Journal of Contemporary Educational Research, 2024, Volume 8, Issue 9
http://ojs.bbwpublisher.com/index.php/JCER
ISSN Online: 2208-8474
ISSN Print: 2208-8466

Design and Application of "STEM+" 6E Teaching Mode in Information Technology Teaching

Yu Zhang, Xiaohong Lan*, Yaqing Lu, Ying Deng

School of Computer and Information Science, Chongqing Normal University, Chongqing 401331, China

Corresponding author: Xiaohong Lan, 2446082755@qq.com

Abstract: The concept of "STEM+" integrates art, humanistic literacy, and social values in the traditional STEM education concept, advocates cross-disciplinary integration, and aims to cultivate compound talents equipped to tackle future challenges. In 2022, the Ministry of Education issued the "Compulsory Education Information Technology Curriculum (2022 Edition)," emphasizing the core literacy of information science and technology and the integration of interdisciplinary disciplines, and encouraging the teaching mode suitable for discipline characteristics. The 6E teaching mode is a student-centered teaching strategy characterized by active exploration and cross-disciplinary integration. This article innovatively designed the "STEM+" 6E teaching mode, which is applied to junior high school information technology teaching, which can better achieve core literacy teaching goals.

Keywords: STEM+; 6E teaching mode; Information technology; Application

Online publication: September 30, 2024

1. Introduction

"STEM+" is a new educational concept innovatively proposed by domestic scholars based on in-depth research on the STEM concept. It has had a significant positive impact on the education sector and has been accepted and applied by more and more educators in teaching practice. "STEM+" advocates the educational concept of integrating multiple disciplines such as science, technology, engineering, mathematics, art, and humanities, aiming to cultivate talents with comprehensive skills and innovative capabilities and promote the formation of students' digital literacy and sustainable development [1]. The "Compulsory Education Information Technology Curriculum (2022 Edition)" (hereinafter referred to as the "New Curriculum Standard") proposes strategies including optimizing the content organization form, setting up interdisciplinary theme learning activities, strengthening the interdisciplinary relationship, promoting the integrated implementation of the curriculum, strengthening practical requirements, following the students' learning rules, systematically designing learning activities, and promoting innovation in learning methods with students as the main body [2]. The 6E teaching is a student-centered teaching model that emphasizes the integration and application of interdisciplinary knowledge. It can effectively promote students' active learning and scientific inquiry and serve as a good teaching model for implementing the "STEM+" concept and implementing the new curriculum standards.

2. "STEM+" education concept

In 2014, the Shanghai Education Commission established the "STEM+" Research Center to promote "STEM+" education empirical research and become a pioneer in education reform. The "+" represents the improvement of scientific literacy and ability, integrating social, humanistic, artistic, and information technology and promoting the development of cognitive and non-cognitive skills. STEM is the initial of the four subject areas of science, technology, engineering, and mathematics. It symbolizes the close connection and mutual integration of these four disciplines, which collectively constitute a multi-dimensional education and research framework. "STEM+" is the future trend of the development of the STEM education concept, which strengthens the combination of social values, humanistic, and artistic elements, and information technology with STEM education, and promotes the integrated development of students' cognitive and non-cognitive skills [3,4]. **Figure 1** is a schematic diagram of "STEM+" education.

In the concept of "STEM+," the cultivation of humanistic care and social responsibility has been given the same importance. It is emphasized that while scientific exploration is important, it is also necessary to cultivate a deep understanding of human values and social ethics. From a perspective of diversification and integration, the "STEM+" concept expands the boundaries of traditional STEM education. It aims to foster students' holistic abilities, broadening their knowledge and deepening their understanding of the world. This approach encourages students to analyze and solve problems from multiple angles. The more precise the underlying principles of "STEM+" [5], the more effectively "STEM+" courses can be implemented to enhance students' learning experiences.

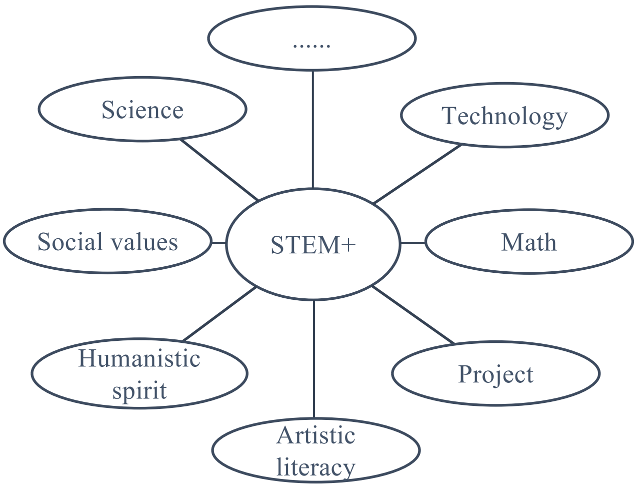

Figure 1. "STEM+" education schematic diagram

3. 6E teaching mode design based on the concept of "STEM+"

In 2006, Professor Barry in the United States proposed the "5E" teaching process [6]. In 2014, the International Technology and Engineering Education Association (ITEEA) proposed the student-centered "6E"—engage, explore, explain, engineer, enrich, evaluate—teaching and study process [7]. The 6E teaching mode puts students at the core of the teaching process, emphasizing the cultivation of students' inquiry consciousness, scientific logic, innovative thinking, and practical operation skills [8]. At the same time, this model also emphasizes the tutoring and leading role of teachers in teaching, which helps to evoke the spontaneous and innovative nature of students. The new model emphasizes teachers' counseling and guidance, stimulates students' innovation, and advocates for new curriculum standards that include scene analysis, principles cognition, and application migration teaching. It integrates digital life and social technology, promotes personalized training, and creates an environment for independent and collaborative inquiry-based learning.

In information technology courses, the traditional 6E model is widely used. This paper summarizes and reflects on previous teaching and designs a 6E teaching model based on the "STEM+" concept, aiming to cultivate students' subject knowledge, innovation, problem-solving, and practical skills. The construction diagram of the 6E teaching model based on the "STEM+" concept is shown in **Figure 2**.

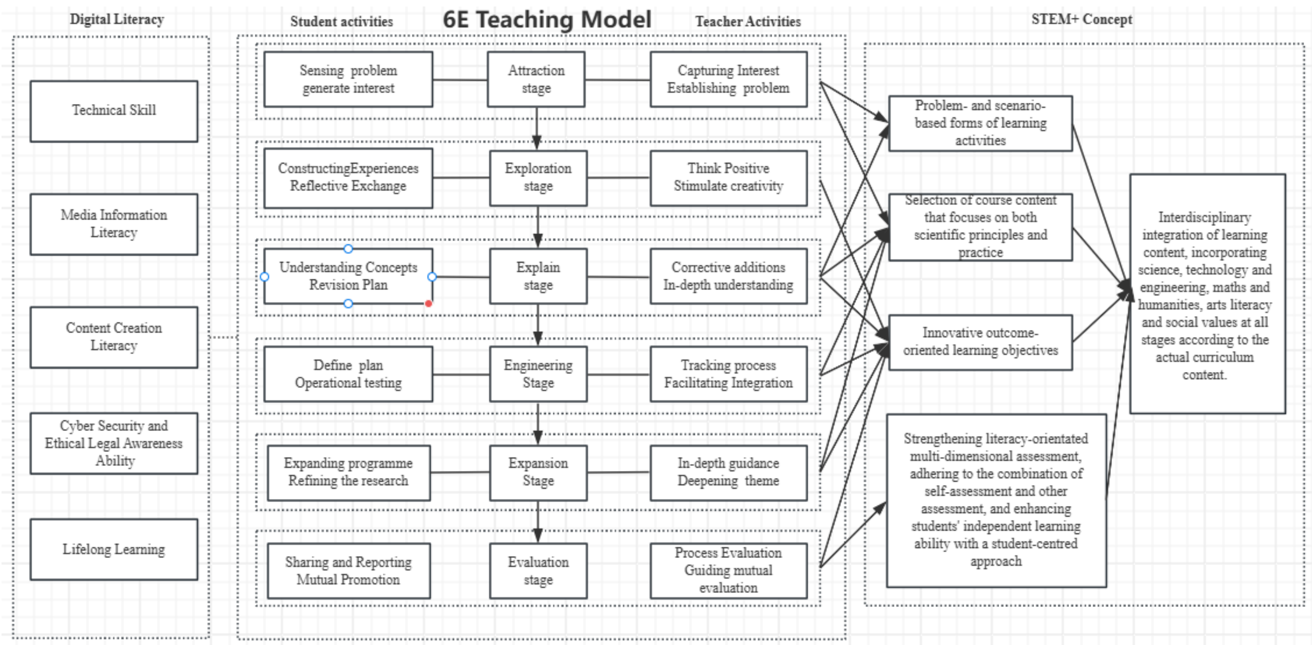

Figure 2. Construction of the 6E teaching mode based on the concept of "STEM+"

(1) Engage: Learning in the theory of constructivism is a process of actively building knowledge. Interest is an important driving force for learning. The teacher stimulates students' interest and curiosity by raising fascinating questions or challenges. It is important to create situations resembling real life, stimulate interest, understand the connection between learning and practice, and emphasize the importance of "STEM+."

(2) Explore: Inquiry learning theory emphasizes that students can build knowledge and understanding by asking questions, exploring, and experimenting. Students explore the concepts of science, technology, engineering, mathematics, and art and humanities through practical activities and experiments at this stage. Teachers incentivize questions and discussions, encourage independent research, and cultivate problem-solving skills.

(3) Explain: Cognitive development theory believes that students deepen their understanding and memory of concepts through explanation and discussion. Students need to explain their discovery and understanding and associate the knowledge obtained during the inquiry process with the existing "STEM+" knowledge system. Teachers guide students to discuss and report, express their ideas clearly, and organize and analyze data. They also help students understand the principles, integrate theory and practice, and build a knowledge system.

(4) Engineer: This involves the ability to emphasize practical operations and design thinking in engineering

education theory, as well as the ability to solve complex engineering problems. Students apply knowledge in implementation projects, with teachers providing resources, cultivating digital literacy, and guiding the "STEM+" fusion design.

(5) Enrich: Diversified intelligence theory advocates different intelligence and potential of students through diverse learning activities. Students are encouraged to participate in community services and competitions outside the classroom. Teachers support practical activities, cultivate social responsibility and teamwork, and promote a deep understanding of knowledge.

(6) Evaluate: Evaluation and feedback theory believes that effective evaluation and feedback are essential for the learning process and help students understand their progress and deficiencies. Students' self-assessment of their learning results, teachers' knowledge and skills, and their innovative collaboration abilities all contribute to feedback that promotes reflection and continuous learning. This approach encourages students' self-reflection and ongoing development.

By incorporating the 6E teaching mode that integrates the concept of "STEM+," students can learn and grow in an interdisciplinary environment, which not only masters the knowledge and skills of the "STEM+" field but also cultivates innovative thinking, critical thinking, and comprehensive solving problems, laying a solid foundation for their future academic and career.

4. "STEM+" 6E teaching mode practical application

The "3D printing" course in junior high school information technology is one of the main contents of the 6E teaching mode practical application. The 3D printing class aims to improve creativity, teamwork, and digital literacy. However, due to the traditional teaching mode, the new curriculum standard brings a new perspective to teachers' teaching [9]. Based on the "STEM+" concept, this article discusses a three-dimensional analysis of 3D printing teaching goals. The goals include mastering 3D printing theory and operating skills, understanding the characteristics of materials; cultivating problems, teamwork, and cross-disciplinary learning; stimulating creativity and self-confidence, enhancing information and digital literacy, and understanding the impact of science and technology. At the same time, the concepts of green design, environmental protection, sustainable development, and intellectual property respect and law compliance, shape responsible innovators.

This article selected seventh-grade students in the printed club class of Grade Section of A City in Sichuan Province. These students are developing abstract thinking and are capable of handling complex concepts. However, their cognitive abilities are still in the growth stage, and their interests can be influenced by the curriculum content, teaching methods, and their peers. They exhibit a strong curiosity for new disciplines, which promotes their learning. Interactive cooperative learning and exploring personalized strategies, such as in-depth thinking and summarization, are key. Students show a strong interest in 3D but have a weak and incomplete foundation in 3D modeling. Teachers need to focus on creating a supportive learning environment, designing interest-driven activities, and providing independent learning resources to help students enhance their skills and realize their innovative ideas. To this end, this article uses the 6E teaching framework under the guidance of the "STEM+" educational concept to conduct research on topics with the creative three-dimensional design as the core to inspire students to take the initiative to explore and learn.

4.1. Engage

4.1.1. Creating the "STEM+" scenario and reconstructing the teaching field

Through video displays of 3D printing technology and its cross-domain applications, students' working principles can be inspired. Case-based learning guides students in designing solutions for practical problems.

Through group discussions on the social and cultural impacts of technology, students explore the effects of 3D printing on life and work, delve into principles and innovative design thinking, and consider aspects like social fairness, sustainable development, and technological trends. This approach encourages students to progress from basic tasks to creative technical analysis, recognizes the importance of digital technology and digital literacy, and facilitates the centralized sorting and specification of problems. At this stage, the issues raised by students are often scattered and lack a focused approach, necessitating deeper sorting, integration, and specification of these issues.

4.1.2. Refining the problem to determine the "STEM+" learning project

Under teacher guidance, students actively engage in exploring concepts related to three-dimensional innovative works. They participate in in-depth discussions on the 3D printing process, including modeling, material selection, and design optimization. By addressing complex issues, students build a "STEM+" project, exploring both design and production while clarifying learning goals. The instructor integrates resources, teaches foundational software skills, and encourages independent learning. Students focus on teamwork to design 3D printing solutions that address practical problems and respond to real-world challenges.

4.2. Explore

The teacher provides effective assistance in designing the preliminary plan for the "STEM+" project. The teacher guided the group to explore three-dimensional works and incorporate design thinking and humanistic care. Students use three-dimensional creative design analysis tables, as shown in Table 1, focusing on project learning goals and predicting challenges. The teacher guides students in understanding the 3D printing process, and the group discusses the design direction, considering social impacts. Students learn 3D printing materials science, use modeling tools, and cultivate skills. In the group discussion and brainstorming, the teacher clarifies the task and achieves teaching goals.

Table 1. 3D creative design analysis

Works	3D creative work names
Shapes	1. Basic village and complex shapes 2. The complexity, symmetry, and proportion of the shape
Proportions	1. Whether the size of the design meets functional needs 2. The proportional relationship between each part
Material selection	Types, physical properties, and chemical characteristics of materials (weight, environmental protection, etc.)
Functional needs	Whether to meet the use function and actual needs
Technical feasibility	The implementation of the design is feasible at the current level
Aesthetics	Whether the design looks reasonable and attractive
Design significance	Whether it has positive humanistic significance

4.3. Explain

The group shares the "3D Creative Design Analysis Form," which clarifies the "STEM+" project goals and solutions. During the lecture, members contribute their ideas, evaluate each other's work, and offer suggestions. The horizontal contrast scheme is developed with teacher guidance and optimization. A "graphic analysis table" is created, and sketches are drawn. The teacher explains the basics of 3D modeling and demonstrates the 3D printing process. Students learn about creative transition models and the importance of each step. The discussion includes the 3D printing mechanism and file formats, emphasizing legal awareness of copyright. Students explain the 3D printing process, while the teacher encourages interaction to deepen their learning experience.

4.4. Engineer

The engineering stage allows students to practice theory and principles, and understand the importance of design drawings. Under the teacher's guidance, students use 3D ONE software to design their works, create sections, optimize designs, and produce three-dimensional entities. They save their designs and proceed with model cutting based on the material. By reading stereolithography models, adjusting parameters, and printing the output, students ultimately create a finished product model. They then complete the processes of peeling, grinding, and coloring, gaining a comprehensive understanding of the principles of three-dimensional printing.

Students make three-dimensional models according to the scheme during the engineering stage and record and share the production process. The outstanding group presents their creation process, while the teacher provides inspections and guidance to help overcome challenges. Through collective discussions and iterative improvements, the 3D printing tasks are completed collaboratively.

4.5. Enrich

Teachers guide students in evaluating reasonable design choices, material selection, humanistic literacy, and social significance. The group discusses optimized designs, utilizes online resources to build optimization models, and explores the characteristics of 3D printing materials. They examine the application of technology across multiple fields and its societal impact. Students gain a deeper understanding of the "STEM+" concepts of scientific exploration and engineering design, while teachers lead in-depth inquiry, address problems, and encourage design improvement and innovation. This stage emphasizes deepening understanding of "exploration" and "engineering," promotes the enhancement and application of knowledge and skills, and facilitates the expansion and refinement of design ideas.

4.6. Evaluate

Each group presents their work, and teachers outline the evaluation criteria. Students then participate in self-assessment and peer evaluation, with the goal of meeting the objectives of the "STEM+" project. The evaluation process is based on the learning goals and processes of the "STEM+" project and relevant evaluation criteria, focusing on formability. Teachers use a student-centered approach, incorporating participation and interactive evaluation activities. They also guide students in reflecting on their progress in digital literacy and identifying areas for improvement. The evaluation form is designed based on the "STEM+" concept, new curriculum course goals, and digital literacy training. It assesses students' innovation abilities, cooperative spirit, critical thinking, and interdisciplinary understanding, aiming to provide effective feedback and enhance teaching.

Students present their 3D printing projects and receive evaluations from both teachers and peers, with a focus on innovation and practicality. Teachers facilitate self-assessment by assigning "STEM+" evaluation scores to each group, guiding students to reflect on their learning experiences throughout the design and printing process. This approach enhances students' sense of satisfaction and pride in their work, sparking enthusiasm and intrinsic motivation for learning in the "STEM+" field. The process also encourages all students to observe, learn from each other, and find inspiration. Some creative works are shown in Figure 3.

Figure 3. Students' 3D creative works

5. Conclusion

Taking the "3D Printing" course as an example, the teaching case design is guided and encouraged by the concept of "STEM+." The 6E teaching mode of "STEM+" can enhance students' innovative thinking and problem-solving, and cultivate their high-level thinking and practical skills. This teaching mode not only focuses on technology and science education but also emphasizes humanities and social science training. It can promote students' good sense of humanistic care and social responsibility. Through its unique teaching process and interdisciplinary educational concepts, the approach has enriched students' learning experiences to a significant extent. This helps cultivate well-rounded talents who are better equipped to adapt to the needs of future society.

Funding

2024 Chongqing Normal University Graduate Research Innovation Project "Construction and Application of Information Technology Knowledge Map based on the Three-Layer Architecture" (CYS240395)

Disclosure statement

The authors declare no conflict of interest.

Author contributions

Conceptualization: Yu Zhang
Investigation: Yu Zhang
Formal analysis: Yu Zhang, Yaqing Lu, Ying Deng
Writing: All authors

References

[1] The Ministry of Education of the People's Republic of China, 2022, Compulsory Education Information Technology Curriculum Standards (2022 Edition), Beijing Normal University Press, Beijing.

[2] Zhang J, 2017, STEM+ Learning Scholar Design Study in Education. Modern Education Technology, 27(10): 100–105.
[3] Liu L, Li Y, 2020, STEM+ High School Traditional Cultural Education Implementation Strategy Exploration. Middle School Chinese (Middle School · Reading and Writing New Space), 2020(10): 55–57.
[4] Li Q, 2020, STEM+ Concept's Implementation of Courses to Promote the Interest of Student Sports Learning. Interactive Software, 2020(8): 2126–2127.
[5] Sun Y, 2022, STEM+ Education Theme Selection and Real Situation Settings. Teaching and Management (Theoretical Version), 2022(7): 95–97.
[6] TJ Moore, KA Smith, 2014, Advancing the State of the Art of STEM Integration. Journal of STEM Education, 15(1): 5–10.
[7] Burke BN, 2014, The ITEEA 6E Learning ByDesign™ Model: Maximizing Informed Design and Inquiry in the Integrative STEM Classroom. Technology and Engineering Teacher, 73(6): 14–19.
[8] Wang B, 2020, STEM Education 6E Learning Model Teaching Mode Initial Examination. Biology Teaching, 45(1): 71–73.
[9] Wu S, 2023, Interest Perspective of Interdisciplinary, Research a Total of 3D ONE Classroom Development Road. New Curriculum Guide, (30): 19–22.

Publisher's note

Bio-Byword Scientific Publishing remains neutral with regard to jurisdictional claims in published maps and institutional affiliations.