Research and Practice of STEM-based Vocational Ability Cultivation System for Higher Vocational Students

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Abstract. Students' mastery of STEM at the stage of higher vocational study will help them to engage in engineering and technology-related careers after graduation, because science and math are the foundation of engineering and technology. Through the research of constructing a STEM-based vocational ability cultivation system for higher vocational students, and through the construction and practice of a STEM-based curriculum system and practice system for the software development direction of the computer application technology major, as well as the feedback from the students' internship enterprises, the effectiveness of the STEM-based vocational ability cultivation system for higher vocational students is proved.

Keywords: STEM, higher vocational education, students' vocational ability cultivation system

1 Introduction

STEM (Science, Technology, Engineering and Mathematics) is an acronym for the four disciplines of science, technology, engineering and mathematics, which was initially proposed in 1986 in the report "Undergraduate Science, Mathematics, and Engineering Education" published by the U.S. National Science Board. But STEM education is not a simple superposition of these disciplines, but by speaking of the four disciplines combined to form an organic whole, the realization of the understanding of the use of scientific knowledge, scientific inquiry project practice, as well as the specific application of engineering design combined, the goal is to integrate the various fields of knowledge, skills, the knowledge of the study of the combination of specific engineering practice, through the solution of real-world practical issues[1]. The goal is to integrate knowledge and skills in various fields, combine knowledge learning with specific engineering practice, and through solving practical problems in the real world, cultivate innovative talents with high comprehensive quality and strong hands-on practical ability. The concrete practice of the United States[2], Finland[3] and other countries[4,5] shows that STEM education helps to cultivate students' scientific inquiry ability, innovative consciousness, critical thinking, information technology referencing ability, and has the potential to continue to play a role in the future life and work of the learner.STEM education has become a powerful enabler to enhance the competitiveness of the country, and it

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will remain an important education strategy that many countries will adhere to in the long run in the future.

In June 2015, the State Council issued the Opinions on Several Policies and Measures for Vigorously Promoting Mass Entrepreneurship and Innovation, and the introduction of the policy of "Double Creation" is an important landmark event that ushered in the development of STEM education in China. In September 2015, the Ministry of Education issued the "Guiding Opinions on Comprehensively and Deeply Promoting Educational Informatization during the 13th Five-Year Plan Period (Draft for Opinion)", which for the first time put forward the concept of "STEM education" and explicitly pointed out that it would explore new education modes, such as STEM education and creator education, and promote the "Crowd Creative Space". In 2016, the Ministry of Education issued a notice on the "Thirteenth Five-Year Plan for Education Informatization", stating that it is necessary to explore the application of STEM education, creator education and other new educational modes.

STEM learning does not occur in isolation, but is based on human interactions - interactions between learners, helpers, and other learners - and human-environment interactions - interactions between real and virtual learning environments[6]. These two interactions form a STEM learning ecosystem, as shown in Figure 1.

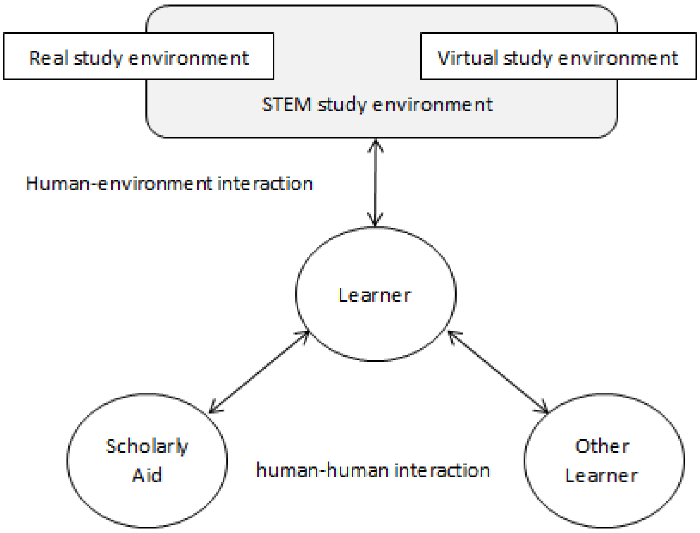

Figure 1 STEM Learning ecosystems

2 Methods

The construction of STEM-based higher vocational students' ability cultivation system includes four parts: literature combing, model construction, teaching practice and result analysis.

Through reading the domestic and foreign literature [7-12], it is found that there are researchers in preschool education, computer, transportation technology, mathematics, Internet of Things, mechanical design and other majors who conduct research on the ability cultivation system of higher vocational students based on the STEM concept of related majors. On the basis of analyzing and organizing the literature and understanding the current situation of higher vocational teaching in China, we constructed a higher vocational teaching model based on the concept of STEM education, then designed specific teaching cases under the guidance of the teaching model, and finally carried out teaching practice in internship enterprises and analyzed and summarized the results of the practice.

Before the teaching practice, a questionnaire was used to find out the interest level of students in higher vocational colleges and universities in computer courses and their attitudes towards the current teaching of computer majors. After the teaching practice, the scoring of the enterprise project was used to find out the students' acceptability of computer science teaching with the concept of STEM education and the impact of the teaching mode on their learning, so as to test the effectiveness of the teaching mode constructed in this study.

The goal of training students in vocational colleges is to meet the needs of enterprises, so the selection of the curriculum and practical training system needs to consider the technology used in actual projects. For example, Java programming in the basic curriculum corresponds to Java project development in the practical training program, and HTML&CSS and Wechat mini-programming in the core curriculum corresponds to Wechat mini-programming in the advanced practical training.

The process of collecting feedback from the internship companies was divided into two parts: the internship company supervisors scored the results of the STEM and non-STEM projects conducted in groups, and the internship company supervisors scored the students' awareness of learning, ability to learn, self-discipline, ability to search for answers, and teamwork during the internship. These two scores were weighted to obtain a composite score.

3 Results

In accordance with the STEM-based vocational ability cultivation system for higher vocational students, we have developed a curriculum system for the software development direction of computer application majors in a higher vocational college and a practice system corresponding to it. The curriculum system includes basic courses, core courses, comprehensive courses and practice platform related courses. The practice system includes basic practice, advanced practice, comprehensive practice and platform practice. Among them, the basic courses of the curriculum system correspond to the basic practice of the practice system, the core courses of the curriculum system correspond to the advanced practice of the practice system, the comprehensive courses of the curriculum system correspond to the comprehensive practice of the practice system, and the practice platform-related courses of the curriculum system correspond to the platform practice of the practice system, as shown in Figure 2.

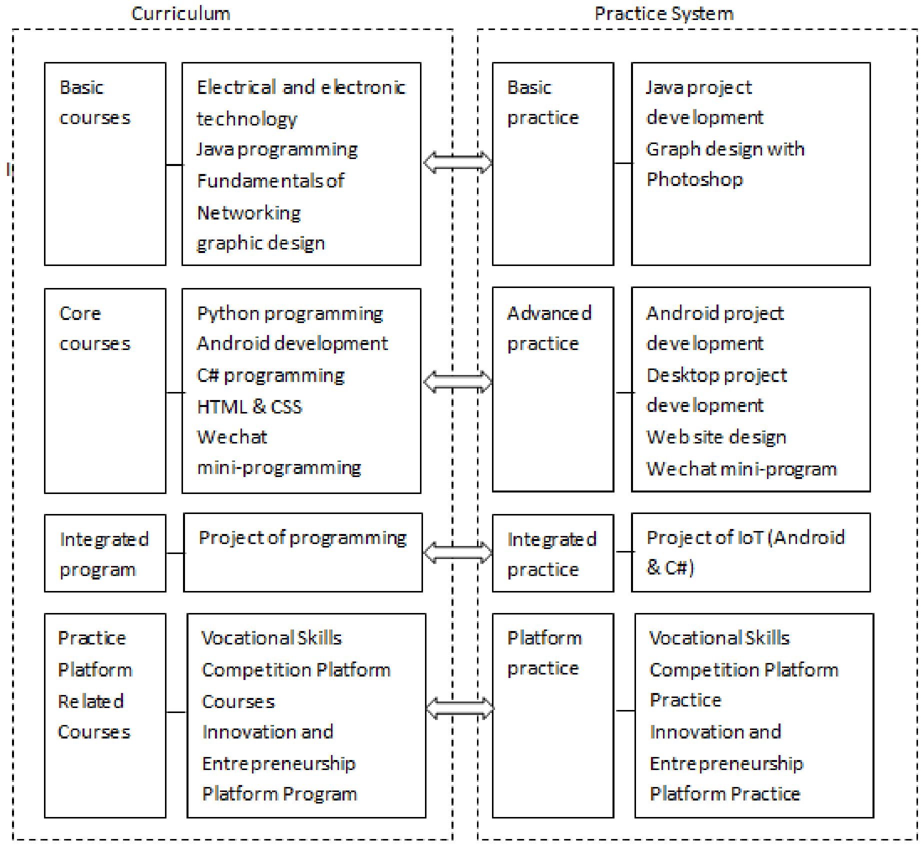

Figure 2 Software Development Major Practice System vs. Curriculum System

The curriculum system consists of a number of projects to practice teaching cases, and Table 1 shows the teaching case of the scientific calculator WeChat app. The project includes several parts of teaching objectives, STEM analysis, resource preparation and 5E teaching. Among them, the teaching objectives are divided into three points: knowledge, skills, and quality.STEM analysis includes four parts: science, technology, engineering, and mathematics. 5E teaching includes introduction, inquiry, explanation, refinement, and evaluation.

In order to analyze the impact of the implementation of the STEM project on students' interest and academic performance, we designed the STEM-containing project in addition to a control non-STEM project. For these two projects, two different student groups were assigned to complete them. After the two student groups completed the assigned projects, the two student groups were tested on the knowledge used in the development of WeChat applets. The results of the t-test on the test scores of the two groups are shown in Table 2, and the average score of the STEM program group is significantly higher than that of the control group, which can indicate that the implementation of the STEM program has a facilitating effect on the students' academic performance, and improves the students' mastery of knowledge.

Both STEM-based practical training projects and non-STEM practical training projects are conducted in internship enterprises, with experienced enterprise engineers serving as practical training teachers to guide students in project development. In addition to the overall grading of the project by the corporate practical training teachers at the end of the project, the students are also graded on their learning awareness, learning ability, learning methodology, mastery of tools, acquisition of knowledge, and problem solving approach when encountering difficulties during the course of the project. These overall ratings and process ratings are fed back to the school teachers, who research and classify these problems, summarize the solutions to these problems and implement them in the next project.

Table 1. Scientific Calculator Wechat mini-program practice teaching case

Project name		Scientific calculator Wechat mini-program
Project introduction		Design and develop a Wechat mini-program
Teaching goal	Knowledge	Understand the framework of Wechat mini-program
	Skill	Mastering Wechat mini-program development skills
	basic essence	Develop project analysis, design, and practice skills
STEM analysis	*Science*	Exponent, square root
	Technology	Sin, Cos, Tan
	Engineering	Logarithm, exponential
	Mathematics	Arithmetic operation
Resource preparation		Wechat mini-programming IDE
5E teaching model	*Engage*	Teachers demonstrate the scientific calculator of the desktop computer
	Explore	Teachers guide students to think about the programmatic implementation of various scientific calculations.
	Explain	Teachers explain the programmatic implementation of various scientific calculations.
	Elaborate	Students further refine the programmatic implementation of scientific calculating, including features and interfaces
	Evaluate	Teachers assess students' inquiry, collaboration, and practice skills based on student performance. Students conduct self-assessment and mutual assessment. The final result is a comprehensive assessment.

Table 2. T-test between groups of STEM project and none-STEM project

	Group	Students	Average	Standard deviation
Score	STEM	22	84.15	8.06
	None-STEM	21	78.36	8.14

4 Discussion

Since students in higher vocational colleges and universities are mostly engaged in technology and engineering related work after graduation, there are more technology and engineering related courses and practices in the curriculum system and practice system accordingly. Due to the relationship between students' foundation and academic system, science and mathematics are relatively lacking in the curriculum and practice system, which are the foundation of technology and engineering and should be strengthened, but it is necessary to further explore how many hours of science and mathematics courses are appropriate for different majors.

In designing the experiment on the effect of STEM program on students' learning interest and academic performance, we divided into STEM program group and non-STEM program group, and only through the implementation of two different programs and then tested, we got the average performance of the STEM program group is significantly higher than that of the control group. In further research, a test should also be conducted before the implementation of the program, which would be more convincing.

5 Conclusion

STEM education in higher vocational has an important role in the development of students' vocational skills, but there are certain difficulties in the implementation process, firstly, due to the fact that the foundation of higher vocational students' own knowledge of mathematics and other knowledge is relatively poor, and secondly, due to the internships in enterprises, higher vocational students have only two years in school, and the schedule of the course is relatively tight. In response to these circumstances, we designed a project with STEM content in the course project teaching, and in order to test the learning effect, we also designed a control non-STEM project, and divided the students into two groups to implement different projects. After the implementation of the project, the two groups of students were tested, and it was found that the average performance of the STEM project group was significantly higher than that of the control group, indicating that this design of STEM content in the teaching project is effective.

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