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Research on High School Mathematics Teaching Strategies Based on the ARCS Model

Yanming Wang*, Jianqiang Liu

Ningxia University, Yinchuan 750021, Ningxia Hui Autonomous Region, China

Corresponding author: Yanming Wang, wym191231@icloud.com

Abstract: As educational technology advances, traditional teaching models no longer fully meet the learning needs of contemporary high school students. More educators are recognizing that strong learning motivation can inspire positive learning attitudes in students, and robust enthusiasm for learning can significantly improve learning outcomes. This is particularly true for mathematics, a subject that heavily involves abstract thinking, where students' motivation levels are typically moderate to low. Thus, stimulating students' learning motivation has become an indispensable issue in educational activities. Through the analysis of the ARCS motivation model and integrating specific teaching practices to refine and adjust the model's four aspects, this paper aims to assist educators in enhancing teaching effectiveness and boosting students' interest in learning.

Keywords: ARCS model; High school mathematics; Teaching strategies; Learning motivation

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1. Introduction

Both the "National Mathematics Curriculum Standards for Compulsory Education" [1] and the "General Plan for Basic Education Curriculum Reform" [2] emphasize that in the process of teaching mathematics, teachers should stimulate students' motivation and interest, fostering a strong curiosity and desire for mathematics knowledge. Reflecting on traditional teaching methods in today's digital age, educators should transform their pedagogical philosophies, activate their proactive abilities, and apply advanced teaching theories and models to empower students to take ownership of their learning. This approach ensures the implementation of the core competencies of mathematics education and prepares students to meet the expectations of the era. As teaching methods and strategies continue to evolve, Professor Keller's ARCS model (Attention, Relevance, Confidence, Satisfaction) has been proven to be an effective teaching framework. Known for its comprehensiveness, specificity, and practicality, the ARCS model is increasingly used in educational settings [3]. This paper introduces the ARCS model and explores its strategies in mathematics teaching to stimulate students' motivation to learn mathematics.

2. Overview of the ARCS model

The ARCS model, introduced by educational psychologist John Keller in his 1983 article "The Systematic Process of Motivational Design," is a teaching design model aimed at enhancing learner motivation and engagement. It comprises four key elements: Attention, Relevance, Confidence, and Satisfaction [4]. This theory, which integrates achievement motivation and Maslow's hierarchy of needs, has been widely acclaimed since its inception and is considered a comprehensive amalgamation of learning motivation theories. It is highly regarded by educators globally, providing a strategic framework for designing instructional models and achieving notable success in educational practice.

3. High school mathematics teaching strategies based on the ARCS model

The ARCS motivational design model is broadly utilized in education. However, its application should not be rigidly standardized across different subjects and educational activities. Instead, it should be adapted and flexibly applied based on the specific characteristics of each discipline [5]. This paper focuses on high school mathematics teaching, emphasizing the distinctive features of mathematics as a subject and the unique aspects of knowledge construction at the high school level. The goal is to derive universally applicable insights that can serve as foundational strategies for widespread implementation in high school mathematics teaching activities.

3.1. Integrating mathematics with student interests – Attention

From the perspective of the Attention component of the ARCS model, capturing students' attention toward the learning content is essential for stimulating motivation. Research by Luo *et al.* (2005) indicates that students' attention is often closely linked to their interests [6,7]. The challenge, therefore, lies in ways to effectively integrate students' interests with the teaching content. During their mathematical education, students often lose interest due to either the dry nature or complexity of the content. In contrast, subjects like chemistry and biology involve chapters taught through experimental demonstrations, which are generally better comprehended by students. This success is largely attributed to the engaging and interactive nature of experimental teaching that significantly stimulates students' curiosity and desire to explore [7]. Thus, it is crucial to align mathematical content with aspects that students find intriguing. Specific strategies include:

(1) Using captivating mathematical stories, historical contexts, or practical problems to pique learners' interest;

(2) Incorporating multimedia elements such as images, videos, and audio to enhance the appeal of mathematical materials. While it is important to make abstract mathematical concepts more tangible, the emphasis on abstract reasoning, a core component of high school mathematics education, should not be entirely neglected.

For example, consider the instruction on the concept of complex numbers in Chapter 7, Section 1 of the compulsory second volume from the People's Education Edition. This mathematical concept, challenging to relate to real-life contexts, has long posed difficulties for educators in terms of student engagement. Traditional teaching methods that fail to engage students often lead to rote memorization, contradicting the principles of modern educational reform. However, integrating the history of mathematics and beginning with the crisis over irrational numbers can effectively stimulate interest. Student interest, akin to a rocket engine, propels them along their educational journey, enabling them to soar through the vast cosmos of mathematics.

3.2. Creating real-world mathematical problem scenarios – Relevance

In the process of stimulating learning motivation, the design of teaching content plays a critical role. Students do not develop motivation for a specific topic arbitrarily. Rather, it emerges from connecting with their existing knowledge and experiences. Among various modern teaching theories, situational teaching is regarded as a pivotal tool for integrating knowledge into students' cognitive domains [8]. Therefore, this paper incorporates situational teaching into the designed teaching strategies. Situational teaching involves the teacher creating a dynamic teaching environment filled with fun, aesthetics, and intelligence to pose questions or set learning tasks, gradually guiding students to immerse themselves in the situation and stimulating their interest in learning [9]. On one hand, situational teaching helps students extract the taught mathematical knowledge from their existing experiences. On the other hand, it deepens their understanding of mathematical modeling and the thought process of using mathematics to solve problems [10]. The specific steps include:

(1) Understanding the learners' backgrounds and interests, providing real-world situational cases that combine the teaching content of the chapter;

(2) Posing problems within the scenario, incorporating the teaching content into the problem situation, and continuously exploring through teacher guidance, deepening the understanding of the problem situation. In the created fun, transform rote memory into a knowledge paradigm that can be flexibly applied;

(3) Applying the learned mathematical knowledge and ideas to solve practical problems, forming an integrated cycle of situation-knowledge-situation [11].

For example, consider the teaching content of solving triangles in Chapter 1 of elective five from the People's Education Edition, in explaining the relevant content, the flexible use of the sine and cosine theorems is key. The teacher might start the first lesson with this question: "Hundreds of years ago when night fell and the moon hung high, mathematicians pondered how far away the moon was. In 1671, two French astronomers used a clever method to calculate the distance to the moon as approximately 385,400 km. How did they do it?" At this point, students have not yet learned the relevant knowledge for solving triangles and are filled with doubts about the question. Through creating a vivid real-world scenario, students freely explore the scenario and through the teacher's life-like situational guidance, they perceive and experience the mathematical content from a realistic perspective. This not only cultivates good mathematical learning interests among students but also enhances the effectiveness of mathematics teaching.

3.3. Cultivating self-efficacy – Confidence

Self-efficacy refers to an individual's judgment about whether they can successfully perform a certain achievement behavior [12]. Introduced by Albert Bandura in the 1980s, the theory of self-efficacy has been enriched and rapidly developed, later being recognized by numerous empirical studies. Bandura (2012) proposed that human behavior is influenced or determined by two factors: reinforcement and expectation, i.e., the outcome factors of behavior and the antecedent factors of behavior [13]. The theory of self-efficacy plays a significant role in teaching and is also an important factor affecting learning motivation. Correct attribution and positive reinforcement are key to forming students' confidence. In the teaching process, making every effort to let each student see their successes, even if they are minor, can still bring students pleasant emotions, thereby motivating them to study hard to achieve greater success. The specific operational steps include:

(1) Establishing learners' confidence, where teachers provide clear guidance and support, and encourage them to believe that they can complete the learning tasks;

(2) Encouraging a positive attitude, using positive language and motivational words to encourage students,

increasing their confidence and positive attitude.

For example, consider the teaching of conic sections in Chapter 3 of the elective one from the People's Education Edition. The difficulty of the knowledge content of this chapter is at the top tier of high school mathematics, a pain point for both teachers and students. Teachers need to invest a lot of effort in deliberating and polishing teaching methods. For such teaching difficulties that are not easily accepted by students, encouraging students and stimulating their internal drive can better complete the teaching tasks. In the teaching of this chapter, teachers can adopt the programmatic teaching proposed by behaviorism, breaking the teaching content into step-by-step stages, making it easy for students to achieve success and build confidence. Specifically, in the content of this chapter, taking the properties of ellipses separately, starting from the simple ones, guiding students to start calculations, and finally completing the teaching of the knowledge points. Although there are many knowledge points about ellipses and they are flexibly applied, taking out a single property is not very difficult, so in the process of programmatic teaching, it is easy for students to build confidence. Meanwhile, during the teaching process, teachers provide timely positive feedback, thus completing the teaching of this chapter.

3.4. Achievement feedback and positive reinforcement in evaluation – Satisfaction

Achievement feedback and positive reinforcement are commonly used motivational strategies in education and can play a significant role in mathematics teaching. Firstly, achievement feedback refers simply to the positive evaluation and recognition that teachers provide to students about their work. This feedback helps students build a positive self-image and confidence, enhances their confidence in their abilities, and stimulates their interest in learning mathematics [14]. Secondly, positive reinforcement involves teachers using rewards and encouragement to strengthen students' positive behaviors and efforts [15]. The specific operational steps are as follows:

(1) Provide timely feedback, giving learners prompt and accurate feedback so they can understand their progress and directions for improvement;

(2) Focus on praise and encouragement, particularly in today's context where an increase in students' self-esteem can cause stress responses to setbacks encountered during the teaching process. Thus, education should be positive and protective of students' self-esteem;

(3) Utilize diversified evaluation standards, and multidimensional evaluation methods, discarding the sole focus on scores and emphasizing process-oriented assessment.

For example, teachers can demonstrate a diversity of evaluation subjects and methods during the teaching process. Evaluation might include mastery of knowledge and skills, emotional attitudes and values during the process, as well as classroom performance, among others. For instance, during the teaching of sequences, a teacher might pose an investigative question: "Bank interest rates." During the students' exploration, classroom activity evaluation forms and observation charts are used to record students' learning activities and provide a score assessment. This is then combined with a comprehensive consideration of students' research outcomes to grade the students. Throughout this process, the emphasis is on motivation and positive education, frequently highlighting different students' strengths to guide students in leveraging each other's strengths. For example, Student A shows unique problem-solving approaches, Student B's calculations are rigorously thought out, and of course, in teaching evaluations, it is not possible to completely overlook the problems that arise; deficiencies in students' learning processes still need to be pointed out timely. Balancing positive praise and criticism is a skill that teachers need to manage based on actual situations.

4. Conclusion

This paper aims to explore high school mathematics teaching strategies based on the ARCS model to enhance students' learning motivation and interest. By applying the ARCS model, a series of teaching strategies addressing attention, relevance, satisfaction, and confidence have been designed, and specific teaching strategies for high school mathematics have been provided. These strategies offer significant guidance for the practical teaching of high school mathematics.

Disclosure statement

The authors declare no conflict of interest.

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