

The Application of STEM Education Concepts in High School Mathematics Teaching

Jiao Xiong

School of Mathematics and Information, West China Normal University, Nanchong, Sichuan 637009, China

Abstract: Quality education awakens the innovative spirit of teachers. In accordance with the requirements of the ordinary high school mathematics curriculum standard (2017 edition), teachers begun actively exploring the concept of STEM education and integrating it into mathematics teaching. They strive to innovate the teaching mode of mathematics using STEM teaching ideas and provide interdisciplinary training for high-quality comprehensive talents. However, STEM education and mathematics education have their differences. Therefore, this paper based on the concept of STEM education idea and its application in mathematics education, explores the relationship between STEM education idea and high school mathematics teaching, specifically through the high school mathematics “chord theorem” content further study. The paper discusses the STEM education idea in high school mathematics teaching application, design of teaching activities centered around the “sine theorem” .

Keywords: STEM Education; High school mathematics teaching; Sinusoidal theorem

1. STEM education and STEM in Mathematics education

1.1 The STEM education

STEM education has gained popularity as a new learning method in recent years. It involves the integration of science, technology, engineering and mathematics across the disciplinary boundaries. It is a comprehensive form of education that emphasizes the integration of disciplines, hands-on inquiry and multiple evaluation. It does not simply mean rigidly combining different disciplines, but rather applying interdisciplinary knowledge in real-life situations to help students integrate fragmented knowledge into a connected system.

1.2 STEM in Mathematics education

STEM in mathematics education refers to mathematics teachers using mathematics as a fundamental tool to extend mathematics knowledge to other three disciplines, as illustrated in Figure 1. In classroom teaching, it is and important to return to mathematics^[5]In the classroom teaching, we should create an active classroom atmosphere and a real problem situation, and the questions raised to the students should be challenging. At the same time, it also requires teachers to change their solidified teaching methods, and integrate and update the fragmented teaching design under exam-oriented education into comprehensive, research and practical project-based

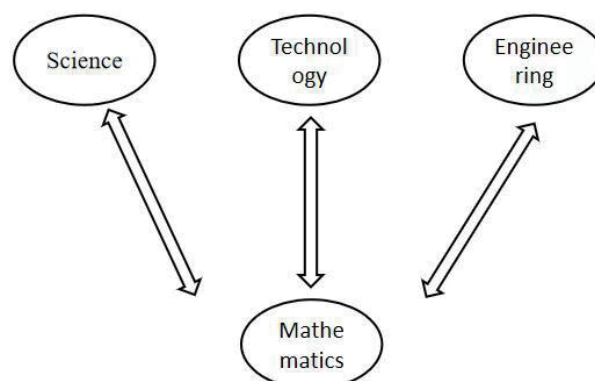


Figure 1: STEM in mathematics education

learning under the concept of STEM education^[1]. STEM in mathematics education completely students from the confines of the classroom, enabling them to acquire knowledge in a more free environment, and apply problem-solving skills, so that they can truly feel the relationship between study and real life. Students often complain about the lack of math learning, and the introduction of STEM education in math teaching can address this issue effectively.

2. The relationship between STEM education concept and high school mathematics teaching

In recent years, Chinese education researchers have attached great importance to the concept of STEM education, and many front-line high school mathematics teachers have made bold attempts in the actual teaching process. Therefore, in order to make STEM education concept play the biggest role in high school mathematics teaching, so that it can truly cultivate students' critical thinking, logical thinking and creative thinking abilities, it is crucial to explore the relationship between the STEM education concept and high school mathematics teaching.

2.1 Teaching content level

The essence of STEM education concept lies in interdisciplinary teaching, and its application in high school mathematics classrooms can provide new ideas and methods for students' mathematics learning. In the STEM education idea, the core thinking advocated by the STEM education idea is "interdisciplinary". And the mathematics teaching content can also be associated with other subjects in various aspects, such as learning the vector knowledge can be linked with the vector in physics, and learning the index function can be linked to cell division in biology and so on. Therefore, the concept of STEM education concept shares similarities with high school mathematics teaching content. It allows mathematics teachers to approach their teaching design from a new perspective, and consider the interconnections among science, technology, engineering and mathematics.

2.2 Teaching method level

STEM teaching emphasizes a shift in the teaching mode that teachers' teaching and students accept, so that students take the initiative to participate, think independently, hands-on practice and be willing to explore. It advocates for the creation of real-life situations to cultivate true knowledge acquisition, develop scientific, technological, engineering and mathematical thinking, and enhance inquiry and innovation abilities. Therefore, STEM and educational concepts have enriched the teaching methods used in high school mathematics, making it easier to stimulate students' enthusiasm for learning through interdisciplinary integration and real-life applications.

2.3 Teaching evaluation level

STEM education concept emphasizes multiple evaluation, moving away from solely relying on traditional paper-and-pencil tests. Instead, it encourages the use of observation, recording and other assessment approaches to evaluate students' innovation ability, observational skills, practical abilities, and other dimensions, incorporating more process-oriented evaluation. The Mathematics Curriculum Standards for Ordinary High School (2017 edition) also emphasizes the importance of process evaluation and quality improvement. The teaching approach of STEM enhances the evaluation process in high school mathematics. By deepening the understanding of science, technology, engineering, mathematics and other aspects of mathematics teachers, so that they understand mathematics, understand mathematics, explore more shining points, enhance their self-confidence, and promote all-round development.

3. The application measures of STEM education idea in high school mathematics teaching

3.1 Create the STEM teaching environment and teaching situation

To begin with, the should enhance the development of both hardware and software resources. This includes improving specialized subject classrooms and providing learning materials, updating multimedia equipment or offering school-based courses based on local characteristics, for students to better understand mathematics and a conducive learning atmosphere, such as posting PI stories on the class wall, so that students can feel the discipline spirit and culture in the hidden curriculum. Three is teachers should through the STEM teaching situation, with the power of information technology, show students more interdisciplinary content, make its closely associated with high school mathematics knowledge, let the student under the guidance of multimedia resources, more scientific autonomous learning, get comprehensive technical support, to promote that the students' independent inquiry and critical thinking ability^[4].

3.2 Strengthen the school-enterprise cooperation in STEM education

Due to limited school resources, it is beneficial for schools to establish partnerships with external organizations. Firstly, introducing excellent STEM concepts and well-designed courses into the school curriculum, such as inviting professionals from related institution to teach STEM courses; the second is to allow students to go out of the campus to learn mathematics in real scenes and learn it in real situations. Combining the “bringing in” and “going global” will promote the effective implementation of the policy of institutional transformation and double reduction.

3.3 Improve the teaching design ability of mathematics teachers based on STEM education

STEM education involves the knowledge from various many subjects, necessitating teachers to possess a diverse knowledge base. Therefore, in high school mathematics teaching, teachers should not only have a profound understanding of mathematics, but also be familiar with other subjects’ knowledge. By integrating mathematical knowledge with other subjects, teachers can deliver more comprehensive and interdisciplinary lessons. In the process of implementing classroom teaching, teachers should actively incorporate STEM teaching methods, so that they can accurately grasp the classroom teaching methods, and make them constantly innovate. Secondly, STEM teaching pays more attention to the teaching level and ability of teachers. Teachers must constantly enhance improve their teaching quality under the guidance of STEM education to effectively cultivate STEM talents.

3.4 Design the mathematics teaching evaluation based on the STEM education concept

STEM education concept places great importance to the cultivation of students’ practical abilities and process evaluation. Therefore, in the teaching process, teachers should design a reasonable process and summative evaluation scheme based on the STEM education concept^[6] Utilizing diverse and multi-directional assessment methods enables teachers to analyze and evaluate students’ performance in a comprehensive manner.. This evaluation process should not solely focus on individual subject performance, but also consider students’ overall classroom participation to foster the development of students’ comprehensive quality.

4. Teaching activity design of sine string theorem based on STEM education concept

After understanding the relationship between STEM education concept and high school mathematics teaching, teachers can effectively apply STEM education concept in the mathematics classroom. Taking the sine theorem as an example, based on the STEM education concept, and on this basis, combined with Meryl’s “five star” teaching principle, it is designed. As illustrated in Figure 2, the whole teaching process is problem-centered, activating the old knowledge, displaying the new knowledge, applying new knowledge, and achieving thorough integration.

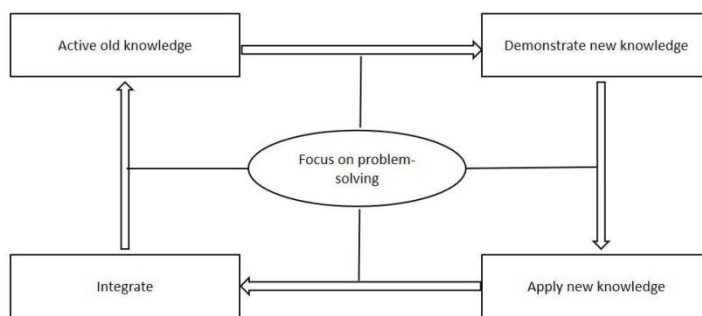


Figure 2 Five-star teaching principle

4.1 Create the engineering problem situation based on the STEM education idea

The core teaching idea of STEM is to extract mathematical problems from real-life contexts. Education should be grounded in practical applications, emphasizing the principles of “learning by doing” and “doing by learning”. With this concept in mind, the teacher designed an activity where students watch a short video about a mountain fire in Chongqing. And ask the students to try to

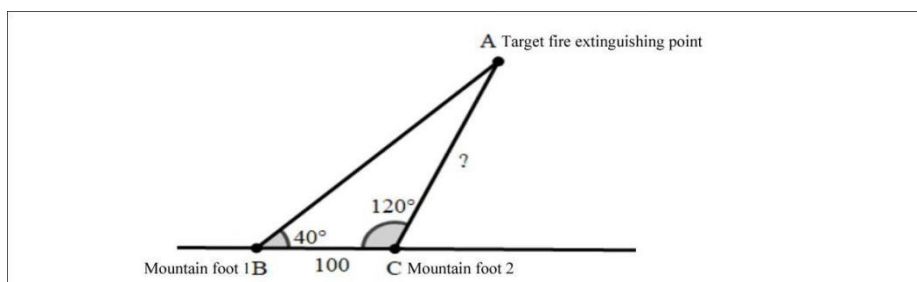


Figure Figure 33. Fire situation diagram

use the knowledge to calculate the distance from the mountain to the foot to the target fire fighting point, so as to help the fire fighters quickly deliver the material. The teacher guides students in abstracting this situation into a mathematical problem, as depicted in Figure 3, known $BC=100\text{m}$, $\angle ABC=40^\circ$, $\angle ACB = 120^\circ$, to find the length of AC , so as to introduce the topic.

The embodiment of E (Engineering) in teaching: By watching the recent fire-related video and extracting mathematical problems to arouse students' empathy, stimulate students' interest in learning and a sense of social ownership, and reflect the engineering of STEM education concept^[7]Through situational teaching, students cultivate their humanistic thinking and mathematical modeling skills while enhancing their problem-solving abilities.

4.2 New knowledge of scientific inquiry based on STEM education concept

STEM, the educational concept focuses on students' learning and exploration, encouraging active participation, independent thinking and cooperative communication. The teacher initiates the lesson by asking students to start from the familiar right triangle, observe the relationship between edges and angles, and get an expression of a sinusoidal theorem, and then ask the students, is this question valid in any triangle? Then use the form of group cooperation and communication, let the students use different methods to prove that in the acute triangle. Several students were invited to demonstrate the process, while the teacher supplements and explains the proof using multimedia aids, as shown in Figure 4 and Figure 5. From left to right, the high line method, vector method and external circle method are followed, respectively.

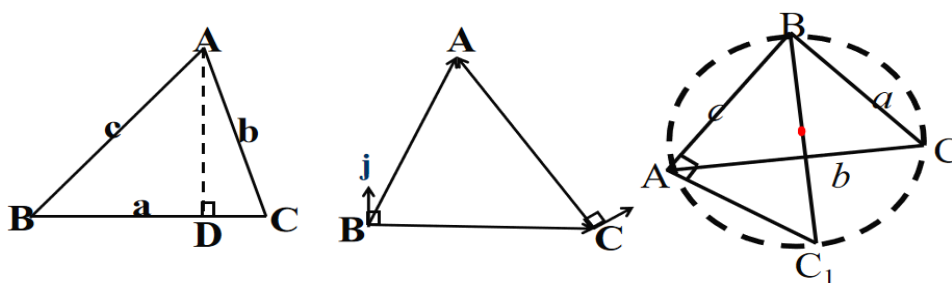


Figure 4. Sharp triangles

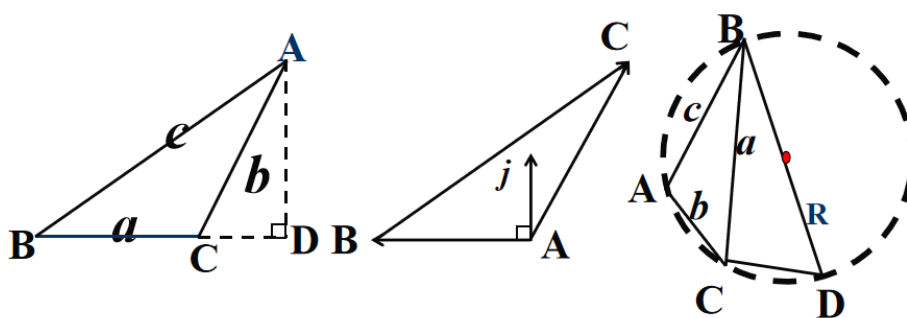


Figure 5 A. Obtuse triangle

The embodiment of S (Science) in teaching: fully embracing the STEM education concept, this teaching approach introduces the new with the old, break the balance of students' original cognitive structure, and naturally let students think and experience the thinking process from special to general. From the perspective of students' comprehensive literacy, students' core qualities such as mathematical operation and logical reasoning are cultivated. In the process of mastering the proof method, students are fully given time to think, cooperate and communicate, so as to stimulate the desire to explore, break through the bottleneck of thinking and promote students' social development.

4.3 Defining technical understanding based on STEM education concept

The STEM education concept emphasizes the cultivation of students' technical literacy, recognizing technology as a in teaching activities. Therefore, the teacher ensures that students master both symbolic and textual description of the sinusoidal theorem, and demonstrates the connotation of the sinusoidal theorem with the geometric drawing board. Additionally, students can also be taught how to utilize the geometric drawing board outside of class.

The embodiment of T (technology) in teaching: Through the demonstration of the geometric sketchboard, students can intuitively grasp the fact that the sinusoidal theorem holds true for any triangle. This enables students to understand the role of information

technology in mathematics and improve their technical literacy.

4.4 Interdisciplinary consolidation exercises based on the STEM education concept

The STEM education concept emphasizes practical application abilities in students.. Consequently, students who have mastered the content of the sine theorem can utilize it to solve various examples.

“How far is the foot 2 and the target fire fighting point?”

Example 2: already known: $A = 16$, $b = 16$, $A = 30^\circ$, find the length of B, C and edge c.

Example 3: Applying the sine-string theorem to solve a static mechanics problem.

Teachers should design more thought-provoking and open-ended question that guide students to think critically and foster their desire to explore mathematical knowledge. When setting exercises problems, synthesis should be emphasized, incorporating exercises that relate to physics and engineering, highlighting the combination of mathematics with other disciplines, and its close connection to real-world applications. This approach ensures that students do not perceive their learning as detached from practical utility. Furthermore, through practice, students gain an understanding of the two distinct applications of the sinusoidal theorem, one involving knowledge of two angles and one side to solve a triangle, and the other involving knowledge of two edges and one side to solve a triangle.

References:

- [1] He Dingyan. Exploration of high school mathematics teaching practice based on the STEM education concept —— Take “solution triangle” as an example [J]. *Mathematics Learning and Research*, 2022 (12): 104-106.
- [2] Dai Tianzhu. Application of STEM education concept in high school mathematics classroom teaching [J]. *Middle School Mathematics*, 2020 (11): 84-85.
- [3] Qin Jinruo, Fu Gang Shan. STEM Education: Interdisciplinary education based on real problem scenarios [J]. *China Audio-visual Education*, 2017 (04): 67-74.
- [4] Zhang Chongyan. Discussion on the application of STEM education concept in high school mathematics classroom teaching [C] // *Proceedings of the 2022 Teaching Development Webinar (I)*. [Unknown publisher], 2022:175-177. DOI:10.26914/c.cnkihy.2022.042308.
- [5] Li Feng, Song Xiaozheng. Analysis of the current status of STEM education in high school mathematics teaching [J]. *New course*, 2022 (36): 40-41.
- [6] Pan Ye Xue, Zhou Jincheng, Chen Xiaohong, Shi Dingpu. Design framework and application of high school mathematics teaching based on STEM education concept [J]. *Classroom Teaching Research in Primary and secondary schools*, 2022 (07): 23-27 + 37.
- [7] Wu Qiuju, Liu Shenggui. Junior middle school mathematics teaching design under the STEM education concept —— Take “similar triangle application —— as the height of the school flagpole” as an example [J]. *Mathematics Teaching and Research*, 2022,41 (05): 26-30.