Research on Cultivation Strategies of Problem-solving Ability Based on Visualization Technology in Primary School Science Course

Tanyu Li
South China University of Technology, China
litanyu@scut.edu.cn

Chaofeng Li
Foshan University, China
20180970216@stu.fosu.edu.cn

Weifa Xie
Foshan University, China
20180970241@stu.fosu.edu.cn

Problem-solving ability is one of the core competence of students in the 21st century. The integration of visualization technology into primary science classrooms meets the psychological and cognitive characteristics of primary school students and provides rich visual teaching resources for teaching. It can support the creation of problem situations in classroom teaching and cultivate students' problem-solving abilities. Through one-way scale, two-way scale, t-tests, and other data collection and statistical methods, this essay tested the problem-solving ability based on visualization technology in the elementary science class. The conclusion is: First, the application of visualization technology-based problem-solving abilities training strategies in primary science classes can significantly improve students' problem-solving abilities, such as improving students' attitudes toward problems, improving their ability to deal with problems, and the quality of problem-solving. Second, the application of visualization technology-based problem-solving abilities and training strategies in primary science classes can significantly improve students' learning effects.

Keywords: Science Course of Primary School, Visualization Technology, Problem-solving Ability, Cultivation Strategies

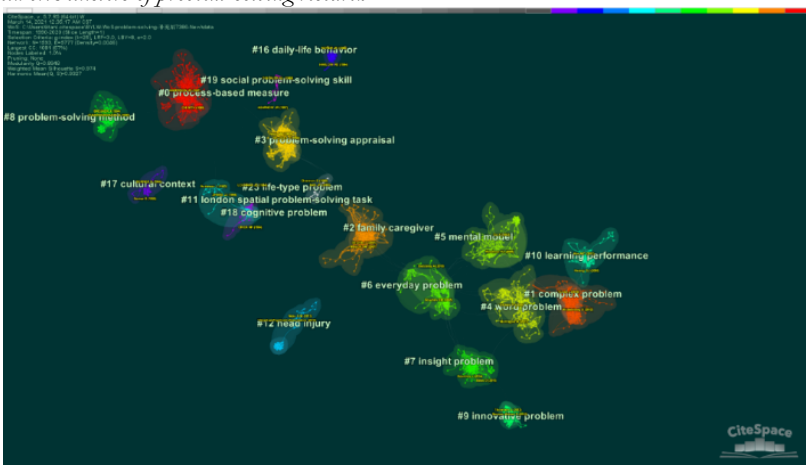
Introduction

Problem-solving ability is one of the core competence of students in the 21st century. The primary school science course emphasizes that students discover and ask simple scientific questions in their daily lives, and try to use scientific methods and knowledge to solve problems. Current primary science classroom teaching has problems such as "lack of attention of creating problem situations, focusing problem-solving processes, and training problem-solving ability". The integration of visualization technology into primary science classrooms meets the psychological and cognitive characteristics of primary school students and provides rich visual teaching resources for teaching. It can support the creation of problem situations in classroom teaching; focus on the problem-solving process; cultivate students' problem-solving abilities. In primary school science classes, research on applying visualization technology to cultivate students' problem-solving abilities has certain theoretical value and practical significance.

This thesis uses CiteSpace 5.7.R2 for visual analysis. The module value Q=0.8948>0.3 and the average contour value S=0.947>0.7 in the references co-citation network clusters of problem-solving research. The community structure divided by this graph is significant. It can be seen in Figure 1 that problem-solving ability is closely integrated with research such as mental models in the field of psychology. Therefore, this research will combine the problem-solving ability, process model, training strategy, and other related content, and try to put forward cultivation strategies of problem-solving ability based on visualization technology in the primary school science classroom, in order to improve students' problem-solving ability.

Figure 1

References co-citation network clusters of problem-solving research



Problem-solving Ability

As one of the core competencies of 21st-century skills, problem-solving ability has been widely studied by scholars in China and abroad. Gagné (1985) regarded problem-solving ability as a higher-level cognitive skill composed of rules and concepts. PISA2012 pointed out that problem-solving ability is an individual's participation in the cognitive process to understand and solve the problem situation. This ability also covers the attitude component of the individual's participation in the problem situation. In PISA2015, collaborative problem-solving ability refers to that in the process of problem-solving, two or more subjects obtain solutions by sharing knowledge, skills, and efforts, emphasizing cooperation in the process of solving problems. Huang Maozai and Chen Wendian (2004) believe that the ability to problem-solving should cover the necessary knowledge, skills, and attitudes.

This study defines "problem-solving ability" as the ability of individuals to actively seek solutions, plan to deal with problems, and effectively solve problems when they encounter problems. It includes "problem-facing attitude", "problem-handling ability" and "problem-solving quality".

Visualization Technology

Visualization refers to any technique used to create graphics, images, or animations for the purpose of communicating information. Zhao Guoqing (2009) believes that the way to convert any abstract affairs and processes into graphics, images, or animations can be called visualization. Bishop (1989) believes that visualization includes visualization content, such as products, objects, and visual images; also includes visualization methods, such as process, activity, and skills. Vavra et al. (2011) believe that visualization objects can be pictures, 3D models, schematic diagrams, geometric illustrations, computer-generated simulations, animations, videos, etc. Quan Guolong et al. (2016) believed that visualization technology refers to a technology that assists people to build mental models and complete mental images. Zhang Huifang (2013) believes that visualization technology refers to the software technology that generates diagrams through diagramming techniques such as flowcharts and mind maps, and a general term for a series of information technologies such as presentation, dissemination, and storage of diagrams.

This study defines "visualization technology" as a general term for the following content: First, graphic technologies such as virtual experiments, mind maps, and video images. Second, software technologies that use XMind, NOBOOK, etc. to generate graphics. Third, information technologies such as presentation, dissemination, etc.

Research Design & Methods

Research Design

The process of this research is divided into five stages: research preparation, theoretical research, empirical research, effect verification, and summary.

In the research preparation stage, the national policy orientation, relevant literature, and the current situation of primary school science classroom teaching will be analyzed, and the research questions of this research will be proposed. The main research objectives are formulated as follows:

Q1: What are the strategies for developing problem-solving ability based on visualization technology in science classes?

Q2: What is the application effect of the problem-solving ability training strategy based on visualization technology in science class?

In the theoretical research stage, on the basis of drawing on and innovating related literature in China and abroad, this study analyzes the psychological cognitive characteristics of primary school students, analyzes the teaching characteristics of primary school science classes, and constructs a strategy for cultivating problem-solving ability based on visualization technology among primary school students.

In the empirical research stage, two classes in the sixth grade of NS primary school were selected to carry out quasi-experimental research. The details will be mentioned in the Method below.

In the summary stage, this study organizes the research conclusions and puts forward future research prospects.

Methods

This study uses the literature research method, questionnaire survey method, interview method, and quasi-experimental method. And it carried out a quasi-experiment in the sixth-grade science curriculum of NS Primary School in Foshan, China. Through one-way scale, two-way scale, t-tests, and other data collection and statistical methods, it tested the problem-solving ability based on visualization technology in the elementary science class.

1. Literature Research Method

This study mainly adopts the literature research method as the main research method in the literature review and strategy construction. By using CiteSpace, it summarizes the knowledge base, research topics and context, research hotspots, and research fronts in the problem-solving research field. By studying domestic and foreign academic journals, doctoral and master theses, books, and other related professional literature on the cultivation of problem-solving ability, the educational application of visualization technology, to analyze the relevant aspects of the cultivation of problem-solving ability supported by visualization technology in primary school science classes.

2. Interview Method

In this study, the interview method was used to interview teachers of science subjects in four primary schools. Through interviews, this research deeply understands the current situation of science teaching in primary schools, and interviews teachers' understanding of problem-solving ability and its influencing factors, the application of visualization technology in primary school science teaching, and the current situation of primary school science teaching. The

interviewees of this study were selected from several primary schools in Shenzhen and Foshan, and the interviewees had taught science for 2 to 11 years.

3. Quasi-experimental research method

This study will use the quasi-experimental research method to evaluate the effectiveness of the construction of problem-solving ability training strategies based on visualization technology in primary school science classes and select two natural classes in the sixth grade of NS primary school to adopt the method of equal group experiments. The experimental class was taught using the training strategy constructed in this study, while the control class was taught in the traditional way. The pre-tests and post-tests collect data on students' problem-solving ability and learning effect in the form of one-way and two-way scale and test questions, in order to test whether the application of teaching strategies can significantly improve students' problem-solving ability and learning effect.

Results

According to the cultivation strategies of problem-solving ability based on visualization technology in primary school science courses, this study accomplished instructional design and selects relevant teaching media, and applies this strategy to the science curriculum of the sixth-grade experimental class. Through quasi-experimental research and t-test methods, the effectiveness of the strategy is verified.

Instructional Design

This lesson is the first lesson of the second unit "Shape and Structure" of primary school science courses which is taught in grade six in the first semester. The instructional design of this lesson is divided into five sessions.

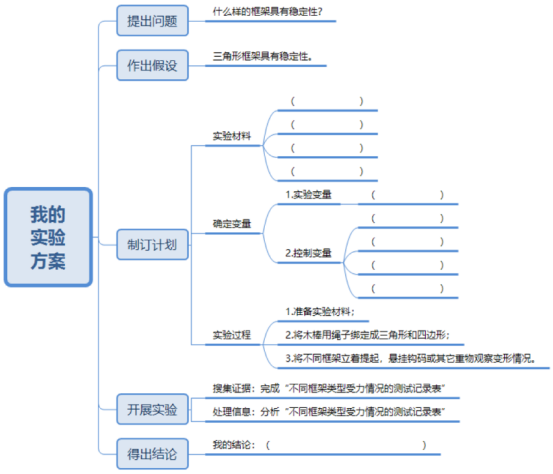
In the problem-finding session, teachers show pictures and let students find problems based on the pictures. Use the method of questioning to guide students to think and cultivate students' ability to find problems.

In the problem determination session, students determine the problems to be solved in this class under the guidance of teachers and focus on the teaching content of this class from these problems.

In the problem analysis session, teachers guide students to pay attention to the "Analysis Problems" part of the learning plan guidance (Figure 2), and follow the steps of the experimental plan to carry out inquiry experiments along the steps of "ask questions; make assumptions; make plans; conduct experiments, and draw conclusions".

Figure 2

Visualization Techniques: Mind Maps of "shape and structure"



In the problem-solving session, teachers ask students to carry out real experiments, and then use NOBOOK which has a virtual experiment (Figure 3) to demonstrate the experiments. After the students watch the demonstration, they record the experimental data and analyze the rules of the experimental data obtained by themselves and the experimental data obtained by the virtual experiment. In addition, in this session of other classes, students are also allowed to make hands-on work(Figure 4).

Figure 3

Visualization Technology: NOBOOK Virtual Experiment

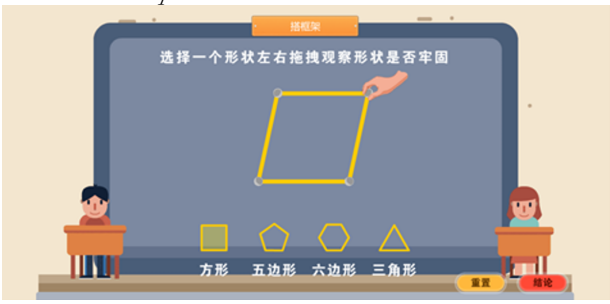
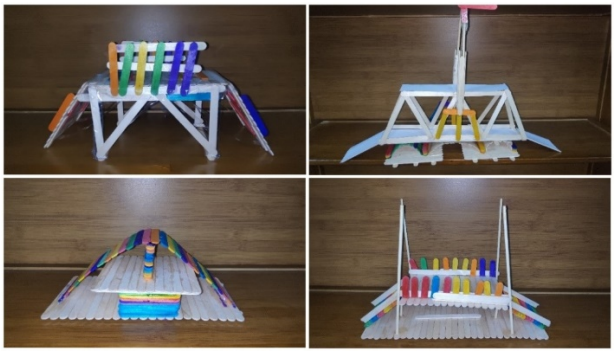


Figure 4

Student's work of Wood Bridge



In the concluding session, the teacher asks the students to analyze the gains and discoveries of the class and allows the students to independently complete the "reflection evaluation" part of the study guide plan, and conduct self-evaluation on their own situation after learning this class.

Data Collection

In this study, the relevant problem-solving ability scales were adapted based on previous research results. The problem-solving ability scale is divided into three dimensions: " Attitude towards problems", " Problem-solving abilities " and " Problem-solving quality ". This study carried out a pre-survey to collect pre-survey data before the start of the experiment and carried out item analysis, reliability analysis, and validity analysis on the original scale to improve the reliability and validity of the problem-solving ability evaluation scale. This study uses IBM SPSS Statistics 25 to deal with the pre-survey data. Before the distribution of the one-way scale and two-way scale of primary school students' problem-solving ability evaluation, this study conducted a reliability test on the pre-survey scale. It can be seen from Table 1 that the Cronbach's Alpha of the whole scale is 0.918, and the reliability index is very ideal.

Table 1

Case processing summary and reliability statistics

		N	%	Cronbach's Alpha
Cases	Valid	238	100.0	.918
	Excludeda	0	0	
	Total	238	100.0	

Result Analysis

After the pre-survey, this study put the problem-solving ability evaluation scale into the research on cultivation strategies of problem-solving ability based on visualization technology in primary school science. Therefore, this study will measure the before-and-after changes in primary school students' problem-solving ability. A total of 84 participants were selected for the research. Specifically, the experimental subjects selected in this study are two parallel classes (Class 1 and Class 2) of the sixth-grade students in NS primary school. Among them, class 1 is an experimental class with a total of 43 students, while class 2 is a control class with a total of 41 students.

Table 2

Group statistics of post-test among two classes

	Class	N	Mean	Std. Deviation	Std. Error Mean
Attitude towards problems	1	43	6.7	5.012	0.764
	2	41	4.3	5.278	0.835
Problem-solving abilities	1	43	24.95	3.891	0.593
	2	41	23.41	4.832	0.755
Problem-solving quality	1	43	9.09	5.58	0.851
	2	41	7.29	6.623	1.034

Table 3

Independent samples test of post-test among two classes

		Levene's Test for Equality of Variances		t-test for Equality of Means						
		F	Sig.	t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	95% Confidence Interval of the Difference	
									Lower	Upper
Attitude towards problems	Equal variances assumed	0.289	0.592	2.123	81	0.037	2.398	1.13	0.15	4.645
	Equal variances not assumed			2.119	79.759	0.037	2.398	1.132	0.146	4.65
Problem-solving abilities	Equal variances assumed	2.041	0.157	2.612	81	0.011	2.93081	1.12196	0.69846	5.16317
	Equal variances not assumed			2.599	77.533	0.011	2.93081	1.12768	0.68556	5.17607
Problem-solving quality	Equal variances assumed	0.01	0.922	2.478	81	0.015	3.55	1.43279	0.69919	6.40081
	Equal variances not assumed			2.48	80.785	0.015	3.55	1.43166	0.70133	6.39867

There was no significant difference in the pre-test data on students' problem-solving ability and academic performance between the two classes. After four weeks of teaching practice, the post-test of "Attitude towards problems", " Problem-solving abilities", and " Problem-solving quality" was conducted for class 1 which is the experimental class, and class 2 which is the control class, and an independent sample t-test was conducted on the data of the two classes.

The results of the independent sample t-test obtained are shown in Tables 2 & 3. To sum up, the problem-solving ability score of the experimental class is higher than that of the control class and there is a significant difference in the overall mean of the post-test scores of the three dimensions of problem-solving ability between the experimental class and the control class. In summary, this study draws the following conclusions:

First, the problem-solving ability training strategy supported by visualization technology is the teaching procedure and teaching of "creating problem situations, discovering problems, identifying problems, analyzing problems, solving problems, reflecting and evaluating" and its implementation measures that incorporate visualization technology.

Second, the application of visualization technology-based problem-solving abilities training strategies in primary science courses can significantly improve students' problem-solving abilities, such as improving students' attitudes toward problems($P=0.592 > 0.05$, $Sig=0.037 < 0.05$), improving their ability to deal with problems($P=0.157 > 0.05$, $Sig=0.011 < 0.05$), and the quality of problem-solving($P=0.922 > 0.05$; $Sig=0.015 < 0.05$).

Third, the application of visualization technology-based problem-solving abilities and training strategies in primary science classes can significantly improve students' learning effects.

Conclusion

This study summarizes the research status of problem-solving ability training and the application status of visualization technology by literature review. Guided by theories such as Instructional System Design theory, it constructs a student-centered, focuses on problem situation creation, and focuses on problem-solving ability development strategies. This research is a further in-depth implementation of the problem-solving ability training strategy in the field of primary school science courses. And it has the effect of enriching the teaching practice of the problem-solving ability training strategy in primary school science courses.

Through quasi-experimental research, this study examines the application effect of the problem-solving ability training strategy supported by visualization technology in primary school science classes. And the conclusion is: In primary school science class, the problem-solving ability training strategy supported by visualization technology can effectively improve students' problem-solving ability and learning effect.

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