Teaching Application of Middle Level "C language programming" Based on STEAM Education Concepts—— Taking "5E" Model as an Example

Deguo Yang[1], Haoran Ma[2*]

{gansuskl@163. com[1],*Corresponding author :mahaoran823@163. com[2]}

School of Computer Science and Engineering, Northwest Normal University, Lanzhou, China

Abstract. In the field of modern education, how to cultivate comprehensive talents with innovative ability is an important part of leading the continuous development and improvement of education levels. This paper discusses the applicability of STEAM education concepts applied to the secondary computer classroom based on constructivist theory, project-based teaching theory, and multiple intelligences theory. The "5E" teaching mode, which has been mature and widely used in China, is selected to design the relevant teaching mode in combination with the teaching content of “C language programming”.

Keywords: STEAM;"5E"; Secondary classroom.

1 Introduction

With the deepening development and reform of vocational education in China, the government has successively issued a series of policies and regulations. For instance, in 2019, the State Council released a document on national vocational education reform, aiming to innovate the development model of vocational education reform and providing significant policy research suggestions [1]. Subsequently, on April 21, 2022, the Chinese government promulgated the "Vocational Education Law of the People's Republic of China," which explicitly states that all levels of government should incorporate the development of vocational education into the national economic and social development plan [2]. In the same year, the revised "Vocational Education Law" stipulated the implementation of vocational education under government coordination, hierarchical management, local emphasis, industry guidance, school-enterprise cooperation, and social participation. Governments at all levels are required to integrate the development of vocational education into national economic and social development, participate in policy formulation, and conduct significant reform research [3], aiming to actively promote the improvement of vocational education.

Amidst this backdrop, the imperative for vocational education teaching reform has arisen, necessitating the optimization of teaching structures, methods, and modes to enhance the quality of vocational education. However, in the intermediate "C language programming" classroom, traditional teaching methods exhibit some shortcomings. For instance, there may be inadequacies in fostering innovation capabilities; traditional methods might not effectively stimulate students' innovative thinking, leading to a lack of independent thought and creative

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problem-solving skills when facing new challenges [4]. Additionally, there may be insufficient training in problem-solving; students might overly rely on teacher demonstrations, lacking the experience of independently solving problems, thereby limiting their problem-solving skills in actual programming scenarios [5].

To address this challenge, the STEAM (Science, Technology, Engineering, Arts, and Mathematics) concept has emerged, aligning seamlessly with the "5E" teaching model. STEAM education emphasizes interdisciplinary and comprehensive learning, complementing the "5E" teaching model. By integrating the STEAM education concept into the "5E" teaching process, we aim to explore its positive impact on students' creativity, problem-solving skills, collaborative inquiry abilities, and core literacy.

Specifically, the research contributions of this paper are as follows:

(a) We incorporate STEAM education in the Secondary vocational school computer classroom, focusing on fostering innovation and interdisciplinary learning. Through constructivist, project-based, and multiple intelligences theories, we create a comprehensive learning environment.

(b) Opting for the well-established "5E" teaching model in Chinese education, students engage in exploration, practice, and collaboration, fostering holistic development. Integrated with STEAM, our goal is to enhance subject literacy and spark student interest.

(c) In the context of the "C language programming" course, we emphasize integrating the "5E" model, offering a practical pathway for applying STEAM. This approach aims to deepen subject learning, increase attractiveness, and cultivate essential programming skills.

(d) We particularly focus on integrating the "5E" teaching model with the content of the "C language programming" course, offering students a practical path to apply the STEAM education concept in a specific subject area. Through this approach, we aim to increase the attractiveness and depth of subject learning, cultivating core skills for students in the field of computer programming.

Through this research, we aspire not only to provide a new teaching paradigm for secondary education but also to propel the comprehensive development and innovative capabilities of students in the field of computer programming. Additionally, we aim to offer new perspectives and methods for future educational research. In this context, we will delve into the practical application of the STEAM education concept under the "5E" teaching model, contributing positively to the continuous development and innovation in the field of education.

2 Definition of the concept

2.1 STEAM Education Philosophy

STEAM is an acronym for Science, Technology, Engineering, Art, and Mathematics, which encourages students to enhance their abilities in the five areas of science, technology, engineering, art, and mathematics and to develop them into a well-rounded person in need of society. In the STEAM education philosophy, science helps us to understand the laws of the world; technology and engineering can transform the world according to people's requirements;

art enriches the world from the point of view of beauty; and mathematics provides a powerful tool for problem-solving.

2.2 The Meaning of STEAM Education Concept

STEAM, an educational philosophy that breaks down barriers between disciplines, integrates the five disciplines of Science, Technology, Engineering, Arts, and Mathematics into a whole. The STEAM education philosophy emphasizes practice. Nowadays, a single skill can no longer support the individual as well as the country in continuing to move forward, which puts a higher demand on the cultivation of a comprehensive new type of human resources,The STEAM education philosophy fits this bill.

We can summarize the implications of the STEAM education philosophy in three areas:

(a) The STEAM education concept is oriented towards problem-solving or project-based learning, placing students in authentic problem situations, solving problems individually or in groups, and constructing cognitive.

(b) The STEAM education concept emphasizes interdisciplinary integration. Interdisciplinary is the core feature of the STEAM education concept, which is not a simple addition of five types of disciplines but an organic integration of them.

(c) The STEAM education philosophy aims to equip students with the necessary skills for everyday life and to improve their ability to handle and solve problems when faced with them, rather than simply learning from books.

2.3 The "5E" model of teaching and learning

The "5E" is a problem-based instructional model for science education that was first proposed by the American Association for Biology Curriculum Studies in the 1980s. The "5E" model is organized into five phases of instruction,whose structure is shown in Fig. 1. Engagement phase, in which the teacher creates a problem that is interesting and relevant to reality or society, and the student understands and thinks about the problem. Exploration phase, in which students reflect and organize information provided by the teacher or from their own searches, as well as record ideas for problem-solving. Explanation phase, in which students share ideas with each other, teachers actively give students a platform to demonstrate and give disciplined knowledge transfer to help students understand knowledge from multiple perspectives[1]. In the elaboration stage, in order to deepen students' understanding of the new knowledge and to be able to apply what they have learned, the teacher asks students to solve a "new problem" and communicate with standardized terminology. Evaluation phase, in which teachers take care to use a variety of assessment methods and to evaluate teaching and learning throughout the teaching and learning activities.

The "5E" teaching model is student-centered, based on problem- or project-based teaching, in which students independently learn the knowledge involved in the problem and solve the problem on their own. The model enhances student engagement in the classroom and promotes communication, evaluation, and collaboration.

Through a study, we found that the "5E" model is more mature in China, which is suitable for China's localized characteristics, and this paper will also lay the foundation for the subsequent secondary school instructional design based on the "5E" model.

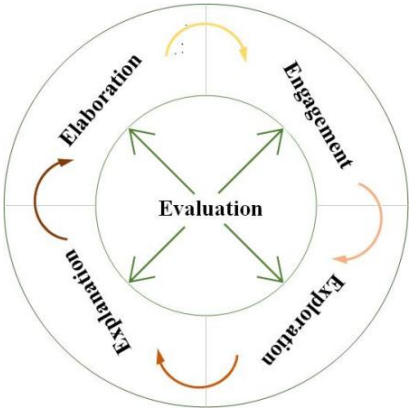

Fig. 1. Diagram of the "5E" teaching model

3 Theoretical foundation

3.1 constructivist theory

The formulation of constructivist theory can be traced back to Jean Piaget at the earliest. In addition, the research results and theoretical perspectives of Robert J. Sternberg, Lev Vygotsky, DavidPawl Ausubel and others laid the foundation for the development of modern constructivist theory.

The constructivist theory perspective suggests that:Learning is a proactive, self-constructive process that involves the active and selective construction of meaning when things are based on prior cognitive structures. The construction of knowledge is influenced by social and cultural factors and is constantly revised and adapted in consultation with others. Knowledge construction varies across learners[7]. "Scenarios" and "collaboration" play a crucial role in the overall instructional design and process, and the focus on communication and collaboration among students is of great value in the construction of new knowledge.

This theory inspires us to pay attention to the subjectivity of students and play the role of teachers as "guides" and "organizers" in teaching design. starting from students' prior experience and respecting their physical and mental development.

3.2 Project-based teaching theory

Project-based teaching is a project-oriented, task-driven teaching model that reintegrates the teaching content of the traditional teaching system in the form of a project, dividing the learning content into several relatively independent teaching projects with tasks. The method realizes the organic combination of theory and practice, takes cultivating students' professional skills as the primary task of teaching, and meets the requirements for the cultivation of secondary vocational talents. This theory focuses on student-centeredness and the realization

of learning before teaching to cultivate students' self-learning ability and innovative consciousness.

The project originates from a real-world problem or social situation. Instructional design needs to consider the intrinsic connection of multiple knowledge sources, systematize the connected knowledge, and then integrate it into an instructional project, which is similar to the connotation of the STEAM teaching concept. Allow each student to enter the designed project or problem, stimulate students' interest in learning, proactively engage in project and problem-solving, improve students' knowledge network, and deepen students' understanding and mastery of knowledge.

3.3 multiple intelligences theory

American psychologist and educator Harvard Graduate first proposed the concept of multiple intelligences. Gardner builds on recent research at the Harvard Graduate School of Education on neuroscience, brain science, cognitive science, the process of knowledge development across cultures, and human potential. Gardner believed that individual humans possessed at least eight intelligences, and that they all existed in different forms. These intelligences include mathematical and logical intelligence, spatial intelligence, musical intelligence, physical coordination intelligence, interpersonal intelligence, reflective intelligence, expressive language intelligence, and nature perception intelligence. Although they each represent different ways of thinking, they are interdependent and complementary. Gardner once pointed out in his works that the view of simply measuring educational effectiveness based on exam results, or even a lifetime based on a single exam, is a bias. This approach actually overemphasizes the intelligence of mathematics and language, while neglecting the development of the other six types of intelligence. The development of a single intelligence in the information age cannot satisfy the strategy of talent training, and it is necessary for all eight intelligences to work together, which means that the equal development of these eight intelligences should be emphasized.

Based on the concept of STEAM education, the teacher focuses on cultivating students' knowledge and skills while developing their ability to communicate, collaborate, and exchange ideas, as well as their comprehensive skills such as critical thinking.

4 Feasibility Analysis of the "5E" Model Applied to the Intermediate "C language programming" Course

4.1 Characteristics of the "5E" teaching model

The "5E" teaching model is student-centered, with teachers playing a guiding and supporting role. The model emphasizes students' independent inquiry, hands-on operation, and cooperative communication and brings into play their sense of solidarity and collaboration. Through transfer, students improve their ability to utilize their knowledge to solve problems and increase their cognitive level.

4.2 Characteristics of secondary school students

Vocational education and training for students in secondary vocational schools. Compared with general high school students, they have less initiative and self-control in learning and need teachers to spend more time and patience helping them master knowledge. Secondary education is oriented toward employment, so secondary students have strong practical abilities and can better apply the knowledge they have learned to the real life. Simple knowledge teaching can not meet the requirements of secondary education, through practical exercises to deepen students' mastery and understanding of knowledge, higher-quality training is needed to meet the needs of enterprises for talent training. Secondary students have the awareness and ability to work as a team to accomplish tasks in a cooperative manner.

4.3 Feasibility analysis

In most "C language programming" classrooms, teachers continue to use traditional teaching methods to impart knowledge by lecture. However, the knowledge of the course is fragmented and complicated, and in the long run, it is very easy to lose students' interest in learning. Teachers fail to achieve understanding and mastery through verbalization, making it difficult to help students apply what they have learned. Based on the above analysis, the application of the "5E" teaching model to middle-level "C language programming" has the following advantages:

(a) Meet the learning characteristics of secondary students

The "5E" teaching model emphasizes practice and independent exploration, which are in line with the learning characteristics of secondary students. The engagement phase of the "5E" model of teaching and learning uses a scenario to link theory and practice, to stimulate students' curiosity, and to help them learn and apply their knowledge. The exploration and explanation stage of the "5E" teaching model encourages independent inquiry and solidarity, and students solve problems through cooperation, communication, and autonomy. The elaboration phase of the "5E" instructional model focuses on the integration of students' knowledge and skills, helping them acquire skills and utilize their knowledge to solve problems[8].

(b) Cultivating students' awareness and ability to learn independently

The "5E" teaching model emphasizes the subjectivity of students, hoping that students will acquire knowledge through independent inquiry and cooperative communication rather than teacher indoctrination. In this process, students' awareness and ability to learn independently are emphasized. Students are prone to a sense of accomplishment in the learning process, which greatly enhances their initiative and motivation to learn the course.

(c) Deepen students' mastery of knowledge and improve learning efficiency

The "5E" model of teaching and learning helps to improve the learning style of students who learn mechanically. Students are actively inquiring and actively engaged in their learning, which leads to a feeling of satisfaction in learning, and students are able to reach a higher level of cognitive ability. Through elaboration, it can help students utilize their knowledge to solve problems and master programming skills. Improve students' course learning effectiveness and efficiency.

5 Classroom Instructional Design Based on STEAM Education Concepts

5.1 Analysis of teaching materials based on STEAM education concepts

The textbooks were analyzed for content suitable for the use of the STEAM education model, and the course content was broadly categorized into conceptual foundations and practical exercises. We should pay attention to the process of analyzing the teaching materials based on the requirements of the curriculum standards and grasp the position of the teaching content in the teaching materials to understand the whole curriculum content links and grasp the teaching of the important and difficult points[9]. The concept of STEAM education emphasizes interdisciplinary integration, so when conducting textbook analysis, we should not only focus on the content of the related courses but also consider the connection points between technology, science, and mathematics in STEAM education and this course to conduct a comprehensive textbook analysis.

5.2 Analysis of learners based on STEAM education concepts

Based on the knowledge related to psychology, analyze the psychological characteristics of students in the relevant age group and understand their learning styles and knowledge base. Identify the impact and influence of pedagogical knowledge on student development and identify relevant STEAM education subject knowledge.

5.3 Determine instructional objectives based on STEAM education concepts

The educational objectives of the thematic content of each module are first determined according to the curriculum standards. Second, the teaching objectives were determined based on the three-dimensional teaching objectives and core literacy. Finally, the science, technology, engineering, and math objectives that need to be met for this instructional content are identified in conjunction with the STEAM education philosophy.

5.4 Instructional activity design based on STEAM education concepts

The STEAM education concept aims to use multidisciplinary knowledge and ideas to solve practical problems; therefore, the design of teaching activities based on the STEAM education concept should first consider the corresponding problem scenarios. Based on the "5E" teaching model, teachers stimulate students' interest and motivation through problems and scenarios related to reality or society. Students think about the problem and initially consider problem-solving ideas in the context of their existing knowledge base. Teachers guide students to learn core knowledge through collaborative inquiry, and teachers should focus on providing guidance and process evaluation for students. Students complete the design to enter the running test session, and the teacher gives scientific guidance. When a problem is encountered, group members should cooperate and make suggestions for improvement. Finally, students exchange learning outcomes and learning experiences, make self-assessments within the group and mutual assessments between groups, and the teacher makes a final evaluation summary.

5.5 Teaching Evaluation Based on STEAM education concepts

Evaluation of teaching and learning through a multifaceted approach and throughout the teaching and learning process. Observe students' reflections during the teaching process. After the completion of the teaching activities, evaluation is carried out on the learning outcomes, paying attention to self-assessment within the group and mutual assessment among the groups. Use process and outcome assessments for student development.

6 Analysis of teaching methods for the application of the "5E" teaching model

6.1 Engagement phase

The beginning of a class often determines whether the class is good or bad. Teachers should choose a variety of appropriate introductory links according to the characteristics of different courses to help students focus their attention at the beginning of the class and stimulate their attention to the maximum extent. Incorporating students' interest in learning will facilitate the teacher's subsequent instructional activities. Through this method, students are sensitized to the contextual nature of STEAM education concepts[10]. Common classroom introduction methods include the video introduction method, the game introduction method, and the question introduction method.

6.2 Exploration phase

Teachers at this stage can use the independent inquiry method and the group inquiry method. Teachers use the independent inquiry method when designing instruction in the face of simpler knowledge that students can acquire through their own inquiry. Instead, when faced with more complex problems, use the group inquiry method. Teachers should divide the group according to the characteristics of each student before class to ensure that each student can participate in classroom activities, play to their advantage, and promote the smooth progress of classroom teaching. Teachers should conduct inspections and provide guidance.

6.3 Explanation phase

In the explanation stage, the teacher needs to provide students with the opportunity to report and display and encourage students to speak boldly to exchange, the group members can not be fixed into one speaker. In the face of the complex process of program execution, teachers can explain with the help of diagrams or videos to visualize the abstract knowledge, help students understand the results of each program execution, and deepen the learning effect.

6.4 Elaboration phase

The session helps students deepen their understanding, mastery, and application of knowledge. Depending on the content of the lesson, the teacher can create a new problem scenario to solve a new problem with the knowledge learned. It can also be an extension of the teaching content, learning the same type of knowledge and expanding and thawing that knowledge. To further expand and deepen knowledge and develop students' understanding and transfer of

knowledge[11]. At the same time, the questions set at that stage should not be too simple or too complex, but should be relevant to the content[12].

6. 5 Evaluation phase

Evaluation methods should be diversified and be used throughout the teaching process, and a variety of evaluation criteria should be used to make the evaluation results more informative[7]. Diagnostic assessment is used to understand the existing knowledge base of students and inform the design of instructional activities. To stimulate students' daily classroom engagement and promote their holistic development through process-based assessment. Through the summative evaluation, we understand the students' mastery of the new knowledge. Teachers make records in real time based on classroom inspections, guiding students to make fair and objective evaluations of themselves and their group members[13].

7 Conclusion

The "5E" teaching model, "student-oriented, teacher-led", has changed the traditional one-way transmission of teaching from teacher to student[14]. Through the "5E" teaching model, students are given clear tasks and systematic learning in the classroom to promote knowledge comprehension and mastery. The "5E" teaching model is more mature and universal in China, based on the learning characteristics of middle school students' love of hands-on and cooperation and the miscellaneous and complicated course characteristics of "C language programming". The application of the "5E" teaching mode in the classroom of secondary "C Programming" is conducive to improving students' independent learning ability, innovation ability and interest in classroom learning. However, due to the author's lack of experience, there are deficiencies in the teaching application model, which I hope to improve in the future teaching and learning process.

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