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Research on the Influence of Robot Teaching on the Creativity of Secondary School Students under the Background of STEM Education

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Abstract: With the development of society, the requirements for the cultivation of learners are different. Nowadays, STEM education has become a boom in various countries, aiming to improve the comprehensive ability of learners in science, technology, engineering and mathematics. Robots are becoming an integral component of our society and have great potential in being utilized as an educational technology. Wonder B is an electronic module that can be freely spliced. This article uses Wonder B as the platform, combines with the actual learning situation of learners, tries to conduct teaching program design research, and aims at provides References for the teaching ideas and method of robot education. This study used the Williams Creativity Tendency Questionnaire to survey 40 Students and analyze s the data to explore the influence of robot teaching on their creative tendencies.

Keywords: STEM, robot teaching, primary and secondary students, creativity tendency

1. Introduction

The continuous implementation of curriculum reform have led to great changes to cultivate learning. In the 21st century, STEM education has got great attention in improving learns' comprehensive ability of science, technology, engineering and mathematics. The rise of Robot education provides an effective way for STEM education to cultivate computational thinking ability, interdisciplinary ability, problem solving ability and teamwork ability. The Robot education in primary and secondary schools in China has developed rapidly, and now it can be used as a carrier for basic education courses, and can also serve as a carrier for extracurricular activities in schools. Although the Robot education in China has developed for several years, there are many problems, such as lack of a standard curriculum, lack of product specifications to contest winners as the value orientation. Middle school is an important period for students to cultivate their ability meanwhile Scientific thinking ability has a strong guiding role in the process of student growth. Innovative ability is based on innovation thinking, which is the core strength of national competition and a strong support for economic development and social progress. Robots involve multiple subject areas in teaching practice of robot education. Recent study found that on the process of teaching robots has mat great challenges. A lot of robot teaching just stay in a superficial way which not only invalided for connecting vertical communication with knowledge, but also increased the burden of students. Therefore, this study combined the learner's actual learning situation based on a platform called "Wonder B" and try to design the teaching project, aiming at providing reference for the teaching ideas and methods of the robot education curriculum under the background of STEM education.

2. Literature review

Robot education has always been a hot issue in foreign education research. The earliest educational robot came from Professor Papert of Massachusetts Institute of Technology who founded the

Laboratory of Artificial Intelligence in the 1960s. In 1994, the Massachusetts Institute of Technology established the “Design and Construction of LEGO Robot” course to improve the design and creativity of engineering design students. In recent years, Carnegie Robot Institute of the United States publicly released a few robot courses based on LEGO, VEX and other different educational robots. Such as Robot Science, ROBOTIC Intermediate Course, VEX Robot Course (Version 2.0), STEM-CAD Modeling Course, Electronics Course, etc. Foreign countries have also made many attempts in robot classroom teaching. In 2004, Mataric proposed that although robots seem to make a good teaching and learning tool, and have certain appeal to students of all ages, but in the application of educational robots, we should still pay attention to their teaching methods. (Mataric, 2004). In 2009, Alimisis and Kynigos suggested that the use of robot in a school environment should not be limited to focusing on technology, it should consider appropriate educational concepts (Alimisis & Kynigos, 2009). For example, Professor Eguchi listed three successful robot projects that show that the integration of STEM, programming and computational thinking can make students a future-adapted person. (Eguchi, 2014). Scaradozzi et al. believe that the introduction and use of robots as a course subject can teach children the technical basis and give them other types of life value, so they tracked the robot-themed and the entire student in the fifth grade of Italian primary school. During the fifth grade, it was found that children can demonstrate better learning skills, including technology and teamwork (Scaradozzi, Sorbi, Pedale, Valzano, & Vergine, 2015).

The robot educational in China has been gradually improved during the past 20 years. The earliest robot educational in China began in 1996, Dr. Wei Weimin took the lead in proposing the concept of educational robots internationally and created the first educational robot brand “Capability Storm which aims to cultivate learners’ technical literacy and scientific knowledge through educational robots. It was guided by robot projects and competitions which allows learners to “learning while doing” and “learning while having fun”. It can also construct a personal knowledge system to solve practical problems in life. Practice relevant domestic robot education of basic education can be traced back to 2000, Beijing Jingshan School has incorporated Robot Education into information technology curriculum in the form of scientific research projects, and has taken the lead in the teaching of robot in primary and secondary schools in China. (Zhang Lifang, 2015). In 2001, Shanghai Southwest Education School and Luwan High School began to explore and experiment with robot popularization education in the form of “school-based curriculum”. In September 2005, Harbin first officially introduced robots into classroom teaching in the city. 41 schools such as Teacher Attached and Provincial Experimental Middle School opened the course of “Artificial Intelligence and Robot” (Zhang Guomin & Zhang Jianping, 2008). In 2003, LEGO MINDSTORM EDUCATION was introduced to China to stimulate children’s technology interest and creativity. Lego robot education is no longer a boring science and technology popularization of knowledge or learning, it is an education that integrates programming principles, physical science, mathematical knowledge, modeling design and practical ability which combined spatial imagination and logical thinking in order to encourage the creativity and potential of learners with abundant teaching forms (Wang Xueyan & Yang Dongmei , 2017) . Of course, China has also issued a series of policy documents to promote the development of STEM education and robot education. Since 2003, the Ministry of Education has decided to experiment with robot education as a high school elective course in some provinces and cities. In 2004, the Ministry of Education and the Central Electrochemical Education Center also included "computer robots" as a competition project in the national primary and secondary school computer production activities. In 2017, the White Paper on STEM Education in China 2017, drafted by the STEM Education Research Center of the Chinese Academy of Sciences, emphasizes the promotion of the successful STEM education model (Wang Su, 2017) with the guiding principles of "collaboration, cooperation, openness, inclusiveness and innovation". In July 2017, the State Council issued the New Generation of Artificial Intelligence Development Plan, emphasizing the educational application of robots. (State Council, 2017).

3. Instructional design

The instructional design is based on the requirements of the curriculum standards and the characteristics of the teaching objects. To be more precise, instructional design is the process that teachers use modern teaching theories, comply with the characteristics of teaching objects and teachers' own teaching ideas, experiences and styles, use systematic viewpoints and methods to analyze problems and needs in teaching, determine teaching goal, establish steps to solve problems, and rationally combine and arrange various teaching elements to optimize the teaching effect. The study designed related instructional design based on project-based learning (PBL).

3.1 Participants

The students who participated in the study came from the first-year students of a middle school in Shanghai. Through the test at the beginning of the semester and interviews with the students, it could be founded that they have certain computer application skills. Some students have certain programming skills. However, they weren't familiar with the mode of group contact and project-based learning, which means their self-management ability is poor.

3.2 Experiment procedures

A total of 40 students were recruited the experiment and data were analyzed to explore the influence of robot teaching on their creative tendencies. The teaching content of this project is to make students who had certain grammatical basis for programming to understand the application of full-color LED and display module , so that they can use the connection of hardware modules related to Wonder B and the compilation of code blocks to complete the project designed by the student team at the end of the learning phase.

3.2.1 Display module

Teaching mode	Teacher behavior	Student behavior
Participate	Use the display screen to guide the students to think about which module of the Wonder B hardware can achieve the display effect.	Associate with the reality of life, discuss and answer relevant questions.
Inquiry (Autonomous research)	The teacher explains the process of "display module" 1. Through the renderings of 2-3 project examples, let the students guess the actual function of the pea spell display module. 2. After guessing the hardware features, let the students guess where the code area for each hardware function should be. 3. Combine the above considerations and summarize the use of the display module. Describe and summarize the problem on a personal basis.	Trying to understand the hardware features of the display module and the software code through 2-3 instances.
Explanation	Summarize the students' answers, standardize the functions of the display module and code writing, and guide students to understand the programming ideas from finding problems to solving problems.	In the teacher's standardized explanation, check the lack of traps, and promptly put forward record doubts.
Migrate	Take neon lights as an example, combined with the use of the display module, guess what modules are needed. Guide students to use the display module and full-color LED lights to achieve a dual effect of lighting and displaying text.	1. Associate with the reality of life, discuss and answer relevant questions; 2. Try to combine the full-color LED with the display module to complete the corresponding small exercises.

3.2.2 All-round LED lamp

Teaching mode	Teacher behavior	Student behavior
Participate	Use the display screen to guide the students to think about which module of the Wonder B hardware can achieve the display effect.	Associate with the reality of life, discuss and answer relevant questions
Inquiry (Autonomous Research)	The teacher explains the process of "display module" 1. Through the renderings of 2-3 project examples, let the students guess the actual function of the pea spell display module. 2. After guessing the hardware features, let the students guess where the code area for each hardware function should be. 3. Combine the above considerations and summarize the use of the display module. Describe and summarize the problem on a personal basis.	Trying to understand the hardware features of the display module and the software code through 2-3 instances.
Explanation	Summarize the students' answers, standardize the functions of the display module and code writing, and guide students to understand the programming ideas from finding problems to solving problems.	In the teacher's standardized explanation, check the lack of traps, and promptly put forward record doubts.
Migrate	take neon lights as an example, combined with the use of the display module, guess what modules are needed. Guide students to use the display module and full-color LED lights to achieve a dual effect of lighting and displaying text.	1. Associate with the reality of life, discuss and answer relevant questions; 2. Try to combine the full-color LED with the display module to complete the corresponding small exercises.
Explanation	Summarize the students' practice answers and strengthen students' understanding and use of the principle of RGB values.	Search for missing and make up for leaks in teachers' standardized explanations and put forward record doubts in time.
Inquiry (Autonomous Research)	1. Let the students complete the comprehensive exercises independently: flashing lights; 2. Answer questions according to the needs of students; 3. Observe the student's progress.	According to the previous knowledge, group work together to complete the corresponding exercises.
Evaluation	Design an open Q&A questions: Use Wonder B to design a program to solve problems in life or learning.	Students complete their own project design after class; Summarize the key points in the course and promptly feedback doubts.

3.2.3 Programming grammar rules

Teaching mode	Teacher behavior	Student behavior
Participate	Draw out the typical case from the last comprehensive exercise to guide the students to think about the cause of the error.	Discuss and answer questions based on previous exercises
Explanation	Summarize the students' answers, explain the comprehensive exercises, and summarize several types of errors.	Search for missing and make up for leaks in teachers' standardized explanations and put forward record doubts in time.
Migrate	Guide students to think about the grammar rules of programming by looking into the typical errors.	Discuss and answer questions based on previous exercises
Explanation	Summarize the students' answers and standardize the grammar rules of programming.	Search for missing and make up for leaks in teachers' standardized explanations and put forward record doubts in time.
Inquiry (Autonomous Research)	1. Let the students complete the grammar rule corrections independently; 2. Answer questions according to the needs of students; 3. Observe the student's progress.	The group cooperated to finish the corresponding exercises by using the knowledge they just learned.
Evaluation	1. Design a retrospective selective Q&A questions (review exercise): Examine the students' mastery of the knowledge they have learned; 2. Design open Q&A questions (inspired practice): Combine the reality of life and propose a problem that is difficult to solve.	1. Summarize the key points in the course, and timely feedback doubts. 2. Complete review and inspiration exercises 3. The students who have the ample force can continue to complete the copy exercise.

3.3 Instruments

Creative tendencies cannot be measured directly by themselves, however, appropriate tools are often used to measure creative tendencies. This scale directly uses the “Williams Creative Tendency Test Table” developed by Williams and revised by Taiwan's Lin Xingtai and Wang Murong. The scale has 50 questions, including four dimensions as adventure, imagination, challenge and curiosity. The options are “Comply Compliant”, “Comparative”, “Uncertain”, “Comparatively Inconsistent” and “Completely Inconsistent”. Subjects make the choice base on their actual situation. The subjects answered according to their actual situation. The scores of the positive questions were 5, 4, 3, 2, 1, and the reverse questions were 5, 4, 3, 2 and 1 respectively. The total score was the total score of the Creativity Tendency Scale. The higher score indicated the stronger creativity tendencies, the lower score indicated the weaker creativity tendencies. The Cronbach’s alpha value of the questionnaire was 0.86.

Robot attitude questionnaire revised from "Computer Attitude Scale (Formal)" developed by Huang Shijie who proposed to divide computer attitude into computer anxiety, computer confidence, computer love, computer obsession, computer use value and computer equipment values.

4. Results

4.1 Descriptive statistics

The following *Figure 1 and Figure 2* are descriptive statistical tree diagrams of the data before and after the adventurous dimension. There are 11 questions in the dimension, and the total score is 55 points. It can be seen from the comparison between the two figures that the students have an anxiety degree before the course of 29, followed by 44, but most of the scores of the pre-test are distributed between 29-30 points, and most of the scores after the test are distributed between 42-44 points.

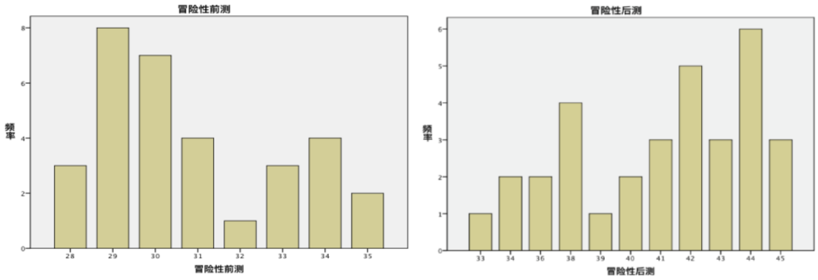

Figure 1 and Figure 2

The following *Figure 3 and Figure 4* are descriptive statistical tree diagrams of the data before and after the curiosity dimension. The total number of dimensions is 14 points, and the total score is 70 points. It can be seen from the comparison between the two figures that the students have an anxiety degree of 36 and 37 before the course. After that, it was 48, but most of the scores were distributed between 35 and 37 points. Most of the scores were distributed between 48 and 55 points.

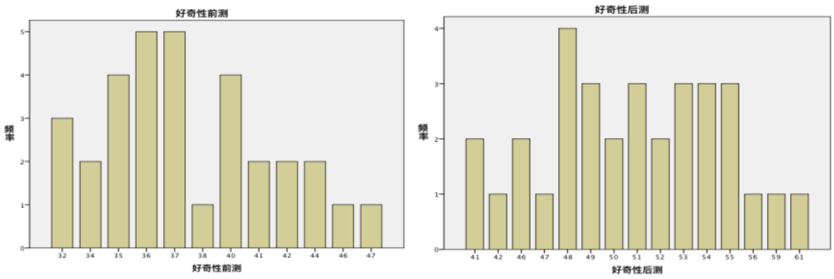

Figure 3 and Figure 4

The following *Figure* 5 *and Figure 6* are descriptive statistical tree diagrams of the data before and after the imagination dimension. There are 13 questions in the dimension, with a total score of 65. It can be seen from the comparison between the two figures that the students have an anxiety level of 34 before the course, followed by 49, but most of the scores of the pre-test are distributed between 33-34 points, and most of the scores after the test are distributed between 48-50 points.

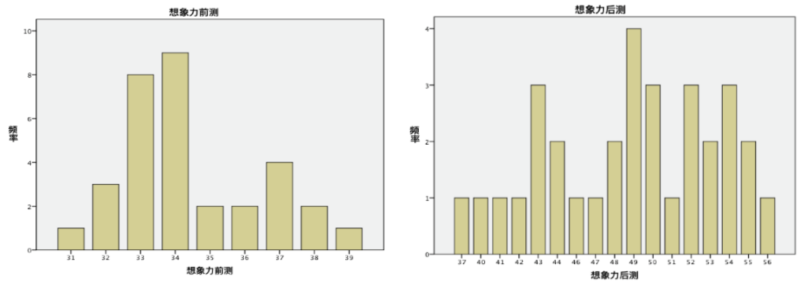

Figure 5 and Figure 6

Figure 7 and *Figure 8* below are descriptive statistical tree diagrams of the measured dimensions before and after the challenge. The total score is 12 points, with a total score of 60. It can be seen from the comparison between the two figures that the students have an anxiety degree of 32 before the course. 37, 46 and 47, but most of the scores of the pre-test are distributed between 32-36 points, and most of the scores after the test are distributed between 44-48 points.

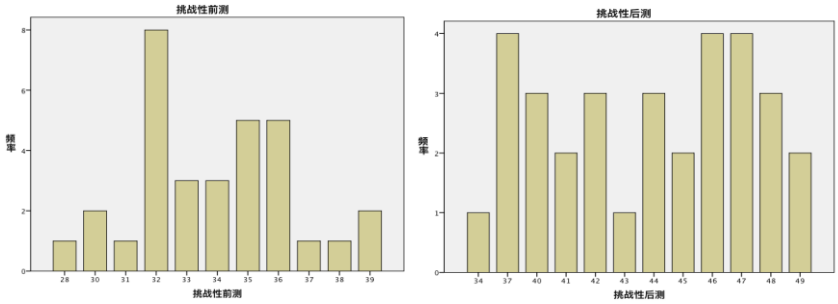

Figure 7 and Figure 8

Figure 9 and Figure 10 below are descriptive statistical tree diagrams of the pre- and post-test data of the Student Creativity Tendency Scale. It can be seen from the descriptive statistical bar graphs measured before and after. The pre-test data is mostly concentrated in 130-140. Between the latter and the measured data, most of them are concentrated between 160 and 200. There has been a significant change in the concentration trend, and the post-test scores tend to be concentrated and stable.

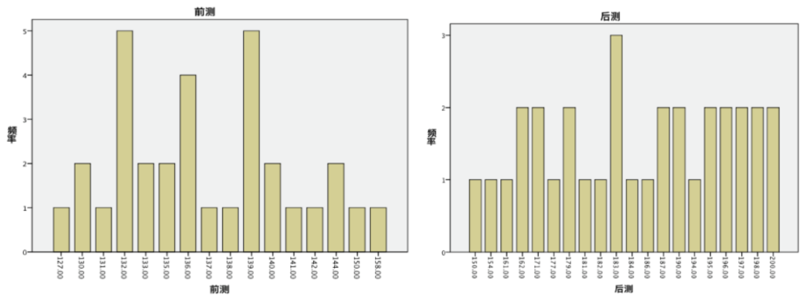

Figure 9 and Figure 10

4.2 Independent sample T test

As can be seen from Table 1 below, the levels of adventurous, imagination, challenge and curiosity are significantly different before and after the robot course in the STEM context.

Table 1

Creativity tends to each dimension independent sample T test

Dimension		S.D.	S.D.	t
Adventurous	Pretest	30.84	2.172	.000***
	Post-test	40.78	3.462	
Curiousity	Pretest	37.94	3.951	.000***
	Post-test	50.66	4.653	
Imagination	Pretest	34.44	2.015	.000***
	Post-test	48.53	4.971	
Challenge	Pretest	33.88	2.612	.000***
	Post-test	43.41	4.079	

It can be seen from Table 2 below that there is a significant difference in the overall level of creativity of students in the STEM context before and after the implementation of the robot course.

Table 2

Creativity tends to independent sample T test results

	S.D.	S.D.	t
Pretest	137.09	6.198	.000***
Post-test	183.38	13.865	

5. Discussion and conclusions

According to the results of Williams Creativity Tendency Scale, there are significant differences in creativity tendencies of students between post and pretest. As for the four dimensions of the scale, there are significant differences in risk-taking, curiosity, imagination and challenge, and there are also significant differences.

In the adventurous dimension, students have significant differences at this level before and after the implementation of the teaching. The reason we found is that students were afraid to start building or writing because of the unfamiliarity with hardware and software and the high cost of supporting facilities. Through the implementation of teaching, gradually have a certain understanding of the software and hardware related to the robot, student started to build it base on their own imagination, and tried to make some physical objects that are different or even non-existent from the construction manual, and they can use the steering gear and the controller to make the object move. In this process, the students' adventurous has changed before and after teaching.

In the curiosity dimension, students have significant differences at this level before and after the implementation of the teaching. Moreover, we found that most of the students in the class were very curious, and only a few students were not very curious during the course. Through analysis, it is found that the dimension of curiosity is influenced by many factors. Different individuals present curiosity in different situations. For example, teachers' expectations will affect students' curiosity, and individual students' cognitive level will also affect curiosity. Wait.

In the dimension of imagination, students have significant differences at this level before and after the implementation of the teaching. Through classroom observation, we found that at the beginning of the implementation of the course, students do not understand what are, the physical objects built in this course and the initial imagination score is low. The imagination is built on existing things. If you don't understand or unfamiliar with those things, it is hard for you to have the image. As the course on going, students pass multiple tasks. During the phrase of completion with diversity hardware devices, students would have more space to explore. At the end of the course, students' imagination be improved.

In the challenge dimension, students have significant differences at this level before and after the implementation of the teaching. The participants have basic knowledge about robot who have stereotypes about lead-in parts and thought it would be boring as usual. With the course carried out, students found the content is more challenging.

6. Limitation and future study

In this study, a one-semester robot course was held in a middle school in Shanghai (one section per week, 1.5 hours per session, totaling 10 sessions). The robot attitude questionnaire and the Williams Creativity Tendency Questionnaire were distributed to the students. There is a significant difference in the attitudes of students before and after the implementation of the teaching (there is no significant difference in the sub-dimension of “belief”), and there are significant differences in the tendency of creativity. Nowadays, there are more and more demand for innovative and comprehensive talents. Robot education can provide an effective way to cultivate innovative and comprehensive talents. Therefore, schools are encouraged to provide certain robot education courses when starting primary and secondary school courses. It provides a platform for developing students' creative tendencies.

We acknowledged that this study has some limitations like it is a quasi-experimental study with no control group to verify the validity of the instructional design. The conclusion of the study has no complete promotion significance but has certain reference value. Besides, the sample size is small with only 32 people and only 4 girls. So it cannot be related to the analysis of gender differences. Finally, this study does not do research based on knowledge content, then we will try to do these in later research further research and development.

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