Research on NetPad Teaching Mode Based on ARCS Motivational Model

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Abstract. Stimulating and maintaining students' learning motivation is the key to fully mobilizing the enthusiasm of students' active participation and realizing the unity of students' learning and teachers' teaching. The ARCS motivational model is an instructional design model proposed by Professor Keller that focuses on motivating and sustaining students' learning motivation. Additionally, NetPad is a web-based dynamic mathematics software with powerful functions and user-friendly interface, it can be organically integrated with teaching, enrich the teaching style, and strengthen students' learning motivation. In this paper, we propose the NetPad motivational teaching mode based on the ARCS model and NetPad. This mode consists of four procedures: interesting cases introduction, detailed cases explanation, group inquiry, and mutual evaluation and sharing. Each procedure is progressive and complementary, reflecting the hierarchy of motivational teaching from shallow to deep and the synergy of motivation stimulating and maintaining. The teaching practice under the guidance of this mode has verified its effectiveness.

Keywords: ARCS Model · NetPad · Learning Motivation

1 Introduction

The deep integration of information technology and subject teaching is the key concern and development in the era of education informationization 2.0. COVID-19 has accelerated the process of applying the Internet for education in China, and put forward higher requirements for the integration [1].

Dynamic geometry software can promote the deep integration of information technology and education [2]. NetPad is one of the dynamic geometry software under the mobile Internet environment, it was officially released in 2016 and gradually entered the mathematics classroom in primary and secondary schools. However, such an outstanding subject tool has not been applied widely yet, and its relevant study is not enough. To make

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the problem clear, we research papers and eventually find the key element i.e., learning motivation. Learning motivation plays a key role in technology-integrated instruction and it can significantly affect students' studies [3]. Therefore, attention should be paid to motivating students in NetPad teaching.

Karakis found that the ARCS model applied in mathematics courses can positively influence students' academic achievement and learning attitudes [4]; Li and Keller showed that the ARCS model has a positive impact on students' learning motivation in computer-based instruction and the IT-supported environment is also the preferred learning environment for the model [5]. Therefore, the article attaches importance to stimulating and maintaining students' learning motivation in the teaching process and proposes a NetPad motivational teaching mode based on ARCS model. Under the guidance of this mode, the teaching practice is carried out, and the students' classroom performance is positive, which verifies that this mode can promote students' learning motivation.

The structure of this article is as follows. Section 2 introduces the connotation of learning motivation and the ARCS model as well as elaborates the connotation and characteristics of NetPad. In Sect. 3, we propose a NetPad motivational teaching mode based on ARCS motivational model. Section 4 is the teaching practice, we have applied the NetPad motivational teaching mode to carry out 10 lessons for junior high school students, and select one of the lessons to specifically elaborate the teaching process. Section 5 concludes the article and provides future research directions.

2 Related Work

2.1 Introduction to the Connotation of Learning Motivation and the ARCS Model

Motivation is the internal state that directly drives human activities to meet certain needs, and is the direct cause and internal motivation for people to learn, which can stimulate, direct and maintain learning behavior, which is the main reason for students' participation in the classroom.

Motivation in mathematics is a conscious behavioral tendency caused by a certain need related to mathematics learning, which motivates and pushes students to behave toward learning goals. The strength of motivation affects individual learning emotion, classroom participation behavior and other related mental activities, and positive learning motivation is conducive to individual effective participation and deep learning [6].

The ARCS model was proposed by Professor Keller in the 1880s to stimulate and maintain students' learning motivation. Professor Keller argues that learning motivation is not unpredictable and uncontrollable; on the contrary, research shows that by integrating ARCS motivational model strategies in the curriculum, teachers can systematically and efficiently stimulate students' learning motivation and maintain their motivation at a relatively high level [5]. Learning motivation plays a key role in students' learning of the subject knowledge and achieving their learning goals, which should be incorporated into the teaching design of NetPad. The ARCS motivational model contains four elements: A-Attention, R-Relevance, C-Confidence, and S-Satisfaction [7]. First, in order to motivate students, teachers and teaching content should attract and maintain

students' attention; second, the learning content should meet learners' needs and should be relevant; moreover, the course should allow students to have successful experiences and build self-confidence through task setting; Finally, when students are satisfied with their achievements and their efforts are consistent with expectations, their motivation to learn can be sustained [8].

2.2 Connotation and Characteristics of NetPad

The development of the NetPad uses dynamic geometry, intelligent reasoning, symbolic operation, and network interaction technology, is an "Internet plus Dynamic Mathematics" learning platform, with the characteristics of dynamic visualization, and has rich online resources [9]. Meanwhile, the NetPad is a powerful subject tool, which can be used as a learning garden for teachers and students to explore mathematics problems. As follows:

Dynamic Visualization. NetPad expresses abstract mathematical knowledge in an intuitive form, realizes dynamic change, and brings visual dynamic demonstration process for teachers and students; using NetPad can effectively build a bridge between students' cognition and abstract mathematical symbols, thereby reducing students' cognitive difficulty, promoting understanding, stimulating learning interest and learning motivation.

Internet plus Dynamic Mathematics. NetPad is fully adapted to the existing Internet environment, and can be simply registered on the web page; NetPad is deeply rooted in the mathematical discipline, which can realize the functions of "writing, drawing, measuring, transforming, editing, acting, reasoning, calculating", not only as an environment for students' daily learning and experimental exploration but also as a platform for teachers' lesson preparation and progressive teaching.

Rich Online Resources. All the resources created by the NetPad users are gathered in the NetPad cloud so that users can search for the resources they need on the website. During the learning and application process, students can appreciate the works of others, thus generating their own creative inspiration, and change from knowledge learners to content creators, which is also conducive to the acquisition of satisfaction and the maintenance of learning motivation.

3 NetPad Motivational Teaching Mode Based on ARCS Motivational Model

3.1 ARCS Motivational Strategy Analysis and Application

This part analyzes four types of strategies for the ARCS motivational model proposed by Keller, namely attention strategies, relevance strategies, confidence strategies, and satisfaction strategies [10, 11]. To adapt to the teaching process of NetPad, this article combines the characteristics of NetPad and proposes action in NetPad instruction strategies. As the figure shown in Fig. 1.

Category	Subcategory	Action in NetPad Instruction
Attention Strategies	Perceptual arousal Inquiry arousal Variability	Introduce surprising cases; Arrange the question inquiry process; Adopt a variety of teaching methods.
Relevance Strategies	Goal orientation Motive matching Familiarity	Inform the students of the main contents and objectives; Set challenging questions and arrange for group cooperation; Select interesting, lifestyle cases.
Confidence Strategies	Learning requirements Success opportunities Personal control	Raise the course learning requirements; Provide successful opportunities frequently; Give students certain autonomy.
Satisfaction Strategies	Intrinsic reinforcement Extrinsic rewards Equity	Provide opportunities to apply new knowledge; Provide verbal praises and material rewards; The evaluation criteria are open, transparent, and equal to all students.

Fig. 1. Motivational strategies and action in NetPad instruction.

Attention Strategies. This type of strategy focuses on responding to students' demand for stimulation and arousing students' curiosity to explore knowledge, including perceptual arousal, inquiry arousal, and variability strategies. Attracting attention is not difficult, the key is how to maintain students' attention [10].

For perceptual arousal, teachers can attract students' curiosity and attention by introducing a surprising piece of information related to course content, so that students can be engaged in the study quickly; For inquiry arousal, question-seeking activities should be arranged during the process of instruction, in order to further stimulate students' curiosity. Meanwhile, the rich online resources of NetPad can provide help and support for students' exploration; For the diversity strategy, teachers are supposed to adopt various teaching methods combined, bring freshness to the classroom, and maintain students' attention.

Relevance Strategies. This type of strategy focuses on meeting students' perceived need, so that students can form positive learning attitudes, including goal orientation, motivation matching and familiarity strategies [10].

For goal orientation, teachers should briefly introduce the main contents and objectives of the course to students before entering into the detailed case study, so that students can understand the course structure. In the process of teaching, teachers are suggested to set challenging questions and arrange group inquiry activities, so that students who are eager to have a sense of belonging or eager to be challenged can both realize the motivation matching. Mathematics is a subject that frustrates many students, and the difficult and abstract theoretical knowledge will make students feel resistant, while the dynamic visualization of NetPad can solve this problem well. At the same time, teachers should select interesting and lifestyle cases for the course, so that students can experience a sense of familiarity and thus maintain their learning motivation.

Confidence Strategies. The focus of this type of strategy is to enable students to hold positive expectations for success and build self-confidence in the learning process, thereby sustaining motivation. Strategies encompass learning requirements, opportunities for success, and personal control [10].

For the learning requirements' strategies, teachers should present the learning requirements in the classroom; during the instruction, teachers should design teaching contents step by step and set progressively difficult problems according to the teaching contents, and reasonably arrange the instructional pacing so that students can achieve success and build self-confidence in the process of continuously solving problems and mastering new knowledge; For personal control strategies, teachers should give students a certain degree of autonomy in the classroom, so that they can set their own pace and regulate their learning behaviors, and at the same time make students realize that they can achieve a certain degree of success by making efforts.

Satisfaction Strategies. Satisfaction is a category emphasizing strategies that help learners feel positive about their achievement, including intrinsic reinforcement, extrinsic rewards and equity [10].

For internal reinforcement strategies, teachers should provide opportunities to apply new knowledge so that students can learn and feel rewarded, and provide feedback to reinforce positive feelings about effort and achievement; for external reward strategies, teachers can provide verbal praises and material rewards to reinforce the satisfaction and sense of achievement that success brings to students; for equity strategies, teachers must ensure that students' work is evaluated fairly, and evaluation criteria are open, transparent, and equal to all students.

3.2 NetPad Motivational Teaching Mode

Based on ARCS model, combined the characteristics of NetPad, we propose the NetPad motivational teaching mode. With the integration of ARCS motivational strategies, the mode encompasses four procedures: interesting cases introduction, detailed cases explanation, group inquiry, mutual evaluation and sharing. Each procedure mainly corresponds to one motivation element, as well as taking one or two other motivation elements into consideration. These four procedures are progressive and complementary, for the stimulation and maintenance of motivation is from shallow to deep. As the figure shown in Fig. 2.

Interesting Cases Introduction. Attracting students' attention is the first element of the ARCS model, and it is also a necessary prerequisite to stimulating students' learning motivation. This step focuses on attracting students' attention, as well as taking relevance element into consideration.

By introducing a classical math story or interesting math experiment related to the course content, students' attention can be attracted immediately. In demonstration and explanation, teachers should establish the connection between the interesting introduction and course content. Using the NetPad, teachers can easily set up the bridge between abstract mathematics theory and students' intuitive imagination, in order to stimulate

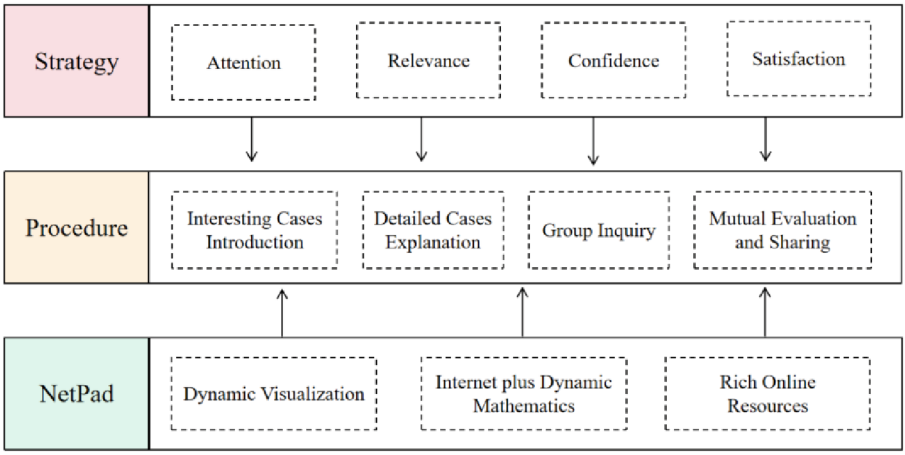


Fig. 2. NetPad motivational teaching mode.

students' curiosity and motivation, reduce the difficulty of students understanding new knowledge. At the same time, the selection of each instruction case serves the core knowledge points of the course and has a logical correlation with the subsequent cases.

Detailed Cases Explanation. This step focuses on creating successful experiences and building students' confidence, and also takes attention and relevance motivational elements into consideration.

After the introduction of interesting cases, teachers should raise the learning requirements, main contents, and objectives of this class, make sure that students hold a positive expectancy for learning, as well as stimulate students' motivation. Then, select both basic case and expanded case that serves the core knowledge points of the course. The difficulty of the case is incremental, and teachers should carry out the instruction step by step, in order to help students build confidence, and make them believe that they can master the course knowledge. The selected cases should be interesting and structurally correlated, to prevent students from feeling boring, irrelevant, and non-challenging. Moreover, the teaching pacing should be timely adjusted with the change in the classroom atmosphere, to maintain students' motivation. Also, teachers should keep track of students' mastery of new knowledge, and further explain the key points, difficulties, and error-prone details, to ensure that students can master the operation of NetPad, attain successful experiences, and build up confidence.

Group Inquiry. This step focuses on producing relevance, and also takes attention and satisfaction motivational elements into consideration.

In this step, a challenging lifestyle question is introduced for group inquiry. Students are asked to apply their knowledge in exploring the question in free groups and create their own works. With the support of NetPad, students can share rich online resources and then generate innovative inspiration. Moreover, students feel satisfied with themselves through the process of exploration and application, and have a sense of familiarity with the challenge and the cooperation of others.

Mutual Evaluation and Sharing. This step focuses on generating satisfaction, and also takes confidence motivational elements into consideration.

Each group is required to select one piece of work for display in class; the work owner is invited to introduce the creative inspiration and idea for other students to learn from. Finally, students are required to summarize their gains today and share in groups. This process can promote students' in-depth understanding of knowledge and tool application, help them generate satisfaction, and maintain their learning motivation at a high level.

4 Teaching Practice

Under the guidance of the mode, a series of NetPad teaching practices were carried out for junior high school students, and the practices contained three parts: graphic design, number-shape combination and iterative fractal, with a total of 10 lessons and 20 class hours. In the following, we select one lesson of the number-shape combination part to elaborate how the teaching process realize the mode.

4.1 Teaching Objectives

Through the widely spread story behind the Cartesian heart function, let the students feel the romance and charm of mathematics, and understand that mathematics exists in all aspects of life. To attract students' attention and stimulate students' motivation.

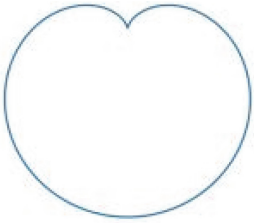
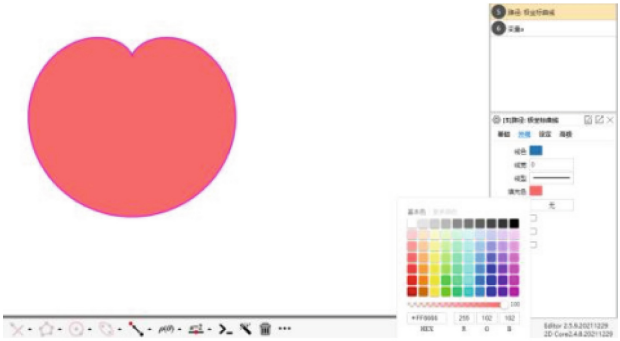
Through the drawing of the Cartesian heart function, make the students understand the meaning of the function, grasp the application of the function tools, and understand that function graphs connect mathematical equations and things in life. Through the drawing of the "Multi-Layer Heart" curve, make the students further understand the application of function, master the function tools, and master the drawing ideas and methods. To help students build up confidence and maintain students' motivation.

Through the exploration and inquiry in groups, cultivate students' exploring and innovating abilities, make them feel satisfied and familiar, then motivate them to further use NetPad in exploring mathematics problems. To help students generate satisfaction and maintain students' motivation.

4.2 Teaching Implementation

Interesting Cases Introduction. In this procedure, asked question 1(Q1) and then told the romantic love story behind Cartesian heart function; which led to the concept of coordinate system and function, established the connection with students' grasped knowledge. Q1 is shown below.

Table 1. Cartesian Heart Drawing Steps.

Steps to Make a Cartesian Heart
Step 1: Basic Graphing
a. Use the "Function Figure toolset -> polar equation" to plot the function curve ρ = a * (1 - sin(thet)), set the "independent variable" 0 ≤ thet ≤ 2*pi, figure is shown below.

Step 2: Interface Optimization
a. Adjust the curve position. Select "Object Group -> Coordinate Origin" and move to the center of the canvas.
b. Optimize the function curve. Select the curve and set it through the "Appearance" property dialog box, figure is shown below.
Steps to Make a Cartesian Heart

c. Beautify the canvas, set the canvas color through the "Base" property dialog, set the polar grid through the "Grid" property dialog, figure is shown below.


Q1: Have you ever heard of the Cartesian heart function?

Students had heard the story behind the Cartesian heart function in their math interest books; some active students raised their hands to express their understanding; and the class was highly participatory and active.

Detailed Cases Explanation. After the introduction of interesting cases, raised learning requirements, main contents and objectives of this class, then began the procedure with a base case - Cartesian Heart function, and then elaborated an extended case - Multi-Layer Heart, to help students grasp the procedure of graphing a function curve.

Base Case - Cartesian Heart Function. Introduced the function figure toolset and appearance attribute box needed in the basic case, explained the drawing process of the Cartesian heart function step by step, controlled the students' screen in the first demonstration, exited the full-screen control in the second demonstration, made sure that all the students can control their learning pacing, and made independent exploration and innovation after completing the heart function draw. The specific operation steps are shown in Table 1.

Extended Case - Multi-Layer Heart. Before getting to the next case, asked students question 2(Q2), Q2 is shown below.

Q2: Based on what you have learned, could you elaborate the steps of graphing the "Multi-Layer Heart"? The figure is shown in Fig. 3.

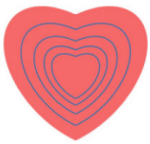
Fig. 3. Multi-Layer Heart.

Used the function figure toolset which was used in the basic case to explain the drawing process of "Multi-Layer Heart", controlled the students' screen in the second demonstration, some students could control their learning pacing and completed the "Multi-Layer Heart" after independent exploration. The specific operation steps are shown in Table 2.

Group Inquiry. Introduced question3 (Q3) and required students to apply their knowledge in exploring the question in free groups and created their own works. Q3 is shown below.

Q3: Could you find another way to graph the heart curves in NetPad? Are there any other function curves you can make that depict real things in our lives?

Table 2. "Multi-Layer Heart" Drawing Steps.

Steps to Make a "Multi-Layer Heart"
Step 1: Basic drawing
a. Use the "Function Figure toolset -> Polar Equation" to plot the function curve ρ = 15 / (17 - 16 * sin(thet) * abs(cos(thet))) ^ 0.5, set the "independent variable" pi / 2 - t ⩽ thet ⩽ pi / 2 + t, figure is shown below. 
b. Use "Transform toolset -> Scale" to scale Figure 4 times, figure is shown below. 
c. Use "Variables and Actions tool group -> Variables" to create variable a, set "Max" to 1, "Increment" to 0.1, "Current value" to 0.76.
d. Use "Variables and Actions tool group -> Animation" to create an animation effect, set "Type" to "Once", "Variables " is "t", "stop" is pi, "interval" is 20.
Step 2: Interface Optimization
a. Use "Show -> Hide Elements" to hide the variable slider for variable a and variable t.
b. Optimize the function curve. Select the curves from the outer layer to the inner layer, and set the color fill and transparency respectively, figure is shown below. 

Students were able to complete innovative cases based on the operations they had learned, and group discussions and exchanges were lively.

Mutual Evaluation and Sharing. Each group was asked to select one piece of work for display in class; the work owner was invited to introduce the creative inspiration and idea for other students to learn from. Meanwhile, teachers gave verbal praises to the outstanding students and progressive students. Finally, students were asked to summarize what they have learned today, and share and communicate with other students. In the

last of the ten classes, we awarded certificates of completion to all students who passed the attendance and prized to those who excelled in class.

5 Conclusion

This article aims to apply ARCS motivational model in the process of NetPad instruction, to stimulate students' interest in NetPad and learning motivation, ignite students' mathematics learning internal motivation, allow students to explore mathematics independently, cultivate students' ability to explore the thinking process of mathematics problems. We propose a NetPad motivational mode based on ARCS model and NetPad, and verify its effectiveness in the teaching practices.

However, the effectiveness of NetPad motivational teaching mode needs to be verified in more practices; and the mode lacks empirical analysis. In the subsequent work, conduct questionnaires and paper design tests for students' motivation level, analyze and explain student data before and after the teaching experiment, to further clarify the effect of experiment on students' motivation and achievement.

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References

1. Yang, Y., Zhang, Z., Wu, G., et al.: Discussion on information technology and online teaching under COVID-19. Basic Educ. **17**(03), 48–60 (2020)
2. Zhang, J., Li, C.: Z+Z Intelligent Educational System Super Sketchpad (Software). Beijing Normal University Press, 2004–2017. http://ssp.gzhu.edu.cn
3. Zhao, Y.: Analysis and reflection on the study of learning motivation in the online environment. China Educ. Inform. **19**, 30–33 (2014)
4. Karakış, H., Karamete, A., Okçu, A.: The effects of a computer-assisted teaching material, designed according to the ASSURE instructional design and the ARCS model of motivation, on students' achievement levels in a mathematics lesson and their resulting attitudes. Eur. J. Contemp. Educ. **15**(1) (2016)
5. Li, K., Keller, J.M.: Use of the ARCS model in education: a literature review. Comput. Educ. **122**, 54–62 (2018)
6. Xu, R., Pei, C., Song, N.: A study on the relationship between constructivist classroom environment and middle school students' motivation in mathematics - an analysis based on survey data from nine provinces (cities) in East, Central, and West of China. J. Southwest. Univ. (Nat. Sci. Ed.) **44**(04), 2–11 (2022)
7. Keller, J.M.: Development and use of the ARCS model of instructional design. J. Instr. Dev. **10**(3), 2–10 (1987)
8. Goksu, I., Bolat, Y.I.: Context and implications document for: does the ARCS motivational model affect students' achievement and motivation? A meta-analysis. Rev. Educ. **9**(1) (2021)
9. Wang, Y., Rao, Y., Guan, H., et al.: NetPad: an online DGS for mathematics education. In: 2017 12th International Conference on Computer Science and Education (ICCSE) (2017)
10. Keller, J.M.: Strategies for stimulating the motivation to learn. Perform. + Instr. **26**(8) (1987)
11. Jeon, E.Y.: What makes them the best English teachers? An analysis of the motivational strategy use based on ARCS model. Educ. Res. Policy Pract. **3**, 1–16 (2020)