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A practical research on the training of middle school students' computational thinking based on problem solving in systematic information process view

Miaomiao Zhao
College of education science
Bohai University
Jinzhou,China
35612724@qq.com

Weixing Hu
College of education science
Bohai University
Jinzhou,China
satellitehu@163.com

***Abstract*—Computational thinking is the process sequence of solving problems and behaves a method of systematic solving problems. Computational thinking is essentially a view of systematic information processing process. In essence, developing the computational thinking of middle school students is to improve their problem-solving ability and the corresponding practical accomplishment. The instructional activity design based on six links of problem solving can well meet the need of cultivating students' computational thinking. The instructional mode of systematic problem solving in middle school can improve students' learning effects and satisfaction, and promote students' computational thinking ability significantly. The method of systematic information processing process can be trained.**

Keywords-component; Computation; Computational thinking; Middle school information technology class

I. INTRODUCTION

The emergence and development of computational thinking are closely related to people's understanding of "Algorithm". [1] Since the beginning of human history, people have been inventing, using and disseminating various "algorithms". Generally speaking, an algorithm is a process of solving problems, an accurate and complete description of the solution, and a clear series instruction for solving problems. [2] Algorithm represents the strategic mechanism that people use a systematic method to describe problem solving. [3]With algorithms, people don't need to invent a solution to solve a problem every time. People are constantly optimizing algorithms. [4]On the one hand, they are constantly seeking ways to make the calculation more convenient and faster. On the other hand, they are constantly inventing and improving various computing tools. [5]Especially at present, the function of the electronic computer is not only a simple calculation tool, it has penetrated into all aspects of human life, and is changing the whole society, making human society step into a new stage: the cultivation and development of computational thinking. [6]After Professor Zhou Yi-zhen of Carnegie Mellon University gave a clear definition of computational thinking in 2006, the educational research on computational thinking has skyrocketed. At present, countries all over the world are attaching importance to the cultivation of computational thinking, and everyone has realized the importance and necessity of it. [7]Computer Science Teachers Association (founded by ACM in 2004) released the US K-12 Computer Science Standards in 2011 and 2016 respectively, including computational thinking as one of the content areas of the curriculum. It is pointed out that computational thinking is developed so that children can learn to solve problems or express their own creativity.[8]The British Ministry of Education also announced a new national program for Computer Science curriculum in 2013. The original ICT course was renamed computing course, and the theory of computational thinking was taken as the guiding theory of the course and the core goal of the course, so that students could learn to understand and change the world with computational thinking. [9] Following the new development trend of computer education in foreign countries, relevant experts, scholars and front-line teachers in China have also been deeply discussing the cultivation of computational thinking in the field of basic education at primary and secondary schools. [10] In particular, the new information technology curriculum standards issued and implemented in 2016 clearly set the cultivation of computational thinking as the core task of the curriculum. [11] It is pointed out that computational thinking is produced by individuals in the process of solving problems.

II. CONSTRUCTION OF COMPUTATIONAL THINKING TRAINING MODEL FOR MIDDLE SCHOOL STUDENTS BASED ON PROBLEM SOLVING

The development of thinking is a kind of rich contextualized process. From the real situation of traditional "educational" teaching, it is difficult to realize students' thinking abilities.[12] At the same time, the essence of computational thinking is the improvement of people's problem-solving ability.[13]Therefore, problem-solving teaching based on specific situations is the starting point of the cultivation of computational thinking. [14] According to the existing teaching mode and computational thinking mode of the middle school information technology course, the author constructs the computational thinking training mode of the middle school information technology course as shown in Figure 1 below. This model adopts the information processing mode with problem solving as the main axis, and implements systematic teaching according to the information processing process of problem solving.

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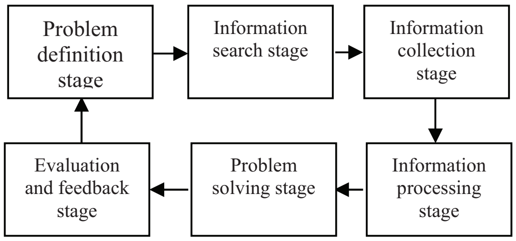

Figure 1. Computational thinking training mode of middle school students based on problem solving

Students' ability to solve problems depends on the improvement of computer skills. Combining students' information technology knowledge with practical ability will better realize the development of students' computational thinking ability. The specific process is as follows: (1) problem definition stage: students use various means of information technology tools (such as E-mail, video conference, social software, etc.) and all can adopt method of team collaboration (such as brainstorming, mind mapping method and Delphi method, etc.), the teacher as a support, communication between students, clear the information needed to solve the problem;(2) Information search stage: according to the key points contained in the problem, determine the scope of relevant resources to be queried, and make an overall planning and design according to the strength of the resource correlation, and clarify the priority and processing sequence of each information; (3) Information collection stage: Determine effective information retrieval strategies from various types of information sources (such as electronic encyclopedias, Internet search engines and digital journal libraries, etc.) to obtain sufficient relevant information. At the same time, the information should be preliminaries processed; (4) Information processing stage: analyze all kinds of collected information related to problem solving in detail, conduct in-depth and systematic analysis, and extract the essence from the case to find the key point of problem solving; (5)Problem solving stage: optimize, organize and form corresponding solutions with specific measures around the key points of problem solving, and keep trying in the application practice. Improving the solutions according to the feedback information until the problem is solved perfectly.(6) Evaluation and feedback stage: encourage students to display their achievements in a diversified way. At the same time, we advocate sharing our process experience with others. This model has a good system and fault tolerance, can provide students with practical methods and processes to solve information problems, and become an effective information problem solver. At the same time, the model can also provide teachers with an effective teaching method. In the process of teaching, implementation can effectively provide students with information skills learning experience, critical thinking and innovation ability training, and then develop students' good thinking about analyzing and dealing with problems.

III. Application Practice of Middle School Students' Computational Thinking Training Mode Based on Problem Solving

In order to verify the validity of the computational thinking training model based on problem-solving process design in the middle school information technology course, computational thinking training instructional practice based on problem-solving is designed in the middle school information technology course. It is composed of ten thematic activities, each with corresponding supporting teaching plans and learning plans. Then, at a middle school in J City L Province has carried out a semester course. At the end of the course, the paper evaluates and analyzes the training mode of thinking from the two dimensions of students' learning effect and computational thinking training effect.

A. *Teaching sample and experimental implementation*

This teaching experiment is to study and analyze the course in information technology in a middle school in J City, L Province. The teaching experiment sample was primary school fifth grade students, a total of 100 people. Participants in the experiment were divided into two classes (Class A and Class B) with different teaching modes. In order to ensure scientific data results, pre-test analysis was conducted on the students respectively to ensure the homogeneity of their classes. Among them, Class A is the control class with 50 students, which adopt the traditional knowledge teaching mode. Class B is an experimental class with 50 students and adopts the computational thinking training mode based on problem solving. The implementation process of teaching activities is divided into two stages. The first stage is the comparative experimental stage, in which the same teacher synchronously implements the teaching activities of the same teaching content in the experimental class and the control class using two teaching modes respectively. At this stage, you need to complete ten learning topics. The second stage is the test and analysis stage. After learning each topic, the corresponding learning effect test is carried out. The test content mainly includes the cognitive learning effect, learning satisfaction and computational thinking ability development of students.

B. *Analysis of teaching Effect*

1) Students' learning effects

In this teaching experiment, the method of controlling variables was adopted, and there was no difference in the measured values between the control class and the experimental class before the experiment. In the experiment, the two classes respectively adopted the traditional teaching method and the computational thinking cultivation method based on problem solving to teach the same teaching content, and the two classes were taught by the same teacher. The assessment method is an in-class test, and the test content mainly focuses on programming understanding, basic programming ideas and program development. Among them, there are 50 students in traditional control class and 50 students in experimental class B based on computational thinking mode of problem solving. 100 test papers were issued and 100 papers were recovered, with a questionnaire recovery rate of 100% and a total score of 50 points. This experiment tests students' understanding, internalization and application of knowledge. Statistical analysis software SPSS was used to conduct an independent-sample t-test on the experimental data of the traditional mode control class and the computational thinking experimental class, and the main analytical results are shown in the table below.

TABLE I. INDEPENDENT-SAMPLES T TEST

Group	N	Mean value	Standard Deviation	T-test for the mean equation
Traditional Mode Comparison class A	*50*	*35.98*	*4.429*	*P<0.05*
Computational Thinking Experimental class B	*50*	*40.18*	*3.595*	

There are 10 questions in the paper, and the points are distributed as follows: objective questions 30 points, subjective questions 20 points, a total of 50 points. It can be seen from Table 1 that the average score of students in the control class A of traditional teaching mode is 35.98, and the average score of students in the calculation thinking experimental group B is 40.18, and the average score of group B is higher than that of Group A. At the same time, the lower standard deviation of group B indicates that the scores of students in group B are more stable than those in group A. In Levene test for homogeneity of variance, $P>0.05$ indicates homogeneity of variance of two samples, and data of two groups are normally distributed. Check the t-value test results of which the homogeneity of variance condition meets $P<0.05$, indicating that students' academic performance is significantly different under the two teaching modes. In conclusion, students in the experimental class of computational thinking have better learning effect.

2) Student satisfaction in learning

This experiment uses a questionnaire survey to understand students' learning satisfaction. The questionnaire includes four dimensions, namely, teachers' teaching, students' learning, changes in students' learning attitude and students' application of problem-solving teaching mode. Among them, there are 50 students in the traditional mode control class A and 50 students in problem-solving computational thinking model experimental class B. 100 test papers were issued and 100 papers were recovered, with a questionnaire recovery rate of 100%. SPSS was used to conduct independent sample t-test for the satisfaction results of students in the traditional mode control group A and computational thinking experimental group B, and the main data analysis is shown in table II.

TABLE II. INDEPENDENT-SAMPLES T TEST

Group	N	Mean value	Standard Deviation	T-test for the mean equation
Traditional Mode Comparison class A	*50*	*73.16*	*7.473*	*P<0.05*
Computational Thinking Experimental class B	*50*	*81.64*	*6.960*	

The questionnaire was set with five-point Likert-type questions, with a total of 20 questions. Each question had five levels of options, with five points for each question and a full score of 100 points. As can be seen from Table 3 above, the average score of students' learning satisfaction in the traditional mode control group is 73.16 points, while the average score of students' satisfaction in the computational thinking experimental group A is 81.64 points, higher than that in group B. And the standard deviation of experimental group A is less than that of control group B, indicating that the fluctuation of experimental group B's score is smaller. In Levene test for homogeneity of variance, $P>0.05$ indicates the homogeneity of numerical variance of the two samples. Further T-test showed that $P<0.05$ when the variances were equal, indicating a significant difference in the scores of students' learning satisfaction between the traditional mode control group and the computational thinking experimental group. Therefore, compared with the traditional lecturing teaching mode, the computational thinking teaching mode based on problem solving can stimulate students' learning enthusiasm, and students' learning initiative is stronger, thus students' learning satisfaction will be higher.

3) The effective analysis of the development of students' computational thinking

The nature of computational thinking is a process of problem solving. The cultivation and development of computational thinking in primary school information technology course is mainly reflected in whether teachers can closely focus on the basic link of problem solving when designing teaching activities. When evaluating the effect, the focus is on analyzing whether the six process abilities of solving problems (defining problems, building computational models, designing algorithms, implementing algorithms, implementing algorithms automatically and evaluating migration and promotion) of students have been significantly improved. Therefore, the computational thinking development test adopted in this study is to ask students to solve a comprehensive project problem (the problem is selected from the integration of some knowledge and skills in the information technology course of primary school), which can be subdivided into six sub-processes, with 15 points for five processes and 25 points for one process, totaling 100 points. The specific result data are shown in table III below.

TABLE III. EVALUATION ON THE DEVELOPMENT OF STUDENTS'COMPUTATIONAL THINKING ABILITY

Evaluation of computational thinking ability	Control class	Experimental class	The Difference Significance Test
	Test scores	Test scores	
Define the question (definition) 15 points	*10.26*	*14.18*	***Independent sample T test, P<0.05***
Establish the calculation model (search) 15 points	*9.55*	*13.63*	***Independent sample T test, P<0.05***
Algorithm design (collection) 15 points	*12.34*	*14.25*	***Independent sample T test, P<0.05***
Algorithm implementation (processing) 25 points	*19.72*	*22.01*	***Independent sample T test, P<0.05***
Algorithm automation implementation (solution) 15 points	*10.26*	*13.49*	***Independent sample T test, P<0.05***
Evaluate, transfer and extension (evaluation) 15 points	*9.98*	*12.37*	***Independent sample T test, P<0.05***

It can be seen from the data in the above table that the six problems solving sub-abilities of computational thinking have been significantly improved compared with the traditional lecturing teaching mode. At the same time, it should also be noted that in the middle school stage, especially in the lower grades, they still focus on concrete image thinking, discovering and understanding various phenomena through direct observation. Therefore, computational thinking at the middle school level should not be taught in rigid principles, but should be developed in a permeable way so that children can develop computational thinking in the process of creating interesting work. In the current middle school information technology courses, in the syllabus for the core accomplishment of rules, it is explicitly pointed out that to develop the students' ability to think calculation, but this is not only a subject duty. Information technology teachers should strengthen the mutual cross exercises. Multidisciplinary teachers work together to develop the students' comprehensive calculation thinking. It is penetrated into all aspects of education, giving full play to the role of computational thinking training in the field of education and explores its broad development potential and application prospects.

IV. Conclusion

- Computational thinking is a method of systematic problem solving, which mainly includes six steps: problem discovery, problem analysis, solution, choice, application and evaluation and feedback. The cultivation process of computational thinking is essentially the process of improving students' systematic problem-solving ability. The method of systematic information processing process can be trained.

- The computational thinking teaching mode based on problem solving can effectively improve the development of middle school students' computational thinking in all aspects. The training mode of computational thinking based on problem solving is feasible and effective in teaching practice.

- The cultivation of the computational thinking ascension is a long-term system development project, which will need a longer period of time with high school information technology course teaching application practice analysis, also need to further find the computational thinking features of the information technology course in high school, and on this basis to carry out effective adjustment and improvement.

- Students' computational thinking ability is often related to creative thinking, comprehensive practical activities, project completion and other elements, so it needs a systematic design, not to separate the relationship between them, but to coordinate development to form a whole.

- The core of computational thinking is to form the model-based problem-solving thinking of middle school students, so that middle school students can learn to form and develop the core quality of hands-on practice in the process of systematic problem solving.

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