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Exploration and Reflection of Mathematical Modeling Activity Course in High School Teaching

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Abstract: *With the deepening of classroom reform, mathematical modeling is more and more widely used in high school classrooms, which is a bridge between the real world and the mathematical world, and plays a very important role in practical teaching. This paper takes "the most energy-saving power of induction cooker boiling water" in real life as an example to design the case of mathematical modeling activity class, and guides students to carry out modeling activities, so that students can experience the process of modeling, learn to use the knowledge they have learned to build models to solve practical problems, so as to cultivate their analysis and problem-solving skills, and stimulate their interest in mathematics Xi. Based on the practice of the activity class, this paper reflects on the teaching, and puts forward a few suggestions on the actual teaching of the mathematical modeling activity class, such as cultivating students' mathematical language ability, digging deep into the content of the textbook, and strengthening the connection between various disciplines.*

Keywords: *Mathematical modelling activities; Practical Problem Solving; Teaching cases; Teaching suggestions*

1. Introduction

The Curriculum Standards for Mathematics in Senior Secondary Schools (2017 Edition, Revised in 2020) (hereinafter referred to as the Curriculum Standards) proposes to enable students to perceive the relationship between mathematics and reality, learn to use mathematical models to solve practical problems, and accumulate experience in mathematics practice[1], which makes the mathematical modeling class in the high school classroom in the form of "activities"[2]. Mathematical modeling activities are a kind of comprehensive practical activities based on mathematical thinking and using models to solve practical problems [3], that is, teachers guide students to participate in or even hands-on operations to experience the whole process of mathematical modeling by designing practical cases, and students cultivate students' ability to discover and propose problems through observation and thinking, and improve students' ability to analyze and solve problems in the process of solving problems.

When Liu Dan studied how to cut into the content of application and modeling in high school classroom teaching, he first evaluated the students' learning situation through the front side, and found that when the conditions are clear and accurate, the students only need to determine the function model according to the corresponding method to solve the problem, but the reflection and even description process of the problem is very vague and confusing, which shows that his awareness of the application of mathematics is not strong [4]. Usually, the practical problems that students are exposed to are often overly abstracted, and they do not need to consider the actual situation, and they can solve such problems by simply refining the quantitative relationship or spatial form in the problem. However, the real problems are often not obvious, the conditions are not very sufficient, many details need to be considered, a complete and careful plan needs to be made, and even the final result is not unique or deviates from the expected. Therefore, the role of mathematical modeling is to simplify complex problems, concretize abstract problems, and clarify logical relationships, so as to create conditions for solving problems [5]. Based on the above analysis, this paper designs an activity lesson with the title of "the most energy-saving power of induction cooker boiling water", guides students to use the knowledge they have learned to establish a mathematical model to solve based on practical problems, experience the whole process of mathematical modeling, cultivate their core literacy in mathematical modeling, and get teaching reflection from the mathematical modeling activity class, and give some teaching suggestions.

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2. The process and nature of mathematical modeling

The process of mathematical modeling can be simplified as: a real-world problem or situation - a realistic model - transformed into a mathematical model - solved using the learned mathematical knowledge - transformed into a solution to a practical problem. Mathematical modeling is a closed and circular system from problem formulation, to model building, model solving, and finally model verification [6].The construction of the practical problem model can be said to be a continuous iterative process, including conditional assumptions, variables, simplification of the model, etc., and continuous repeated feedback and modification, so as to approach or obtain the required model, the mathematical model is to make some simple assumptions for a specific object in the real world, and then use mathematical tools to establish a mathematical structure to solve the problem through the mathematical model. Therefore, mathematical modeling is closed and iterative in nature.

3. Case design for mathematical modeling activity class

3.1 Topic selection

The course standard requires that mathematical modeling activities need to be arranged in both compulsory and elective stages, and the end of chapter 4 of the first volume of the 2019 edition of the new textbook (Renjiao A edition) requires a mathematical modeling activity.

3.2 Activity Objectives

First of all, students are required to refine mathematical problems according to practical problems, clarify experimental principles, accurately collect and analyze data, establish appropriate function models, solve and improve models through the knowledge they have learned, and finally be able to return to solving practical problems. Secondly, students participate in the whole process of mathematical modeling, find ways to transform from practical problems to mathematical problems, experience the close connection between the mathematical world and the real world, and improve their application awareness in the process of modeling. Finally, modeling requires students to work in groups, which can develop students' sense of cooperation and communication skills.

3.3 Learning situation analysis

On the one hand, students have learned the images and properties of exponential functions, logarithmic functions, power functions and other functions, and have initially learned the simple application of related practical problems, which shows that they have the ability to obtain information from images and make inferences, and will also use some parameters and variables of physics that students have learned, so students can try to solve the problems raised in this modeling activity under the correct guidance of the teacher.

On the other hand, considering that it may involve the relevant knowledge of computer execl software, which can be used to draw function images, most of the students should have preliminarily mastered the application, which has an auxiliary role in the establishment of the model.

3.4 Organization and arrangement of activities

After grouping according to a group of 3-5 people, prepare experimental equipment: induction cooker (unified use of Midea RT22E0103 induction cooker), stainless steel pot, timer, thermometer, graduated cylinder, etc., choose to carry out modeling experiments in the laboratory or a conditional place (to fully ensure the safety of students), and borrow the school computer room to complete the operation when you need to process data and draw function images.

Each team needs to complete the following tasks: the whole group will work together to formulate a research plan, improve the research process and ideas, and discuss the required mathematical model; Determine a team leader to grasp the overall direction and progress, and have strong mathematical literacy and organization and coordination skills; For example, team member A is responsible for preparing experimental equipment and specific experimental operations, team member B is responsible for collecting information, calculating and sorting data, and team member D is responsible for recording the discussion and experimental process, writing reports, and checking the results.

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Students are not familiar with the specific process of modeling, so this modeling activity is mainly guided by teachers, and guides students to continue to explore and move forward by setting up question strings.

3.5 Questions

With the continuous development of scientific and technological progress, people's living environment and quality of life have been greatly improved, and as a representative of convenient and fast family life - induction cooker has also entered thousands of households, becoming one of the important heating tools for people's daily life, as a more practical and efficient creative in contemporary times, it has a very high heating efficiency, but in advocating a conservation-oriented society today, heat loss should be reduced as much as possible, so how to use the induction cooker to boil water to save the most electricity?Is it better to choose a more expensive induction cooker, or choose a more affordable one?What is the relationship between the time to boil water and the setting of the power of the induction cooker?Does the initial temperature of the water have any effect? Does it have anything to do with the size of the pot? Different people have different opinions on these problems, and we hope that through this experimental research, we can unify our understanding and master the reasonable and correct way to save electricity.

3.6 Analysis and simplification of problems

First of all, the teacher asks the question: in order to explore the most energy-saving power of the induction cooker to boil water, what angles should be considered?Students may respond in the following ways:

Student 1: Is it that the greater the power set by the induction cooker, the more power saving?

Sheng2: The smaller the pot, the more energy-saving it is?

Sheng3: Whether it has anything to do with the material of the pot?

Sheng4: The less water you boil at one time, the more electricity you can use?

Sheng5: The heating time is related to the initial temperature of the water?

There are many factors that need to be considered, but in the process of building the model, it is necessary to distinguish between the main and secondary causes, and after full discussion with the students, we finally choose to solve the problem raised by student 1. Because for the problems raised by Sheng2 and Sheng3, we can't solve them temporarily, because the amount of people's daily boiling water is related to the demand, so the problems raised by Sheng4 have no meaning, under the condition that the power remains unchanged, the higher the initial temperature proposed by Sheng5, the faster the boiling water efficiency is obvious, this paper mainly explores the influence of the setting of the power of the induction cooker on the boiling efficiency, Therefore, we will not consider this factor for the time being.

3.7 Model building and problem solving

In response to the question raised by Student 1, we must first clarify the purpose and principle of the experiment. The purpose of the experiment was to investigate the relationship between the power consumption of the induction cooker and the useful efficiency when boiling water with an induction cooker. The experimental principle is to use the same induction cooker, boil the same quality of water in the same pot at different powers, and heat it from one temperature to another, to calculate the useful efficiency of the induction cooker. The useful efficiency of the induction cooker refers to the ratio of the internal energy added by the substance to the total electrical energy consumed by the induction cooker when the water is heated from one temperature to another, mathematical expression： $\eta = \frac{CM\Delta T}{Pt}$, where“ P” refers to the power set by the induction cooker,“ t” refers to the time to boil water, and“ C” refers to the specific heat capacity of water (take 4.2×10^3J/kg·℃), “M” is the mass of water, “ΔT”is the amount of change in the temperature of the water, and the increase in the internal energy of the water is“ Q=$cm\Delta T$”.

The following guides students to build a model through experiments, the experimental steps are as follows:

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(1) Put the Midea RT22E0103 induction cooker on the table and turn on the power supply;

(2) Add 3000ml of water to the stainless steel pot and measure the initial temperature of the water with a thermometer Turn on the switch and turn it to boiling mode, select 600W power to boil water, and start timing at the same time, when the water temperature increases to (98°C), stop the timer, turn off the power of the induction cooker, write down the time t at this time, wait for the pot, induction cooker, thermometer and other tools to cool down, and then repeat this operation 3 times;

(3) Set the power of the induction cooker to 800W, 1000W, 1200W, 1400W, 1800W, 2000W, 2200W respectively, and then repeat back.

In the process of the experiment, the corresponding team members should be arranged to record the whole process of the experiment, and the collected experimental data are shown in Table 1 below.

Table 1: The average useful efficiency of induction cooker calculated from 600W-2200W power boiling water.

Power P (W)	Frequency	The quality of the water M(kg)	Time t (s)	Initial temperature (℃)	End-of-temperature (℃)	Temperature changesΔT(℃)	Total power (J).	The increase in the internal energy of water Q (J).	Useful efficiency of boiling water	Average useful efficiency
600	1	3	2600	11.9	98..0	86.1	1560000	1079694	69.2%	
600	2	3	2598	12.2	98..0	85.8	1558800	1075932	69.0%	69.1%
600	3	3	2590	12.4	98..0	85.6	1554000	1073424	69.1%	
600	4	3	2579	13.0	98..0	85.0	1547400	1065900	68.9%	
800	5	3	1830	12.0	98..0	86.0	1464000	1078440	73.7%	
800	6	3	1825	12.2	98..0	85.8	1460000	1075932	73.7%	73.5%
800	7	3	1840	12.3	98..0	85.7	1472000	1074678	73.0%	
800	8	3	1814	12.8	98..0	85.2	1451200	1068408	73.6%	
1000	9	3	1384.1	12.9	98..0	85.1	1384100	1067154	77.1%	
1000	10	3	1382.6	13.0	98..0	85.0	1382600	1065900	77.1%	77.2%
1000	11	3	1373.3	13.2	98..0	84.8	1373300	1063392	77.4%	
1000	12	3	1371.6	13.4	98..0	84.6	1371600	1060884	77.3%	
1200	13	3	1101.0	12.4	98..0	85.6	1321200	1073424	81.2%	
1200	14	3	1095.3	12.6	98..0	85.4	1314360	1070916	81.5%	81.4%
1200	15	3	1091.2	12.8	98..0	85.2	1309440	1068408	81.6%	
1200	16	3	1090.9	13.2	98..0	84.8	1309080	1063392	81.2%	
1400	17	3	888.1	13.5	98..0	84.5	1243340	1059630	85.2%	
1400	18	3	896.5	13.2	98..0	84.8	1255100	1063392	84.7%	85.0%
1400	19	3	899.2	12.8	98..0	85.2	1258880	1068408	84.9%	
1400	20	3	893.8	13.0	98..0	85.0	1251320	1065900	85.2%	
1800	21	3	657.0	13.3	98..0	84.7	1182600	1062138	89.8%	
1800	22	3	655.1	13.4	98..0	84.6	1179180	1060884	90.0%	89.7%
1800	23	3	658.9	13.5	98..0	84.5	1186020	1059630	89.3%	
1800	24	3	661.2	13.0	98..0	85.0	1190160	1065900	89.6%	
2000	25	3	595.1	12.6	98..0	85.4	1190200	1070916	90.0%	
2000	26	3	593.2	12.8	98..0	85.2	1186400	1068408	90.1%	89.9%
2000	27	3	594.1	13.0	98..0	85.0	1188200	1065900	89.7%	
2000	28	3	592.1	13.2	98..0	84.8	1184200	1063392	89.8%	
2200	29	3	537.8	12.8	98.0	85.2	1183160	1068408	90.3%	
2200	30	3	537.7	12.9	98.0	85.1	1182940	1067154	90.2%	90.1%
2200	31	3	539.5	13.1	98.0	84.9	1186900	1064646	89.7%	
2200	32	3	535.9	13.2	98.0	84.8	1178980	1063392	90.2%	

The relationship between useful efficiency and power consumption from the data in Table 1 is shown in Figure 1.

As can be seen from the table above, the useful efficiency of induction cooker for boiling water is 69.1% at 600W, 73.5% at 800W, 77.2% at 1000W, and 81.4% at 1200W/b18>85.0% at 1400W, 89.7% at 1800W, 89.9% at 2000W, and 90.1% at 2200W. As can be seen from the figure above, the useful efficiency changes quickly with power below 1800W, and changes very little after 1800W. The function model of the power and useful efficiency of the induction cooker can also be obtained from the image: y=0.17490ln x-0.42880.

Through experiments, it can be concluded : when it is greater than 1800W, the power of the induction cooker has little effect on the useful efficiency of boiling water, and exceeds 89%, so the power of the induction cooker is more than 1800W in practical life, and the useful efficiency of boiling water is higher. Below 1800W, the higher the power, the higher the useful efficiency.

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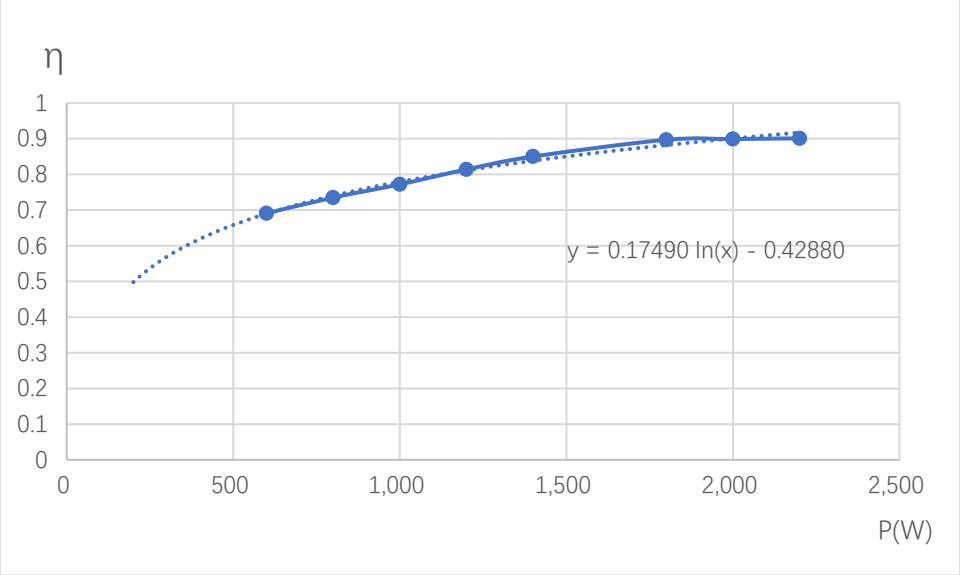

Figure 1: Relationship between the actual power and the average useful efficiency of the induction cooker.

3.8 Model analysis and testing

In fact, the useful power of the induction cooker also needs to consider other factors, such as the size of the pot, the initial temperature of the water, etc., so the model can be further optimized, and the above conclusions also need to be tested.

4. Reflection on the teaching of cases in the Mathematical Modeling Activity Class

4.1 Develop students' mathematical language skills

Mathematical language ability refers to the ability to understand and master mathematical knowledge on the one hand, and the ability to clearly express one's thoughts and opinions in the process of solving problems on the other hand [7]. At present, classroom teaching does not pay much attention to students' mathematical modeling, students only need to be able to solve application problems, and the impact of students' grades is not large, so many students can only do problems but cannot express, and when they need to carry out mathematical modeling activities, they will face great difficulties. In the process of establishing the model, mathematical modeling activities require group cooperation and discussion, which requires group members to have good mathematical language expression skills, and teachers should also consciously cultivate students' ability to accurately express their own views in their daily teaching activities.

4.2 Dig deep into the content of the textbook

In fact, the practical application of mathematical modeling ideas is interspersed in high school mathematics textbooks, but teachers often only stay at the simple application of functions, pay attention to problem solving and fractions, but do not dig the textbook in depth. Therefore, teachers should improve their understanding of the teaching materials, answer students' doubts in detail, and then explore the teaching of mathematical modeling suitable for students through continuous practice, so as to cultivate students' core literacy in mathematical modeling.

4.3 Strengthen the linkages between disciplines

In the process of solving practical problems, it is not only necessary to have knowledge of mathematics, but also the knowledge of physics is involved in this article, which is actually a basic course, which is closely related to various disciplines, such as calculating the probability of heredity in biology, balancing calculations of chemical equations, etc. [7]. Therefore, teachers should skillfully integrate the knowledge of other disciplines into their own classrooms, and solve related problems in other disciplines

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through mathematical modeling, so that students can fully understand the significance of mathematical modeling and actively learn the ability of Xi modeling.

4.4 Pay attention to the combination of theory and practice

In order to improve students' comprehensive practical ability, teachers should pay attention to the close integration of teaching knowledge with practice in life, and guide students to think deeply, observe and research, and practice inquiry through a series of designs, so as to improve the practical effect of teaching [8]. For example, when calculating the consumption level of residents in a certain place, the teacher asks students to list the frequency distribution based on the existing data, draw a histogram of the frequency distribution, and then model other problems, so that the students can experience how to transform theoretical knowledge into practice.

4.5 Pay attention to the use of information technology

For example, in the process of this case practice, it is necessary to import the data into an Excel sheet for analysis and processing to obtain the relevant formula model. In addition to learning to use simple Excel tools, teachers should also Xi learn to use SPSS and MATLAB and other statistical and analysis software to improve their data processing ability, so as to teach students to use these technologies to collect information, process information, Ability to analyze data and more.

References

[1] Ministry of Education of the People's Republic of China. General High School Mathematics Curriculum Standards (2017 Edition, Revised in 2020) [M].Beijing: People's Education Press, 2020.
[2] Shangzhi Wang, Shihu Lv, Siming Zhang. Understanding the Eight Key Issues of the General Senior Secondary Mathematics Curriculum Standards (2017 Edition) [J].)People's Education, 2018(09):54-55.
[3] Jianyue Zhang, Yanjiao Zhang, Keqin Jin. Curriculum Understanding, Teaching Material Design and Teaching Implementation of Mathematical Modeling Activities [J].Middle School Mathematics Teaching(Reference (First), 2020(5): 13-19.
[4] Dan Liu. The Practice of Mathematical Modeling in High School Mathematics Classroom Teaching: A Case Study of the Application of Functions[J]. Chinese Mathematical Bulletin, 2018, 57(04):36-39.
[5] Jianshun Lu. Application of Mathematical Modeling in Solving Mathematics Problem Solving in Junior High School[J].Research on Mathematical and Physical Problem Solving, 2023(26):50-52.
[6] Jiageng Li. Research on the current situation and teaching strategies of integrating mathematical modeling activities into high school mathematics teaching[D].Southwest University, 2023.
[7] Changmao Mei. Research on teaching strategies of high school mathematics classroom based on the core literacy of mathematical modeling[C].2023 Proceedings of the 2nd "Research Forum on Efficient Classroom and Effective Teaching Mode" on Educational Theory and Management (Special Topic 1), 2023.
[8] Shanqi Peng. Analysis of effective teaching strategies in high school mathematics classroom under core literacy[C].Proceedings of the 5th Teaching Symposium of Guangdong Provincial Society of Continuing Education for Teachers (4), 2022.