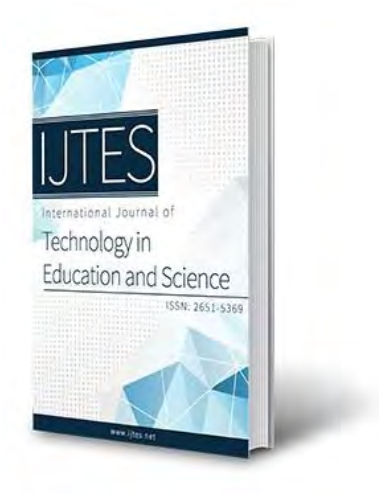

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Abstract

With the continuous development of education informatization, STEM education has become the global trend of education. Project-based learning is widely discussed and applied as a learning method suitable for combination with STEM education concept. Currently, the problem of "how to teach" in STEM education is widely focused on two typical teaching methods, namely problem-based learning and project-based learning. Project-based learning is also learner-centered and tends to comprehensively apply multidisciplinary knowledge, which attracts more attention. Based on the analysis of the impact of combining applied subjects and STEM education with project-based learning on students and other aspects, this paper proposes the connotation of middle school information technology project-based learning under STEM education concept and how to practice the application of project-based learning in junior high school information technology classrooms under STEM education concept in order to promote the further development of STEM education.

Introduction

STEM education was first proposed in the United States in 1980. Subsequently, the UK and Japan also actively introduced various bills, and STEM education developed rapidly worldwide. STEM education emphasizes the cross integration of multiple disciplines, integrating the four disciplines of Science, Technology, Engineering and Mathematics in a rational way to enhance the overall quality of students[1].

In contrast, STEM education only started in China in 2008. It is clearly pointed out in the 13th Five-Year Plan of Education Informatization that "Actively explore the application of information technology in new education models such as 'crowdsourcing space', interdisciplinary learning (STEAM education), and creator education. ". The development of information technology under the concept of STEM education has become popular, and STEM education concept as a new educational concept will be an important direction for future development. Currently, the problem of "how to teach" in STEM education is widely focused on two typical teaching methods, namely problem-based learning and project-based learning. Project-based learning is also learner-centered and tends to comprehensively apply multidisciplinary knowledge, which attracts more attention.

Characteristics of Junior High School Information Technology Curriculum

Comprehensive Nature

"The information technology curriculum involves numerous marginal and basic sciences, and has the characteristics of both a basic cultural curriculum, labor and technical education, and vocational education, as well as a subject curriculum, a comprehensive curriculum, and an activity curriculum." It contains different researches from multiple disciplines and fields. Combining theory and practice, focusing on improving students' information literacy and promoting their all-round development of moral, intellectual, physical and aesthetic development, all these fully reflect the comprehensive nature of the information technology curriculum.

Fundamentality

The "Information Technology Curriculum Guideline for Primary and Secondary Schools (for Trial Implementation)" states that information technology curriculum should be set up in primary and secondary schools nationwide to comprehensively promote quality education. In the age of information technology, information literacy has become an indispensable basic literacy for every citizen. To let students understand and master the knowledge of information technology can lay a necessary foundation for them to adapt to learning, working and living in the information society.

The unique interdisciplinary integration of STEM education is compatible with the comprehensive nature of the information technology curriculum, which emphasizes students' flexible use of interdisciplinary knowledge to solve problems. STEM education is practice insights learning, encouraging students to innovate in practice and cultivate problem-solving skills in practice, while the information technology curriculum also requires teachers to focus on cultivating students' hands-on practice and practical problem-solving skills. In addition, the four disciplines of science, technology, engineering, and mathematics have mutual connectivity in the information technology curriculum. Thus, the information technology curriculum under the concept of STEM education is more advantageous.

Project-Based Learning is an Important Method to Implement the Concept of STEM Education

A project is a one-time, multi-tasking effort that achieves a definite result within a certain time frame. Project-based learning activities have a certain activity cycle [10], which meets the characteristics and requirements of junior high school students. Students at the junior high school level have a certain amount of knowledge, and their practical ability have improved compared to those at the elementary school level, but they still lack a little. Project-based learning activities consist of several independent and related activities, while learners can constantly discover and solve problems in the process of activities, and gradually cultivate their practical and problem-solving abilities so as to better realize the concept of STEM education.

Therefore, project-based learning is an important method to implement the concept of STEM education. Project-based learning activities based on the concept of STEM education in junior high school information technology

classrooms can achieve integrated interdisciplinary learning and acquire knowledge in various aspects, which meets the requirements of junior high school information technology; at the same time, it can adapt to the learning situation and practical ability of students at the junior high school level, and work in groups to accomplish the established task goals.

Method

Under the guidance of the STEM education concept and drawing on the five processes of project management, the overall process of junior high school information technology project-based learning activities based on the STEM education concept is determined, and the framework of the specific activity process is designed with students and teachers as the main perspectives.

The Overall Process Model of STEM Project-Based Learning Activities

As shown in Figure 1, STEM project-based learning activities mainly include: initiation process, design process, implementation process, and evaluation process. The design process mainly includes inquiry event design, collaborative format design, and management control of learners in terms of time and quality. During the evaluation process, students report their results and the teacher makes a summative evaluation to complete the termination of the project.

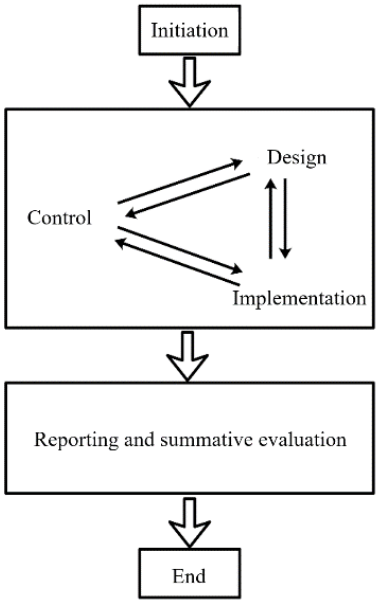

Figure 1. Overall Process Model of STEM Project-Based Learning Activities

Framework for the Flow of Project Learning Activities in STEM

According to the overall process of project-based learning activities, the specific process of project-based learning activities is designed from the perspective of students and teachers around time and quality, as shown in Table 1.

Table 1. The Specific Process of Project-Based Learning Activities

Activity Structure		Activity Body		Activity Management	
Activity Participants		Student	Teacher	Control	Time
Activity Process	Start	1.Analyze project themes. 2.Identify the problem to be solved.	1. Layout of project themes. 2. Guide students to identify the problem.	Teacher Control	10min
	Design	1. Negotiating the division of labor according to the drawings. 2. Assign respective tasks.	1.Provision of project drawings. 2.Distribution of project materials.	Teacher Control Student Control	10min
	Implementation	1. Team leaders to control the overall project progress and record data. 2.Project implementers implement according to established arrangements. 3. The project tester tests the project and records a reasonable prediction of the next operational risk.	1.Ensure a clear division of labor and full participation of each member of the team. 2.Overseeing the implementation of the teams. 3. Guaranteed low risk operation for each group of projects.	Teacher Control Student Control	30min
	Evaluation	Report group results	Assessment of acceptance of project results.	Teacher Control	10min

During the initiation process, teachers assign project topics according to students' cognitive level and learning. After receiving a specific project topic, students analyze the project topic and define the problem to be solved according to their own knowledge and experience. For students who have difficulty defining project goals, teachers need to guide them accordingly, guiding learners to identify and define problems from different perspectives so as to ensure successful project initiation.

During the design process, the project team leader leads the team members to discuss and analyze the identified problems to be solved, determine the solution method, and discuss the task division with the team members to determine the tasks to be completed by each team member. Teachers provide project drawings, slightly reduce the difficulty of the project, and distribute project materials according to the predetermined schedule.

During the implementation process, the project team leader controls the project implementation schedule appropriately according to the actual situation to ensure that the project is completed in accordance with the expected time; The project implementer completes the work according to the project drawings and the established division of labor to ensure the time and quality of the task completion; The project tester tests the project and records it. At the same time, teachers determine the division of labor among team members to ensure full participation; and supervise the implementation of each team's project, and may supplement project materials for different project teams according to the actual situation; and supervise the completion quality of each team to ensure that the project is completed with low risk and high quality.

During the evaluation process, the project team selects a team representative to report on the results of the team project. According to the group's report and actual observation, the teacher makes a summative evaluation of the group results from time, quality and other aspects.

The above is a specific design of the five processes of STEM project-based learning activities, which is a practical study of project-based learning activities for junior high school information technology under the guidance of the STEM education concept, based on the overall process model of STEM project-based learning activities.

Results

This study selected XX middle school in XX city to conduct a practical study of project-based learning activities. According to the principles of project-based learning activity design for middle school information technology curriculum under the concept of STEM education, the study chose "Helicopter" in the Scratch programming club class as the teaching content under the guidance of the experience of information technology teachers in the school, taking into account various factors such as the length of the activity, the cost of materials and the cognitive level of students in middle school. The teaching content determined the theme of the project-based learning activity "Airplane Take Off", and the project-based activity "Little Pilot" was carried out. The theme involves STEM domain knowledge mostly in engineering, involves partial drawing and the activity phenomenon is relatively easy to observe. The materials needed to build the helicopter in the course are highly workable, and the software ScratchPI, which controls the rotation of the rotor and tail of the aircraft, is open source and free software, so classroom management can be guaranteed. In this lesson, we first analyzed the subjects of the "Little Pilot" project-based learning activity, investigated their interest in learning information technology, their motivation and participation in group activities, and tested their prior knowledge level. Then, we designed the content and organization of the "Little Pilot" project-based learning activities based on the learning objectives of the lesson "Helicopter". According to the design framework of project-based learning activities, the "Little Pilot" project-based learning activities were designed in detail from the perspective of students and teachers. Finally, the project implementation was carried out in the experimental class, and the analysis was recorded.

Basic Learner Profile Analysis of Project-Based Learning Activities

The research subjects for the practice of junior high school information technology project-based learning

activities based on the concept of STEM education were selected as students in a class of an information technology club in a middle school in Hangzhou. Before the experiment, a questionnaire was used to understand the class students' learning attitude, learning interest and prior knowledge. The survey on "whether they like information technology classes" is shown in Figure 2. Among them, more than half of the students said they liked information technology classes, but less than half of them did not like information technology classes, and some of them even disliked information technology classes very much.

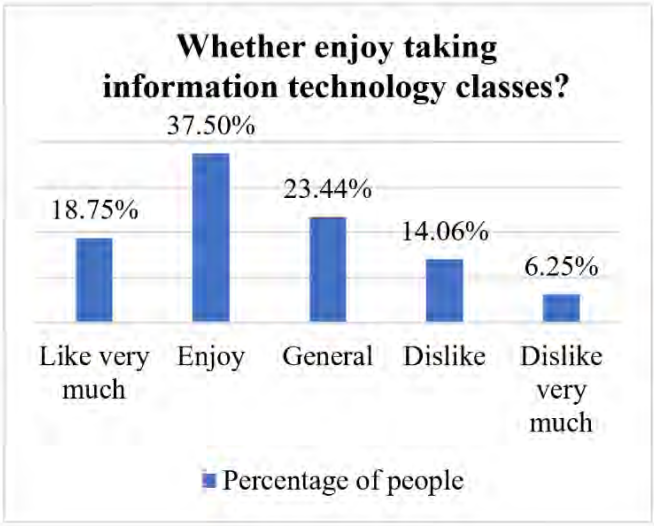

Figure 2. Whether They Like Taking Information Technology Classes

As shown in Figure 3, the two main reasons for enjoying information technology classes are: interest in information technology course content and the relaxed atmosphere of information technology classes. In addition, there are two main reasons for not liking information technology classes: on the one hand, they are not interested in the class content, and on the other hand, the information technology teacher is boring in class, as shown in Figure 4.

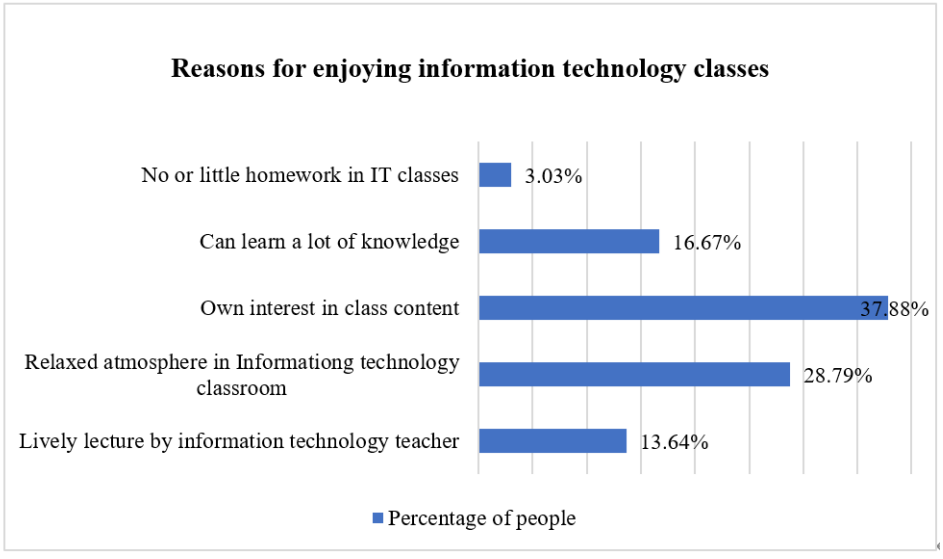

Figure 3. Reasons for Liking Information Technology Classes

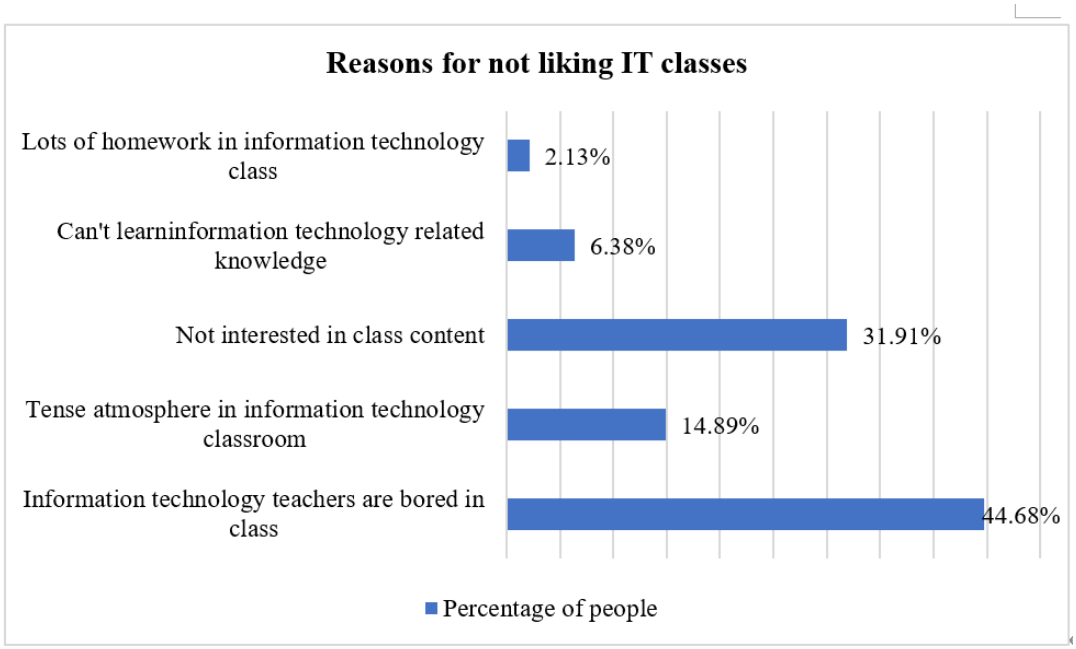

Figure 4. Reasons for Not Liking Information Technology Classes

At the same time, students have their own expectations about the form in which the information technology class should be conducted, as shown in Figure 5.

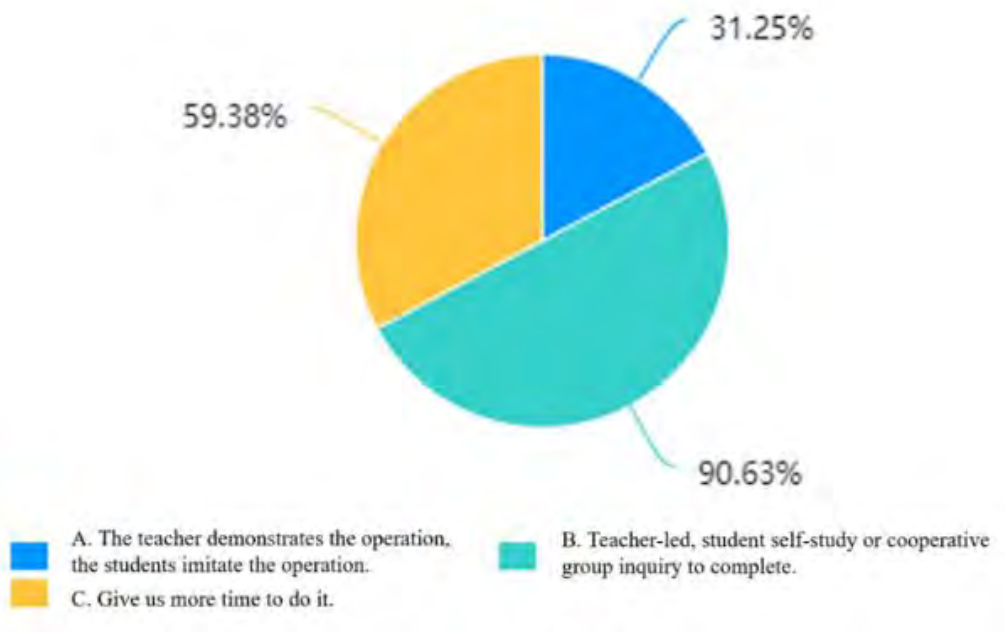

Figure 5. Students' Favorite Information Technology Class

In the survey and analysis of the students' basic knowledge level, the questions covered the structure of helicopters, the basic content of Scratch programming and other knowledge points in a total of 8 questions. Students did well in questions about helicopter knowledge, but did not have a solid grasp of basic knowledge points of Scratch programming, as shown in Figure 6.

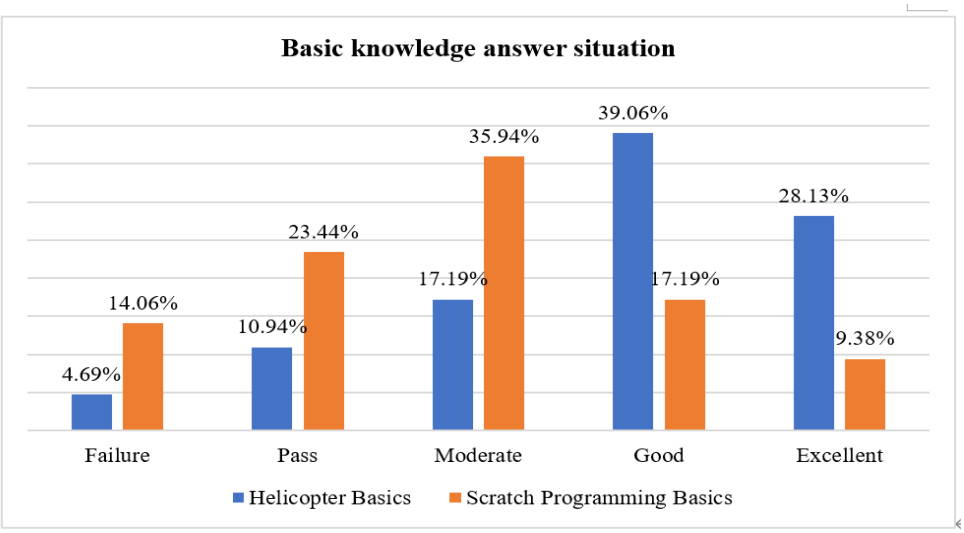

Figure 6. Students Answering Questions On Basic Knowledge

Design of Junior High School IT Project-Based Learning Activities under the Concept of STEM Education

On the basis of understanding the experimental objects and meeting the design principles of student subjects, we designed the "Little Pilot" project-based learning activities that meet the characteristics of learners and adapt to the teaching objectives of "Helicopter".

Activity Content Design

Based on the theoretical knowledge of constructivism, discovery learning theory and activity theory, the "Little Pilot" project was designed as two activities, namely, "virtual helicopter flight" and "physical helicopter flight simulation". The two activities have their own project materials required, project requirements and teaching objectives, as detailed in Table 2.

Table 2. Materials Required for the Project, Project Requirements and Teaching Objectives

Project Name	Little Pilot			
Activity Name	Project Overview	Project List	Project Requirement	Teaching Objectives
Virtual helicopter flight	Writing programs to fly helicopters using ScratchPI.	Software ScratchPI	1.Draw the helicopter and determine the distribution of characters. 2.The program written can make the painted helicopter rotor and tail rotate.	1.Master the rotation center point setting. 2.Recognize variables and their applications. 3. Master the variable data transfer between roles.

Physical helicopter flight Simulation	Build and program a helicopter with blocks to control its movement.	Lego blocks "treasure chest"	1. Build the helicopter according to the drawing. 2. Write programs to control the rotation of the rotor and tail of the physical helicopter.	1. Understand the basic knowledge of helicopters, their construction. 2. Motor speed control using variables.

Activity Evaluation

The evaluation of project-based learning activities is carried out by a combination of teacher evaluation and student self-assessment, with the teacher mainly focusing on the implementation of the two parts, the student subject and the activity object, during the initiation, implementation and reporting of the two sub-project activities. In addition to evaluating the process related to the project, students are required to self-assess whether they have improved their abilities. After the experiment, the questionnaire was analyzed again for the class to study whether the experiment had some positive effects on students' learning attitudes and their own abilities.

Discussion

The purpose of the two questionnaires was to collect students' attitudes and emotions about information technology and their mastery of knowledge principles; the questionnaires used before and after were similar in scope and the difficulty level of the knowledge questions. In the post-practice questionnaire, the difficulty of the test for the knowledge points related to the fundamentals of Scratch programming was slightly increased.

Among them, the students' preference for information technology class is obviously improved, while the proportion of students who do not like information technology class is reduced, indicating that the project-based learning based on STEM education concept can enhance students' learning interest in junior high school information technology, as shown in Figure 7.

Figure 7 Comparison of students' enjoyment of information technology classes before and after the experiment
The questionnaire also showed that the students' knowledge mastery increased and the teaching objectives were well accomplished. As shown in Figures 8 and 9, it can be judged from the students' answers that they have a more proficient and solid grasp of the basics of Scratch programming.

In addition, according to the analysis of the questionnaire, students' ability to apply knowledge across disciplines was improved through the project-based learning activities under the STEM concept, and their ability to apply knowledge in a comprehensive manner to solve problems was also cultivated to a certain extent. As shown in Figure 10.

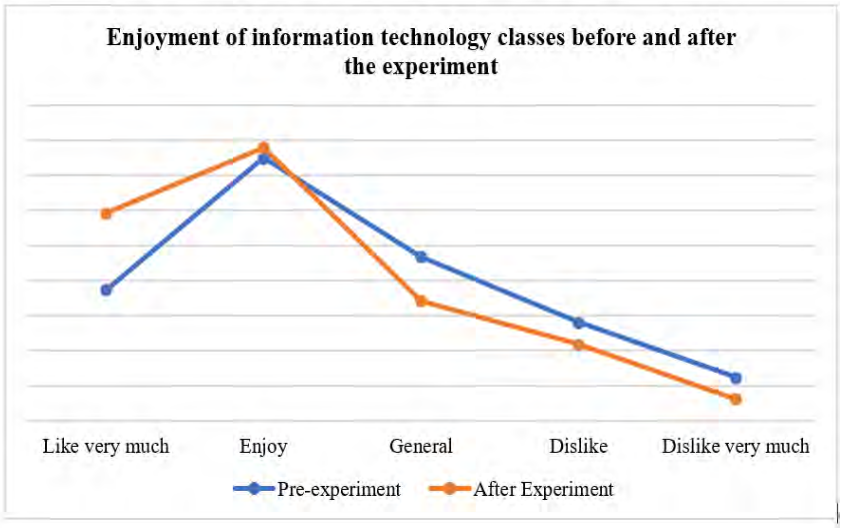

Figure 7. Students' Enjoyment of IT Classes before and after the Experiment

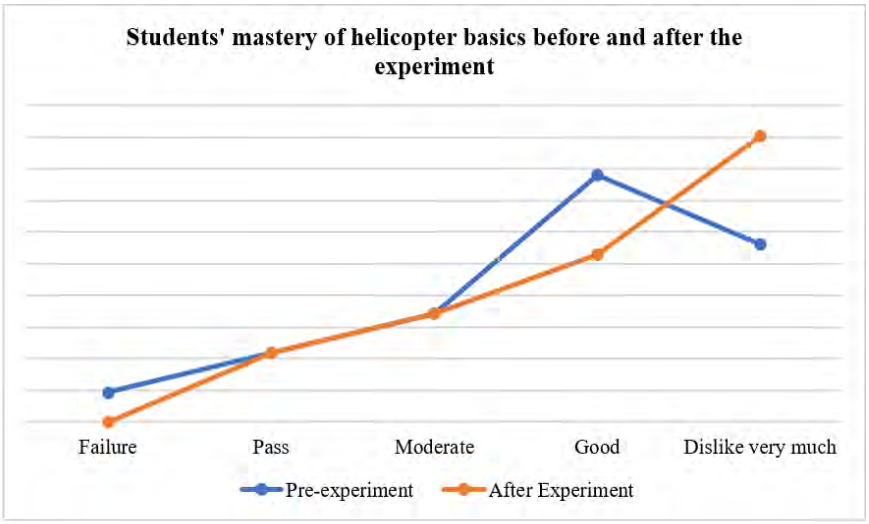

Figure 8. Students' Mastery of Helicopter Basics before and after the Experiment

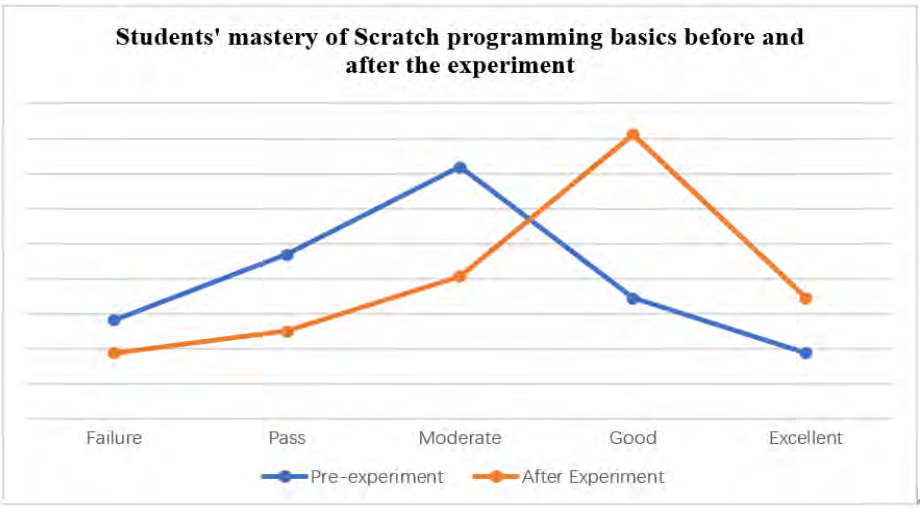

Figure 9. Students' Mastery of Scratch Programming Basics before and after the Experiment

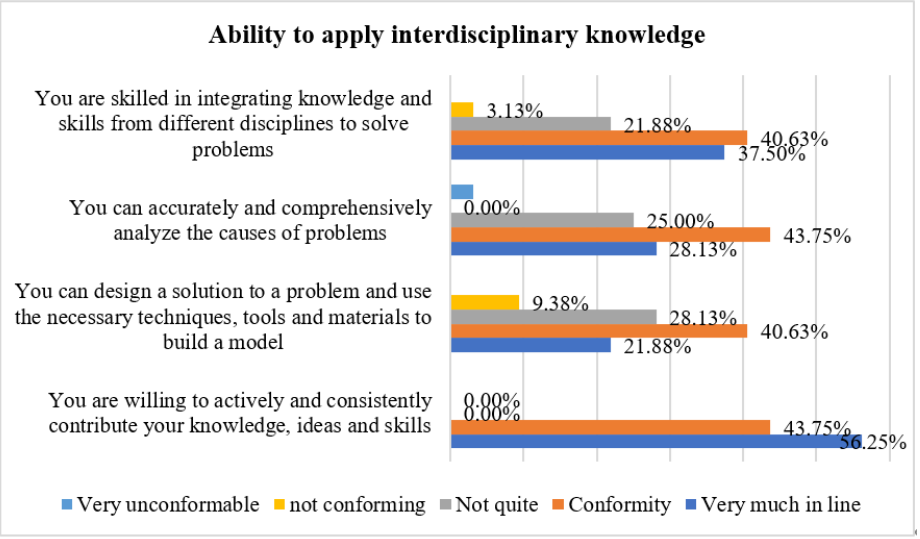

Figure 10. Embodiment of Related Capacity Enhancement

Conclusion

As an interdisciplinary and comprehensive education, STEM education consists of four disciplines: science, technology, engineering and mathematics, emphasizing the cross-fertilization of multiple disciplines, and striving to improve the overall quality of students. The STEM education concept has changed the traditional way of education, and the combined use with project-based learning provides new ideas for secondary school information technology education.

The practical results show that: (1) the implementation of project-based learning in junior high school information technology classrooms based on the concept of STEM education can encourage students to use a variety of subject knowledge to discover and solve problems in life-related situations, which helps students to understand and master the knowledge. (2) Increased students' interest in learning and using information technology, and increased motivation to learn. (3) It cultivates students' practical, problem-solving and group cooperation skills; it also makes students appreciate that sharing knowledge is common progress and understand the importance of group cooperation in the process of the activity.

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