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Experience "Doing Mathematics" in Project Teaching

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Abstract: Mathematics project teaching enables students to complete projects and learn knowledge in the process of "doing mathematics". Mathematics project teaching can not only give full play to the instrumental value and cultural value of mathematics, but also promote students to establish a correct view of mathematics and mathematics learning. Taking the project "Designing the optimal manufacturing scheme of the can" as an example, this paper studies the teaching process of the mathematics project. First, teaching, learning and doing are integrated in the process of completing the project. Second, different manufacturing schemes are presented under the condition of giving full play to students' subjectivity. Thirdly, students' reflective ability is enhanced in the process of examination and assessment. Fourthly, mathematical knowledge is systematized under the guidance of teachers.

1. Introduction

Cramming mathematics teaching distorts students' mathematical view and mathematical learning view. Most students believe that mathematics is a collection of concepts, theorems, laws, formulas and problem-solving skills, and that mathematical learning is to solve mathematical problems compiled by others. Mathematics project teaching can not only improve students' professional ability [1], but also enable students to "do mathematics" in the process of completing practical tasks. Mathematics project teaching can not only give full play to the instrumental value and cultural value of mathematics, but also promote students to establish a correct view of mathematics and mathematics learning to a certain extent.

Taking the project "designing the optimal manufacturing scheme of the can" as an example, this paper studies the teaching process of the mathematics project. First, teaching, learning and doing are integrated in the process of completing the project. Second, different manufacturing schemes are presented under the condition of giving full play to students' subjectivity. Thirdly, students' reflective ability is enhanced in the process of examination and assessment. Fourthly, mathematical knowledge is systematized under the guidance of teachers.

2. The Concrete Process of Mathematics Project Teaching

The following is divided into four parts to study the specific process of mathematics project teaching.

2.1 Teaching, Learning and Doing are Integrated in the Process of Completing the Project

In cramming mathematics teaching, students' main task is to memorize and retell declarative knowledge, such as various concepts, theorems, laws and formulas. Declarative knowledge is then transformed into procedural knowledge through practice from imitation to manipulation. Finally operational skills are developed. The teaching procedure is that the teacher tells the knowledge first and the students do the exercises later. The underlying assumption of this teaching model is that teachers' teaching and students' learning are two processes, and students' learning and doing are two processes, and students can only do what they know first.

Mathematics project teaching requires teachers to design valuable and meaningful projects based on the content to be learned and combined with practical tasks in the working world or the living world. Then the project activities as the main line to expand the teaching process. The basic assumption of this teaching model is that teaching, learning and doing are integrated, and students are more interested in knowing what they are doing. In understanding the meaning of "integration teaching, learning and doing", we should grasp two levels, one is that the main activities have the significance of teaching, learning and doing. "Tntegration teaching, learning and doing" is doing for things, teaching for people, and learning for oneself. Another is that the different positions and roles of different subjects in activities are integrated. Both teaching and learning should be based on doing. Those who can do teach others, and those who cannot do learn from others [2].

For example, the main objective of mathematics teaching in a unit is to find the extremum and maximum value of a function by using the derivative of a function of one variable. In traditional mathematics teaching, teachers first teach the concept of extreme value and maximum value of unary function, decision theorem and examples, and then students do exercises. In the mathematics project teaching, the teacher designed the project -- designing the optimal manufacturing scheme of the can.

Project: Xinxin Manufacturing Co., Ltd. is ready to develop a can production line. Coca-Cola, Sprite, Tsingtao beer and other drinks are available in cans, but filling amounts vary. Suppose we consider the can as a positive cylinder with a capacity of 355 ml. Please help Xinxin Manufacturing Co., Ltd. to design the optimal manufacturing solution for the can.

2.2 Different Manufacturing Schemes Are Presented under the Condition of Giving Full Play to Students' Subjectivity

In cramming mathematics teaching, teachers are the subjects and controllers of teaching, while students are passive receivers. In mathematics project teaching, students are the subjects of learning, while teachers are the organizers and guides of teaching. Under the guidance of teachers, students can actively learn relevant knowledge such as mathematics or interdisciplinary knowledge according to the needs of the project. For example, the related knowledge of unary function extremum and maximum value, vernier caliper application. Students can use multimedia to look up relevant materials: the materials used to make cans, the manufacturing process of cans, the thickness of cans, etc. Students can also observe the structure and shape of cans.

Due to the differences in the resumes, experiences and existing knowledge of students in each group, they think differently and solve problems in different ways. When the students did the project "designing the optimal manufacturing scheme of the can", three representative solutions emerged.

In Scheme 1, the optimal manufacturing scheme of the can is obtained without considering the thickness of the can. The radius and height of the bottom surface of the can and the relationship between height and radius are $r \approx 38.4mm, h \approx 76.8mm \; and \; h = 2r$ respectively. When the height of the can is equal to the diameter of the bottom, the surface area of the material is the smallest.

In Scheme 2, considering the thickness of the can, the thickness of the upper and lower bottom surface of the can is about 0.11 mm, and the thickness of the side wall is about 0.22 mm. The optimal manufacturing scheme of the can is obtained. The bottom radius of the can, the height of the can and the relationship between height and radius are $r \approx 30.5mm, h \approx 121.8mm\, and\, h \approx 4r$ respectively. That is, when the height of the can is equal to about 2 times the diameter of the bottom surface, the volume of the material is the smallest.

In Scheme 3, the thickness of the can was also considered, but different from Scheme 2, the students noticed the structure of the two pieces of the can. Students observe the cans of Tsingtao Beer, which have a two-piece structure. That is to say, the thickness of the side of the can is the same as that of the bottom of the can, while the top of the can is another thickness. The students measured the thickness of the Tsingtao beer can. The thickness of the side of the can and the bottom of the can are $d_1 \approx 0.25mm$, while the thickness of the top of the can is $d_2 \approx 0.68mm$. It is calculated that the bottom radius of the can, the height of the can and the relationship between height and radius are $r \approx 31.2mm, h \approx 116.1mm\, and\, h \approx 3.72r$ respectively.

2.3 Students' Reflective Ability Is Enhanced in the Process of Examination and Assessment

The process of students doing a project is a complete action process guided by thinking, which includes information, planning, decision-making, implementation, inspection and evaluation. Information is to obtain information. Planning is to make steps. Decision-making is to choose the way. Implementation is to act. Inspection is to review the process. Evaluation is to evaluate the results. Students' reflection runs through every link of the action process. Students' reflection can not only monitor the whole action process, but also promote students' knowledge construction. That is to say, the acquisition of knowledge comes from the subsequent reflection on knowledge [3].

Because the students consider the problem from different angles, the optimal design of the cans for the company is also different. Is each team's design really optimal? Each group of students should check and evaluate themselves in the process of doing the project. After the completion of the project, the groups should have mutual evaluation and teacher evaluation.

Teachers' comments on the three programs are as follows. We are more familiar with Coca-Cola cans, Sprite cans, Tsingtao beer cans, do not need to measure, just visually know that the height of these cans and the bottom diameter is not equal. The company produces thousands of cans every day, and the materials used for making cans are calculated by ton. We ignore the thickness of the materials, and the boss of the company may not allow us to do so. Therefore, Scheme 1 is not appropriate. Scheme 2 and Scheme 3 consider the three-piece and two-piece structure of the can respectively, measure the thickness of the corresponding structure of the can in the market, and then get the optimal design scheme. Both of these options are feasible.

In order to stimulate the students' deep thinking, the teacher asked, "Some cans are round and cylindrical. What kind of design plan will there be for such shaped cans?"

2.4 Mathematical Knowledge Is Systematized under the Guidance of teachers

Project teaching needs knowledge preparation. However, teachers must not directly talk about knowledge to help students successfully complete the project, but students learn knowledge in the process of completing the project. Project guidance and knowledge follow-up is one of the core concepts of project teaching. Students learn by doing and do in learning, which can not only stimulate students' interest in learning, but also improve the efficiency of doing things. In mathematics project teaching, we should desalinate the form and pay attention to the essence. In other words, the formal description of concepts and theorems is diluted, and more attention is paid to their application. The knowledge that students learn by doing can only make students "know" and can't make students "know why".

There is no perfect teaching method. The lack of systematic knowledge is a shortcoming of project teaching. The knowledge students learn is scattered. F. Rauner believed that the development of professional ability needs the support of systematic theoretical knowledge. [4]. Therefore, in order to improve students' professional ability, teachers must lead students to expand knowledge and sort out knowledge on the basis of experience and knowledge already acquired.

2.4.1 Expanding Mathematical Knowledge

In the completion of the project "designing the optimal manufacturing scheme of the can", the students applied constraints to transform the binary function into the unary function, and then transformed the conditional extreme value problem into the unconditional extreme value problem. Finally, the optimal value knowledge of unary function is applied to solve the problem.

Some conditional extremum problems are difficult to transform into unconditional extremum problems. The classical method to solve conditional extremum problems is Lagrange multiplier method. Teachers should break the order of knowledge presentation in textbooks and guide students to learn partial derivatives of binary functions and Lagrange multiplier method in the process of doing projects.

2.4.2 Summarizing Mathematical Knowledge

After the completion of the project, students have mastered the method of finding the best value for practical problems, but most students are not very clear about the deep theoretical knowledge. The theoretical knowledge of the method of finding the maximum value of practical problems includes the concept of the extreme value of the function and the decision theorem and other related knowledge. Of course, it also needs to use the derivation formula and derivation rule that have been learned. Teachers should guide students to "review the past and learn the new" and make students "know why".

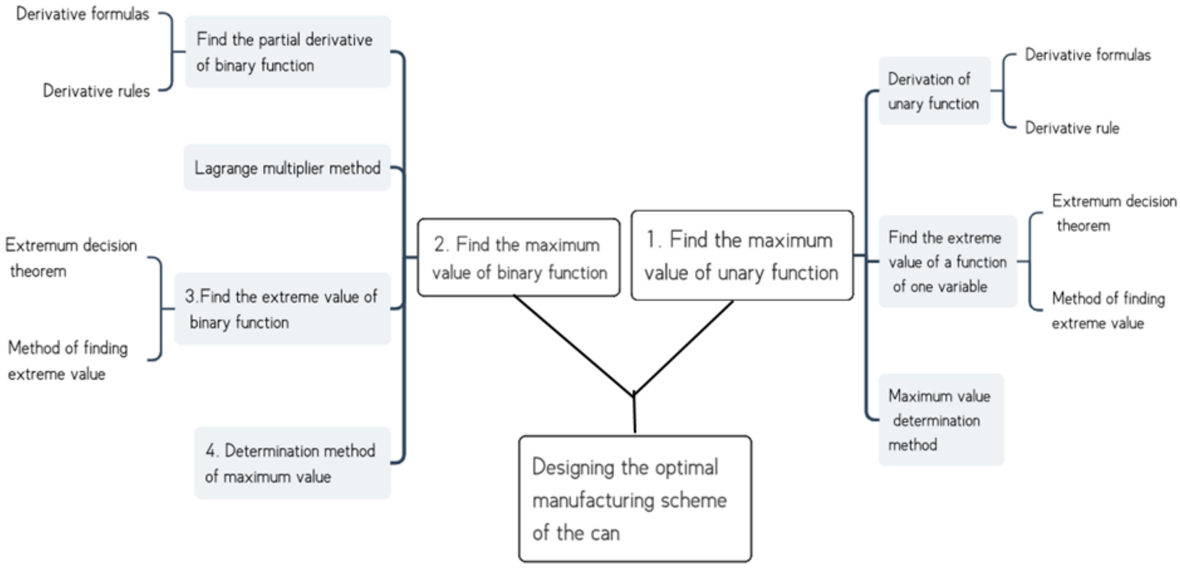

Figure 1: Knowledge tree driven by project

M. V. Laue believes that education is nothing more than what remains when everything learned is forgotten [5]. Different subjects give students different knowledge, so what is left is different.

Compared with the specific knowledge of mathematics, the mathematical thought and method given by mathematics has its wider applicability and is more difficult to forget. In this project, teachers can explain the idea of transformation to students, and reduce the problem of partial derivative of multiple functions to the problem of derivative of unary functions.

In order to better improve the cognitive structure of students, the knowledge tree is presented to students (Figure 1). In the figure, the problem of "2. Find the maximum value of a function of two variables" can sometimes be reduced to the problem of "1. Find the maximum value of a function of one variable". "3. Find the extreme value of the binary function" and "4. Determine the method of the maximum value of the binary function" are the content selected by students after class.

3. Conclusions

Taking the project "designing the optimal manufacturing scheme of the can" as an example, this paper studies the teaching process of the mathematics project. First, teaching, learning and doing are integrated in the process of completing the project. Second, different manufacturing schemes are presented under the condition of giving full play to students' subjectivity. Thirdly, students' reflective ability is enhanced in the process of examination and assessment. Fourthly, mathematical knowledge is systematized under the guidance of teachers.

However, this paper is only a brick to attract jade. There are still many problems about project teaching that need further investigation and research. For example, How to develop mathematics teaching project? How to mobilize the learning initiative and enthusiasm of each student in the group? How to cultivate students' cooperation ability?

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References

[1] Cunrong Wang. (2011) The Curriculum Reform of Higher Vocational Mathematics from the Perspective of Vocational Ability. China Vocational and Technical Education, 23:65-69.

[2] Cunrong Wang. (2011) The Application of the Theory of "Integration of Teaching and Doing" in the Implementation of Project Courses. China Vocational and Technical Education, 32:32-34+39

[3] Dayuan Jiang. (2007) Research on the Mainstream Teaching Ideology of Contemporary German Vocational Education -- Theory, Practice and Innovation [M]. Beijing: Tsinghua University Press, 103.

[4] Dayuan Jiang. (2007) Research on the Mainstream Teaching Ideology of Contemporary German Vocational Education -- Theory, Practice and Innovation [M]. Beijing: Tsinghua University Press, 101.

[5] Yanbin Yang. (2005) Creative Thinking Method [M]. Shanghai: East China University of Science and Technology Press, 25.