

# Study on blended teaching mode and its application based on the ARCS motivational model

## Taking bioinformatics course as an example

Yinfeng Yang, PhD<sup>a,b</sup>, Ting Ouyang, master<sup>a</sup>, Lei Zhang, master<sup>a</sup>, Jinghui Wang, PhD<sup>c,\*</sup> 

### Abstract

With the advent of the “Internet +” era, technologies like big data and artificial intelligence are emerging, and teaching models are constantly being innovated. Blended teaching mode combines the advantages of online teaching and traditional classroom. However, during the process of specific teaching practice, there are many problems such as insufficient use of intelligent platform, insufficient dominant position of students, difficult to maintain a high learning motivation for a long time, and a mere formality of blended teaching. Therefore, this study first uses the Attention, Relevance, Confidence, and Satisfaction motivational model to explore its application in Bioinformatics course blended teaching. The classroom teaching mode was reconstructed from 3 aspects: pre-class guidance, in-class research, and after-class promotion. This model provides new ideas and directions for teaching innovation and curriculum reform in the colleges.

**Abbreviations:** A = Attention, C = Confidence, ARCS = Attention, Relevance, Confidence, and Satisfaction, R = Relevance, S = Satisfaction.

**Keywords:** ARCS, bioinformatics, blended teaching, learning motivation

### 1. Introduction

The development of information technology such as cloud computing, big data, and artificial intelligence has promoted the arrival of the “Internet +” era, and has also continuously affected the reform and innovation of teaching models in the field of education.<sup>[1]</sup> In order to make up for the deficiency of traditional teaching mode, to meet the needs of teaching development under the new environment of “Internet + education,” and to respond to the demands of the country on the sharing of high-quality education resources, the blended teaching mode of “online” + “offline” came into being.<sup>[2]</sup>

Blended teaching is a kind of teaching mode which combines traditional classroom teaching with modern network teaching.<sup>[3]</sup> As an innovative and flexible curriculum design method, blended teaching can integrate various teaching approaches, teaching theories, teaching media and teaching environment, fully emphasizing the subjectivity of students in the learning process and highlighting the leading role of teachers in the

teaching process, that is, “student-subject” and “teacher-lead-ing.”<sup>[4]</sup> During this process, teachers can extend teaching activities in space and time to cultivate the autonomous learning consciousness of students.

Although blended teaching has achieved certain results in the innovation of traditional teaching methods, there are still many problems in its practice.<sup>[5]</sup> For instance: the implementation of mixed teaching wisdom platform is not fully utilized; without the supervision and guidance of teachers, it is difficult for students to actively and independently complete the online learning tasks.<sup>[6]</sup> Therefore, in order to perform the personalized learning of blended teaching and ensure its teaching effect, the key lies in how to stimulate the internal learning motivation of students during the curriculum design and so that they can continue to learn actively and gain some rewards.

The Attention, Relevance, Confidence, and Satisfaction (ARCS) motivational model is a well-known and widely applied motivational model, which was first created by American

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<sup>a</sup> School of Medical Informatics Engineering, Anhui University of Chinese Medicine, Hefei, China, <sup>b</sup> Anhui Computer Application Research Institute of Chinese Medicine, China Academy of Chinese Medical Sciences, Hefei, China,

<sup>c</sup> School of Integrated Chinese and Western Medicine, Anhui University of Chinese Medicine, Hefei, Anhui 230012, China

\*Correspondence: School of Integrated Chinese and Western Medicine, Anhui University of Chinese Medicine, Hefei, Anhui 230012, China (e-mail: jhwang\_dlut@163.com).

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psychologist Professor John Keller in the 1980s and validated by other researchers.<sup>[7]</sup> Based on the expectancy-theory, the model is systematically designed from the aspects of analyzing the motivation of the target objects, designing the motivation strategy based on the motivation analysis constraints, implementing the strategy, and evaluating the effects.<sup>[8]</sup> As a method to improve motivational demands, the ARCS motivational model not only pays attention to the stimulation of learners' learning motivation, but also focuses on the maintenance of learning motivation and the real experience and gain of learners, providing a motivational framework for how to stimulate learners' learning motivation in classroom teaching.<sup>[9]</sup> Actually, it has been widely used to evaluate the motivational appeal of many persuasive and behavioral change systems in many domains such as education, health, and persuasive games, and also has been widely used and validated across different cultures.<sup>[10-12]</sup>

Consequently, with the help of Chaoxingtong smart platform, Dingding live broadcast, EV recording and broadcasting, and the existing high-quality teaching resources of Bioinformatics online, this study carried out a mixed teaching model and application research based on the ARCS model for the Bioinformatics course offered by our college's 2019 biomedical engineering major. By integrating the advantages of online and offline learning, it aims to fully mobilize students' learning initiative, improve their ability to analyze and solve problems sand practical innovation, and ultimately optimize the teaching effects, providing a basis for the undergraduate colleges to improve the quality of talent training and teaching innovation.

**2. The theory of ARCS motivational model**

The ARCS motivational model consists of 4 components, in which ARCS accounts for Attention (A, Attention), Relevance (R, Relevance), Confidence (C, Confidence), and Satisfaction (S, Satisfaction). The model theory believes that during the teaching process, how to stimulate and maintain the learning motivation of students is mainly related to 4 key factors of A, R, C and S.<sup>[13]</sup> These factors are interlocking to form a whole, and lack of any one of them will make learners lose their motivation to learn and reduce the overall teaching effect.<sup>[14]</sup> Each key factor

includes 3 sub-link elements, as well as the strategy to stimulate or maintain each motivation element is shown in Figure 1.

Among them, attention (A), as the most important part of the ARCS motivational model, is to emphasize that the knowledge taught by teachers should attract the attention and interest of learners, and make students have "cognitive curiosity," thereby inspiring their desire for inquiry and active action on learning goals and content.<sup>[15]</sup> At the same time, in the learning process, it is necessary to be able to maintain the strong attentions of learners. Strategies to attract attention mainly include perceptual arousal, inquiry arousal, and focus on variability.<sup>[16]</sup>

With respect the Relevance (R), it refers to the fact that the teaching contents and activities are closely related to the learners' existing knowledge reserves and value orientation.<sup>[17]</sup> After the attentions of students are attracted, in order to maintain the persistence of their attentions, teachers need to design their teaching in accordance with the learners' future development goals, matching their learning motivation, and being connected with the learner's existing cognition.<sup>[18]</sup> Only by making students fully aware of the correlation between learning content and goals and themselves, can they strongly stimulate their positive learning attitude and full learning enthusiasm, thereby improving learning efficiency and academic performance.

Additionally, self-confidence (C) means that learners can increase their self-confidence by participating in activities or completing tasks, so they are willing to explore and dare to challenge.<sup>[19]</sup> This is closely related to learners' self-efficacy, namely, learners' belief that they have the ability to achieve certain achievements or goals. Therefore, assessing the learner's ability to complete the learning task actively is the key to help learners enhance their self-confidence. The strategy of enhancing "self-confidence" in the ARCS motivational model is that teachers can issue reasonable and specific learning requirements to make students have positive expectations of learning effects, thereby increasing the success rate of learning.<sup>[10]</sup>

In terms of Satisfaction (S), it refers to the positive emotional experience gained by learners in learning activities, that is, the learners' learning results reach their expectations, thereby producing a sense of accomplishment and value.<sup>[20]</sup> This helps learners continue to learn actively, namely, to maintain learning motivation and be willing to learn further. Actually, S can be

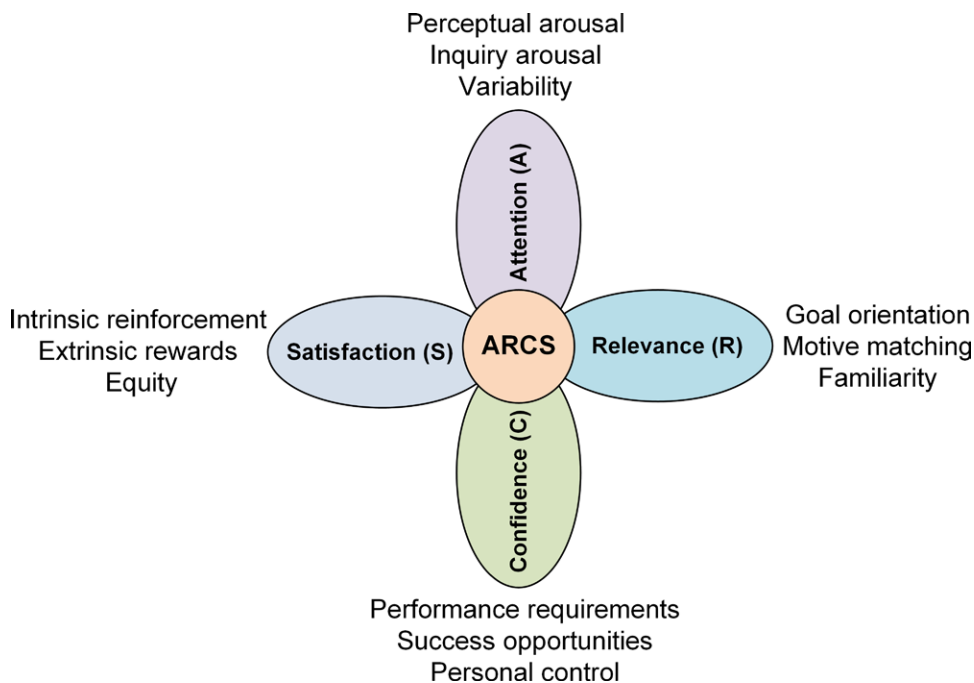


Figure 1. ARCS motivational model theory. ARCS = Attention, Relevance, Confidence, and Satisfaction.

obtained from internal reinforcement, that is, the inner satisfaction of the learner and it can also come from the external rewards, such as positive feedback.<sup>[21]</sup> Consequently, the evaluation system is consistent with daily learning activities, which also helps improve learners' satisfaction.

Indeed, in the ARCS motivational model, the 4 key factors of A, R, C, and S are hierarchically progressive, reflecting the sequence of operations inspired by motivation.<sup>[22]</sup> Firstly, at the beginning of the teaching activity, the individuals should have strong attention and interest in the learning task, so as to stimulate their learning motivations. Secondly, teachers should let the students understand the task closely related to the learning results and learning methods. Thirdly, through carrying out appropriate teaching design tasks, we make students believe that they have the ability to achieve better learning results during the activity. And finally, students can experience the achievement and satisfaction of completing the learning or work task from the internal and external feedback of the individual, and make continuous efforts to achieve long-term learning goals.

To sum up, the ARCS motivational model closely integrates the teaching goals and the learning motivation of students through these 4 links, allowing students to experience self-confidence and satisfaction from learning, with the ultimate goal of improving their learning efficiency. This model has been highly valued by the educational community since its establishment. Through theoretical research and extensive experiments, its effectiveness has been fully affirmed.<sup>[23]</sup> Also, it is the most systematic theory that integrates the principle of motivation into instructional design so far. The application of ARCS motivational model in teaching design can improve learners' attention to the curriculum, enhance their relevance, self-confidence and satisfaction in the learning process, thereby improving their cognitive ability.

### 3. Research on the application of ARCS motivational model in blended teaching of "bioinformatics"

#### 3.1. Research objects

To test the learning effectiveness of blended teaching of "Bioinformatics" based on the ARCS motivational model, a total of 99 undergraduates majoring in Biomedical Engineering were selected as the research objects. We used the class as a unit, and randomly chose class 1 as the experimental group (mixed teaching group, n = 48), and class 2 as the control group (traditional teaching group, n = 51). For the sake of a research study, the ages, genders, and academic levels of the 2 groups were compared, and it was found that the differences were not statistically significant and comparable. The teaching intervention period is from March to June 2021 and the learning effectiveness and knowledge of students to understand the impact of the ARCS motivational model on student learning outcomes were investigated at the end of the semester.

#### 3.2. Research methodology

The methods used in this article mainly include literature research approach, experimental research approach, survey research, and statistical analysis methods. The workflow of this study is depicted in Figure 2.

**3.2.1. Literature research approach.** Through searching the domestic and foreign documents related to this study, the current research status of the mixed teaching model of "Bioinformatics" course based on the ARCS motivational model were carefully studied, which lays the theoretical foundation for the research of this topic.

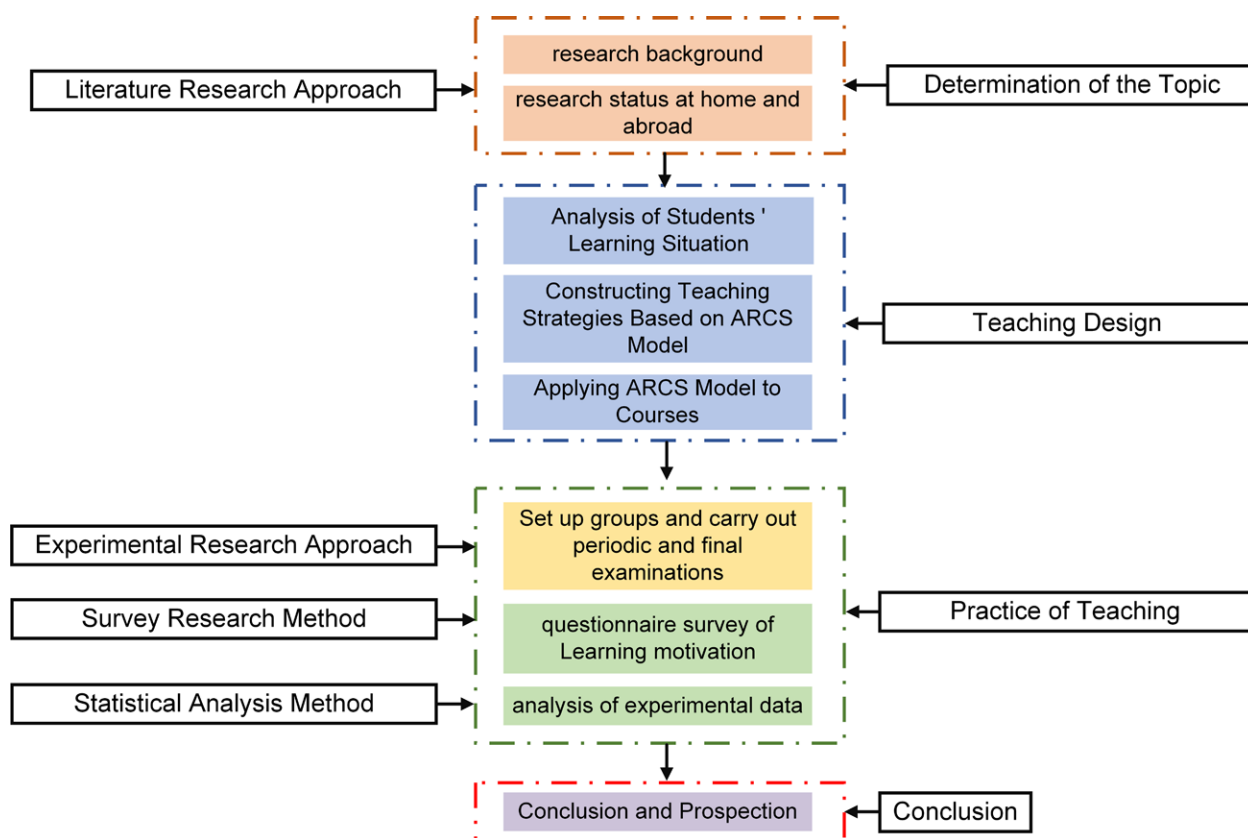


Figure 2. The workflow of this study.

**3.2.2. Experimental research approach.** Two experimental groups including the mixed teaching experiment group and the traditional teaching control group are set. Presently, Class 1, majoring in Biomedical Engineering, School of Medical Information Engineering, Anhui University of Traditional Chinese Medicine, was set as a mixed teaching experiment group (n = 51) and class 2 as a traditional teaching control group (n = 48). The age, gender, and academic levels of these 2 groups were compared, and it was found that the differences were not statistically significant and comparable.

**3.2.3. Survey research method.** Questionnaires were used to investigate the teachers and students to understand the implementation of the new teaching mode, whether there are problems and the evaluation of the implementation effect of “Bioinformatics” blended teaching mode based on ARCS motivational model, so as to provide improvement suggestions for the follow-up study of hybrid teaching mode.

**3.2.4. Statistical analysis method.** In order to comprehensively reflect the classroom behavior and provide reference for the improvement of the classroom, the learning data counted before, in, and after class are analyzed statistically during the implementation process. Using SPSS 21.0 statistical software, the data analysis was performed and the calculation results were expressed as mean standard deviation (Means ± s). Additionally, independent sample *t* or *p* test was also performed for comparison between groups. *P* < .05 indicated that the difference was statistically significant.

**3.3. Teaching model design**

**3.3.1. Designing teaching objectives.** Purposeful, connected with students and challenging instructional goals are the starting point for motivating and maintaining learning. Whether the design of teaching objectives is reasonable is the key to the arrangement of teaching content and the implementation of incentive strategies.<sup>[24]</sup> The teaching objectives of this work can be designed according to ARCS motivational model from the following 2 points.

- (1) Definition of the overall goals and phased goals of learning

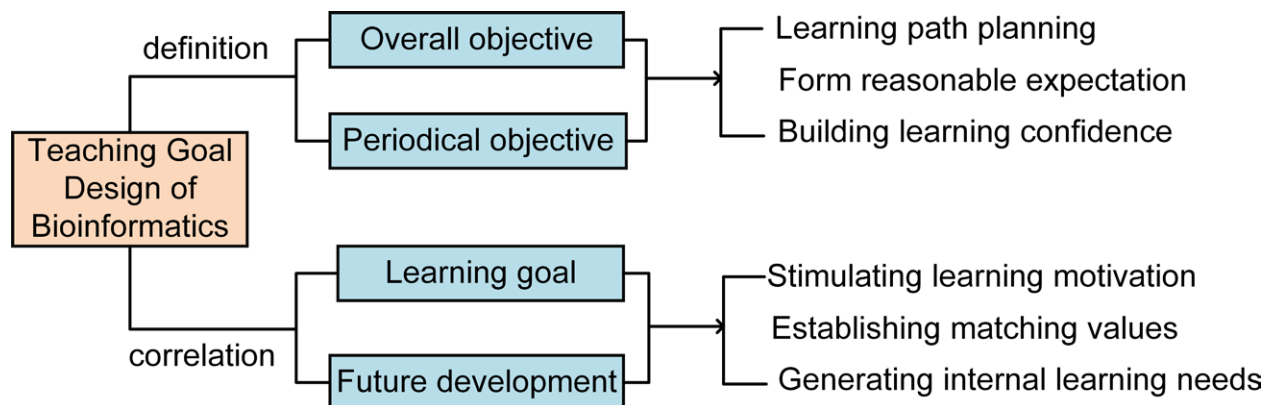
ARCS theory believes that at the beginning of the learning, clearly telling students the overall goals and phased goals that should be achieved through learning is conducive to plan their own learning path of students, to form reasonable expectations for learning goals, and also to establish the self-confidence of students.<sup>[25]</sup>

Therefore, in the design of the teaching objectives of this study, teachers can place video presentations, learning instructions, curriculum schedules, and other information in the cloud, so that students can understand and judge the learning standards and contents in advance. At the same time, the phased self-test questions was also offered to facilitate the learning test of students. Overall, the above measures can enable students to predict the possibility of achieving curriculum goals according to their own abilities and efforts, constantly stimulate students to increase their learning engagement, and further to ensure the final learning quality.

- (2) Making relevance to learning goals and planning for future development

Emerging evidence reveals that the higher correlation between the learning goals and learning expectations, learning readiness and future development of students, the more attention they can attract.<sup>[26,27]</sup> Therefore, during the design process of teaching objectives of this study, teachers can send questionnaires to analyze the learning situation through the information platform before the beginning of the course. Through the analysis of students’ learning situation, teachers can fully understand the situation of students, which can not only avoid teaching deviating from the learning needs of students and growth rules, but also help students establish personalized learning expectations and learning paths to stimulate their learning motivation. At the same time, teachers can also provide rich media resources that include industry development prospects, curriculum orientation, salary and career development path of related positions. All this will help students establish the values that match specialty and curriculum, strengthen students’ understanding of learning objectives, improve the correlation between students and learning objectives, and then let students perceive the significance of learning objectives for their future learning and life, producing internal learning needs. The specific teaching goal of the design process is shown in Figure 3.

**3.3.2. Construction of blending teaching mode of bioinformatics course based on ARCS motivational model.** The blended teaching mode of Bioinformatics course based on ARCS motivational model can be divided into 3 stages: pre-class guidance, in-class research, and after-class promotion. Among them, the online learning part in blended teaching is mainly arranged in the stage of pre-class guidance and after-class promotion, and the off-line learning part is mainly arranged in the stage of in-class research, which is dominated by teachers to complete different and complementary learning tasks in the classroom. However, no matter what stage, teachers should maintain interaction with students and make timely evaluation feedback to students. Figure 4 shows the “Bioinformatics”



**Figure 3.** Design process of “Bioinformatics” blended teaching objectives based on ARCS motivational model. ARCS = Attention, Relevance, Confidence, and Satisfaction.

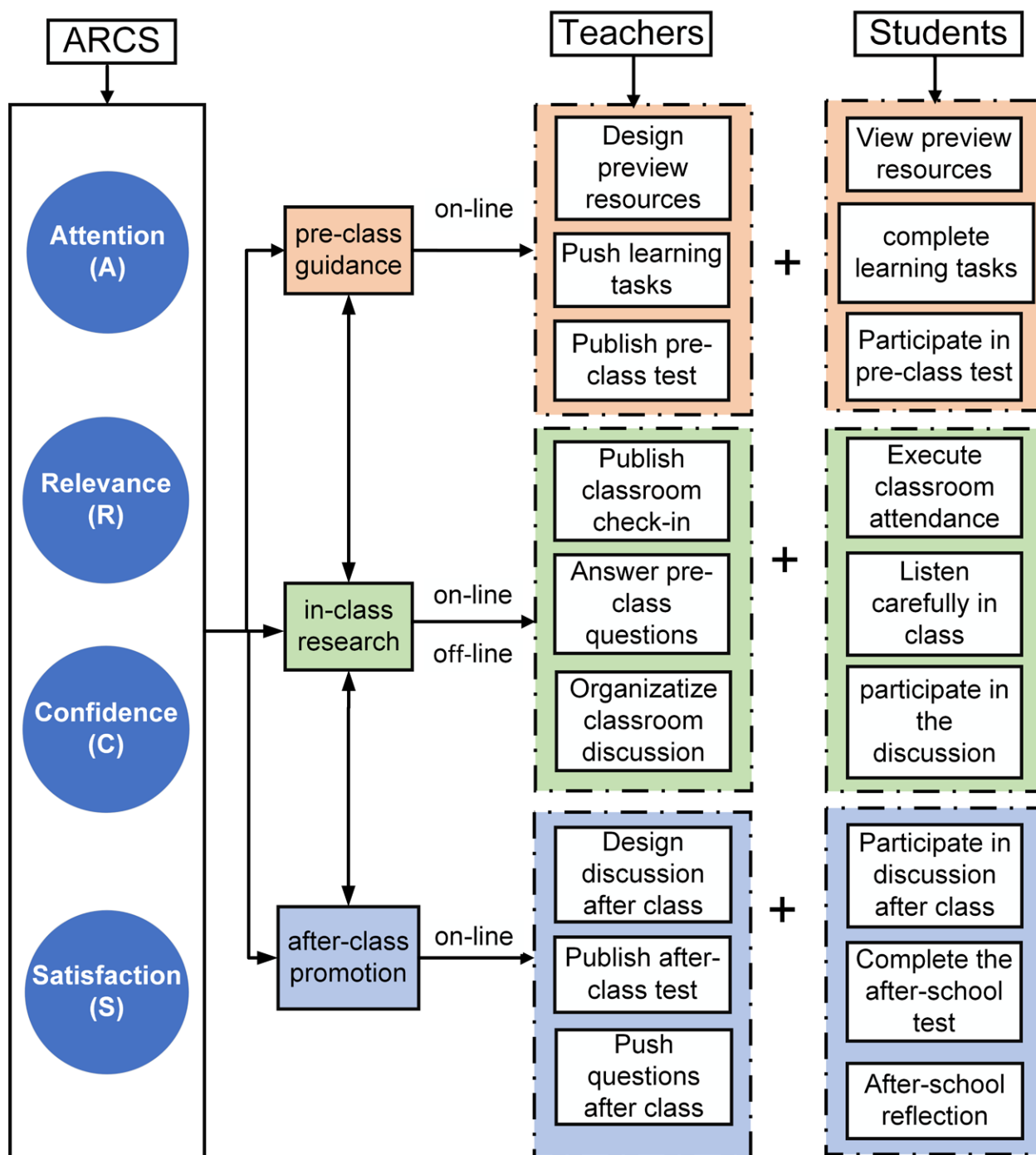


Figure 4. ARCS-based blended teaching model for Bioinformatics course. ARCS = Attention, Relevance, Confidence, and Satisfactions.

blended teaching model based on ARCS motivational model, and the specific teaching design process is as follows:

(1) Pre-class guidance

This part is mainly for teachers to design preview resources, push learning tasks, upload relevant resources of autonomous learning through the network teaching platform of Anhui University of Traditional Chinese Medicine, and publish pre-class test questions. With respect to the students, they mainly view resources, complete learning tasks according to stratification, and participate in pre-class tests. The purpose of this stage is to help learners have the ability to learn new knowledge. It is also the first step to stimulate the learning motivation

of learners, which is mainly reflected in the “A” in the ARCS motivational model. At the same time, it is also to guide learners to actively find problems and ask questions. After the students complete all pre-class tasks and complete the test, the teacher based on the test results in the “class” stage targeted teaching. Therefore, at this stage, teachers should selectively publish resources and select interesting and attractive resources through A strategy.

(2) In-class research

The stage of in-class research is the stage of face-to-face interaction between teachers and students, and the stage of intensive teaching of knowledge content. In this stage, teachers

publish the sign-in and explain deeply the important knowledge. Additionally, teachers should also use “heuristic” and “guiding” methods for flipped teaching to explain the difficult knowledge points collected in the pre-class guidance stage. At the same time, classroom teaching is organized by teacher-student interaction and student-student interaction. In order to stimulate and maintain the learning motivation of students, cooperative learning and case teaching were performed, which make students actively participate in classroom activities, effectively absorb knowledge and solve problems, reflecting the “R” of ARCS motivational model.

(3) After-class promotion

As a personalized learning stage after class, teachers can issue discussions, tests, and questions in this stage. Also, teachers can expand and extend classroom knowledge to facilitate students to strengthen the consolidation of knowledge points. Meanwhile, problems in the process of exploration should be reflected in time, and teaching strategies should be modified to improve teaching methods. In terms of students, students continue to use online resources to complete the post-class test, discussion, and reflection of teacher arrangement in this stage, which reflects the “C” in ARCS motivational model. By completing the after-class tasks arranged by teachers, students not only consolidate the knowledge acquired in class, but more importantly, the knowledge acquired by students has been transferred and truly applied. Students truly feel the sense of achievement in learning, reflecting the “S” in the ARCS motivational model, which plays a positive role in maintaining the learning motivation of students.

3.4. Construction of multi-curriculum evaluation system

The assessment and evaluation of the course is one of the important teaching links, which plays an important role in ensuring the realization of learning objectives and the completion of teaching content.<sup>[28]</sup> Usually, the traditional summative assessment uses a set of test papers to assess the knowledge mastery of students. However, there are problems such as narrow test scope and less attention paid to the learning process. In this study, the learning process and learning effect of students are included in the assessment category. Meanwhile, the combinations of online learning evaluation and offline classroom learning evaluation, formative evaluation and summative evaluation, knowledge evaluation, and ability improvement were carried out for comprehensively assessing the students from the 3-dimensional, multi-level, and multi-dimensional aspects and also constructing a diversified curriculum assessment and evaluation system of bioinformatics.

In this system, final examination belongs to summary evaluation, which is accounted for 50% to 60% of the total course score through the paperless examination system platform. In addition to the final examination, the examination belongs to

the formative evaluation and accounts for 40% to 50% of the total score of the course, which is based on the data statistical analysis function of the superstar learning platform. These assessments include online preview before class, test discussion, check-in in class, online test, online selection and answer, after class online homework, periodic examination, offline practice, group independent reporting, etc. In addition, the periodic assessment results will also be timely feedback to the teaching process, so that teachers can adjust teaching methods and contents, effectively regulate the teaching process, and improve the quality of classroom teaching. The detailed formative evaluation indicators are shown in Table 1.

3.5. Results

3.5.1. Analysis of questionnaire. At the end of the semester, a questionnaire survey on the implementation effect of blended teaching was conducted to understand the implementation of the current new teaching mode, whether there are problems and the real effect of the implementation, so as to provide suggestions for improvement in the follow-up study of blended teaching mode. The results of the questionnaire survey are shown in Figure 5, and the evaluation grades of the results are as follows: A, High Satisfaction; B, Medium Satisfaction; C, No Satisfaction.

Figure 5 shows that 15 % of the students have high satisfaction on their learning effect, 79% of the students have medium satisfaction, and 6% of the students are not satisfied with their learning effect. With respect to the effect of new teaching mode, 52% of the students have high satisfaction on the new teaching mode, while 48% of the students expressed medium satisfaction. On the whole, it shows that students can accept this teaching mode and 94% of students believe that the application of this new teaching mode can improve their learning effect and deepen their understanding of knowledge. Besides, this teaching mode has many practical operations, which is conducive to the cultivation of the ability to analyze and solve problems. In addition, most students think that the blended teaching mode based on ARCS motivational model is more conducive to the training of communication and cooperation ability. Therefore, the feedback of students on the teaching mode shows that compared to the traditional teaching mode, the blended teaching mode of ARCS motivational model is more effective in enhancing the interest of students on learning, improving the knowledge of the students, and cultivating the ability of students.

3.5.2. Comparison of the 2 groups of assessment results. After the end of the course, the statistical analysis on the completion of 2 sets of bioinformatics courses in this semester was performed and the results are shown in Table 2. The observation found that the scores of usual exam, stage test, final

Table 1

The contents of formative evaluation index.

Categories	Evaluation categories	Teaching activities	The contents of criteria
Online learning evaluation	Learning process	Online preview Signing in Interactive discussion	Degree of preview, length of study, feedback of questions, results of answers Attendance rate Question answer, Resource sharing
	Learning effect	In-class test After-class test	Online test results After-school unit test results, answer time
Off-line learning evaluation	Learning process	Teacher-student communication Autonomous reporting Practice on computer	Answer questions positively, ask questions voluntarily Whether to actively participate in group discussion and put forward personal views Whether the experimental steps are perfect and the results are correct
	Learning effect	Interest in learning Learning ability Learning thinking	Is there a positive interest in learning the course and whether to listen carefully Mastering learning methods and improving practical ability Put forward new views, dare to question

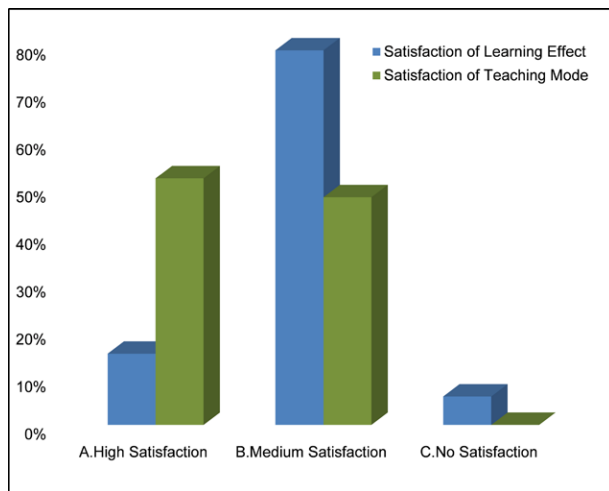


Figure 5. Satisfaction survey of learning effect and teaching mode.

exam, and total score of experimental group was significantly higher than that of the control group, and the difference was statistically significant ( $P < .05$ ). This indicates that compared to the traditional teaching method, ARCS motivational model carefully designed the teaching process, adopted various teaching methods to attract and maintain the attentions of students as well as the classroom vitality. At the same time, it increased the correlation between the knowledge and the actual learning life, making the students feel that the knowledge was closely related to themselves. This makes students better become the main body of learning in the classroom, improving their autonomous learning ability. Moreover, in order to enhance the learning effect of the students and improve the level of learning theory, teachers supervise and feedback the effect of autonomous learning through learning platforms.

**3.5.3. Comparison of ARCS motivation scores between 2 groups.** Besides, in order to greatly mobilize the enthusiasm and subjective initiative of students and make them happy, good and able to learn, teachers in the process of teaching design make full use of pre-class resources employing the superstar,

MOOC and B station network resources and publish micro lesson, operation video, and other related teaching materials. Meanwhile, teachers increase classroom discussion, teacher question answer, stage test, and after-class reflection. The results of the ARCS motivational model are depicted in Table 3. The results show that in the fields of attention and establishment of relevance, the average score of the experimental group was higher than that of the control group, and the difference was statistically significant ( $P < .05$ ), which was consistent with the results of Zhao,<sup>[29]</sup> indicating that the teaching design can stimulate the learning motivations of the students.

**4. Conclusion**

In the era of “Internet +,” the application of a new generation of information technology based on cloud computing, big data, and mobile internet in the education industry is becoming more and more mature, and the supporting and leading role of educational informatization in the reform and development of educational modernization is becoming increasingly prominent. However, Bioinformatics with multidisciplinary characteristics requires interdisciplinary knowledge background, and it is also difficult to learn. Therefore, in this study, the use of ARCS motivational model has important guiding significance for the construction and implementation of the blended teaching model for Bioinformatics, which reflects the teaching concept of “student-centered.” This satisfies the individualized learning needs, avoids the formality of blended teaching, stimulates and maintains students’ learning motivation, and also promotes the transformation of their learning methods. Overall, this teaching mode can optimize the curriculum structure, give full play to the advantages of teaching in time and space, providing new ideas and directions for teaching innovation and curriculum reform in local colleges and universities.

**Author contributions**

**Data curation:** Yinfeng Yang, Ting Ouyang.  
**Formal analysis:** Yinfeng Yang.  
**Investigation:** Yinfeng Yang, Ting Ouyang.  
**Project administration:** Jinghui Wang.  
**Resources:** Lei Zhang.

**Table 2**  
**Comparison of the 2 groups of assessment results (means ± s, score).**

Groups	Usual examination				
	Autonomous learning	Experimental scores	Stage test	Final examination	Total score
Experimental group (n = 51)	90.25 ± 6.78	87.45 ± 12.03	78.42 ± 9.88	79.87 ± 9.24	78.90 ± 7.89
Control group (n = 48)	84.73 ± 8.34	80.56 ± 13.67	67.54 ± 8.39	75.76 ± 8.34	72.21 ± 8.23
t Value	6.69	5.34	3.89	3.56	2.14
P value	.00	.00	.01	.00	.03

**Table 3**  
**Comparison of ARCS motivation scale test scores between the 2 groups (mean ± s).**

Groups	Experimental group (n = 51)	Control group (n = 48)	t Value	P value
Attention (A)	3.38 ± 0.78	1.8 ± 0.88	8.67	.01*
Relevance (R)	3.73 ± 0.84	2.5 ± 0.39	6.59	.00*
Confidence (C)	3.79 ± 0.64	2.3 ± 0.59	7.56	.03**
Satisfaction (S)	3.33 ± 0.71	2.1 ± 0.63	6.71	.00*

ARCS = Attention, Relevance, Confidence, and Satisfaction.

\* $P < .05$ .

\*\* $P < .01$ .

**Writing – original draft:** Yinfeng Yang.

**Writing – review & editing:** Yinfeng Yang.

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