve problems in different situations, and promotes the in-depth understanding and application of knowledge. Promote students' learning based on the characteristics of deep learning, students should be guided to conduct critical review, encourage to actively face challenges, take the initiative to participate, and construct new knowledge. Once students acquire knowledge, they need to integrate it. In order to promote students' true understanding of knowledge, they also need to carry out transformational training and develop higher-order thinking. Teachers should also guide students to make their own generalization, summarize systematically, actively reflect and evaluate their own learning, and encourage students to actively apply what they have learned to solve problems. Teachers should focus on the core quality of mathematics and develop students' advanced thinking, promote students' learning based on the advantages of unit teaching. Unit teaching of mathematics conforms to the internal logic of mathematics knowledge, implements the core quality of mathematics, and meets the actual requirements of mathematics teaching. As a subject based on concept, mathematics is characterized by logic and systematicness. Unit teaching can fit well with the characteristics of mathematics and promote students' understanding of mathematics. The cultivation of mathematical ability and mathematical literacy needs a medium and long-term training process. The teaching design is carried out by unit, and the way of multiple unit spiraling can achieve this goal.

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