Construction of Teaching Mental Model in Web-based Education Human-computer Emotional Interaction System

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Abstract With the development of modern information technology, network education is becoming more and more popular, showing a trend of rapid development. Compared with traditional education methods, online education is conducive to breaking the restrictions of time and geographical environment on learners, obtaining richer multimodal education resources, and realizing personalized learning. However, in the actual network education, there are some problems such as the lack of students' autonomous learning ability, the lack of effective learning supervision, the disharmony of classroom relations, and the lack of intelligence and emotion in human-computer interaction systems. In the face of this situation, this paper studied the teaching mental model in the network education environment, with a view to building a more harmonious human-computer emotional interaction system, so as to enhance the level of students' positive emotional input and improve the efficiency of students' learning. This paper drew the following conclusions through the analysis and evaluation of the application needs of the mental model of network teaching. 91.77% of the students thought their level of positive emotional input is not high, and 93.07% of the students thought their efficiency was not high enough. Most students were not satisfied with the human-computer interaction system in online education. Experts have high scores in the feasibility evaluation and effectiveness evaluation of the mental model of online teaching. The mental model of network teaching has obvious application demand, and has certain feasibility and effectiveness.

Index Terms Teaching Mental Model, Human-computer Emotional Interaction System, Online Education, Level of Positive Emotional Involvement

I.   Introduction

The rapid popularization of network education has brought convenience to students' learning behavior. For learners, online education can help them get rid of the limitations of time, space, age and other factors on learning activities. It can provide rich resources for their learning activities and realize personalized learning methods. Network education is of great significance for learners. However, it is worth noting that there is a relatively lack of effective means of learning supervision under the network education environment, which puts forward higher requirements for students' active learning ability. In addition, the network education mode also puts forward requirements for the quality of network courseware and human-computer interaction environment. Based on these reasons, this paper studies the teaching mental model, so as to create a better human-computer emotional interaction environment for students and improve the level and efficiency of students' positive emotional input in learning. It is hoped that it can provide valuable reference for related research.

Many scholars have studied mental models. Willingham Daniel T explored the mental model of learners and proposed empirical observation, theoretical statement and cognitive hypothesis methods [1]. Fratiwi Nuzulira Janeusse developed a mental model representation tool based on Newton's law to identify students' mental models. He concluded that the mental models of most students, especially female students, did not follow scientific knowledge [2]. Jarukasemkit Setthanan outlined the causes, views and negative consequences of abuse in medical education, and explored a comprehensive mental model of public humiliation [3]. Utami Anita Dewi studied the initial mental model of freshmen when they understood the concept of function [4]. Zhao Fang thought that text was more able to provide clear conceptual guidance in mental model construction than pictures, and pictures support mental model adaptation more than text [5]. Bilir Volkan studied the mental model of chemical reaction of future science teachers, and proposed the use of reaction related visual materials based on atomic models rather than particle based materials [6]. All these scholars have conducted research on mental models and put forward valuable suggestions.

Online education is widely used in educational practice. Liang Wei proposed a network teaching mode based on virtual reality modeling language by using the constructivist learning theory [7]. Adem Aylin analyzed the ranking of

distance education platforms based on human-computer interaction standards, providing a reference for teaching institutions to choose online online teaching platforms [8]. Based on human-computer interaction algorithm and face recognition algorithm, Hu Liang proposed a method to effectively identify the human-computer interaction process and classroom learning state of students in online teaching [9]. Wong Jacqueline reviewed the research on methods to support self-regulated learning in various types of online learning environments and how they address human factors [10]. Song Hayeon studied the role of teachers' self disclosure and social existence in online education [11]. Palvia Shailendra outlined the connotation of online education, analyzed the current situation, impact and future development trend of online education [12]. Singh Vandana introduced the definition of online learning by scholars, and understood the core elements of defining online learning through content analysis of the collected definitions [13]. Dhawan Shivangi elaborated on the importance of online learning and the advantages, disadvantages, opportunities and challenges of e-learning model in the crisis period, and provided academic institutions with suggestions on how to deal with challenges related to online learning [14]. The form of online education is of great significance to educational activities. Based on this, this paper studied the teaching mental model in online education.

This paper proposed several strategies to optimize network education, such as optimizing infrastructure, software and website quality, strengthening teachers, strengthening network education monitoring, and building a mental model of network teaching. This paper analyzed the application needs of the mental model of online teaching from three aspects: the level of positive emotional attitude investment, learning efficiency, and satisfaction with the human-computer interaction system, and it invited experts to evaluate the mental model of online teaching.

II. Problems in Online Education

The problems in online education are reflected in the following aspects. As shown in Figure 1, it includes problems in infrastructure, software and website quality, insufficient teachers, untimely feedback, excessive reliance on students' self-control and lack of effective supervision. These are not conducive to the establishment of harmonious classroom relations and the imperfect evaluation mechanism.
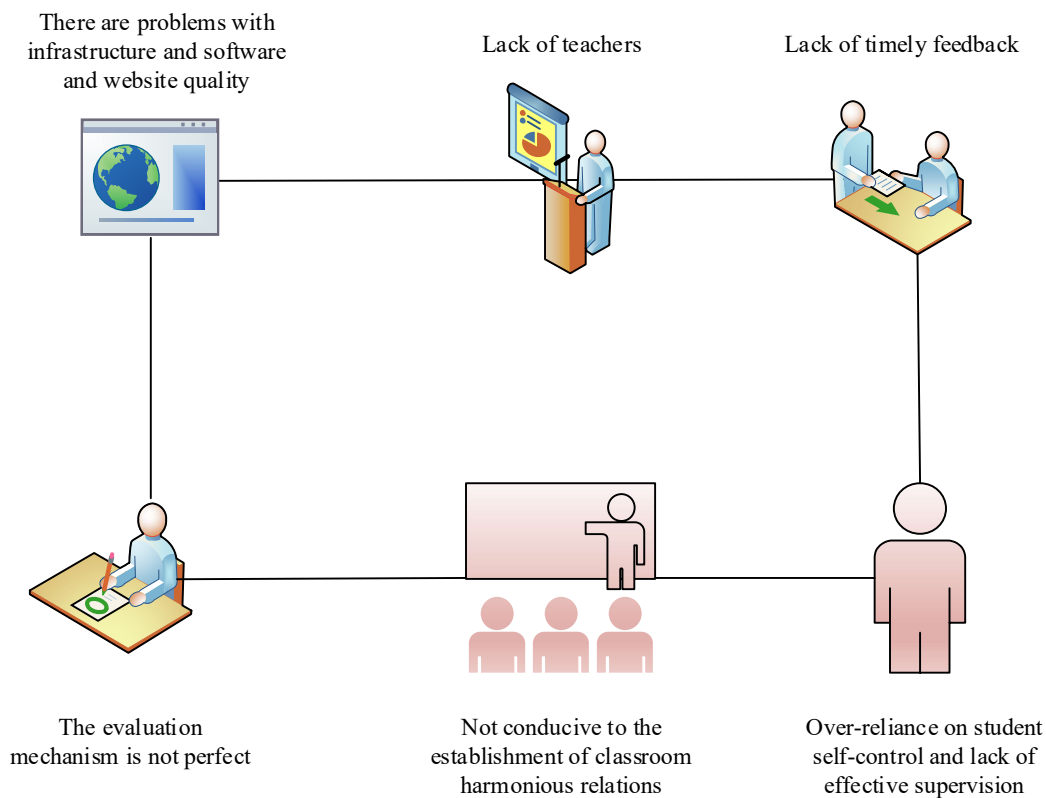

Figure 1: Problems existing in online education

(1) Problems in infrastructure, software and website quality

Although the popularity of computers is high at this stage, there are still problems of unstable network transmission and low quality. For people in backward areas, the popularity of network infrastructure cannot be

effectively guaranteed, and the development of network teaching is not easy. Although the software suitable for online education shows a prosperous development trend, the quality of the software is uneven, and the subject of online education needs to be screened. The quality of websites is the same. Some websites are boring. The sharing and interaction of some websites are poor, and there are many teaching resources, but the quality is not guaranteed.

(2) Insufficient teachers

Like traditional education, online education can not be separated from the effective participation of teachers. If online education wants to achieve better results, it can not only pursue technological progress, but also need to combine the personal level of teachers, the actual needs of the educated and the educational content. Teachers play an irreplaceable role in online education, but there is a shortage of teachers in online education at this stage. There are relatively few teachers who can effectively use online education technology. Some teachers' mastery of network technology can not meet the requirements of network education, which affects the integration of network education and curriculum development, making the effectiveness of network education unable to play.

(3) Feedback is not timely enough

Under the traditional education environment, when students are confused in learning, they can timely put forward their own questions to teachers, and teachers can also timely give feedback to answer students' questions. When the teaching participants are in the network environment, students cannot ask questions to teachers in real time when they encounter difficult knowledge, and they must use the network education equipment. Teachers also need to know the questions raised by students through equipment, and because the network environment is different from the real environment, students' question information may have the risk of being missed by teachers. This affects students' learning interactivity and learning experience, and this mechanical human-computer interaction system also affects the establishment of a harmonious emotional relationship between teachers and students.

(4) Overdependence on students' self-control and lack of effective supervision

Under the traditional education mode, teachers can effectively guide and restrict students' behavior, thus standardizing students' learning behavior. However, this mode also leads to some students' dependence on teachers, which makes students take teachers' requirements as their motivation for learning. Under the network education mode, because there is no face-to-face supervision of teachers, students' learning environment has more free space, and learning methods are more liberal and autonomous, which puts forward higher requirements for students' self-control and active learning ability. If students have poor self-control, they may indulge in the Internet environment full of temptations rather than devote themselves to learning. In addition, there is also a lack of corresponding supervision means in the daily evaluation and examination, which is difficult to fully guarantee the authenticity of students' scores.

(5) It is not conducive to the establishment of harmonious relations in the classroom

Face to face teaching environment can provide good conditions for teachers and students to carry out positive emotional exchanges and establish harmonious classroom relations, while the network environment lacks effective means of emotional expression between teachers and students. This kind of emotional expression in the virtual environment is not true enough, and the care and guidance from teachers are like being discounted, which cannot achieve the desired effect. In addition, there is also a lack of face-to-face communication between learners in the context of online learning, resulting in a dull learning atmosphere.

(6) The evaluation mechanism is not perfect enough

Evaluation is an important link in the education process, including the evaluation of students and teachers. The subject of evaluation and the object of evaluation are diversified. Under the traditional education mode, the evaluation subject can evaluate the quality of teachers' education by such factors as teachers' educational content, educational process design, educational means and attitudes. Under the network education mode, it focuses on the evaluation of students, but relatively ignores the evaluation of teachers.

III. Strategies for Optimizing Online Education

Strategies for optimizing online education include the following aspects, as shown in Figure 2. Specifically, it includes optimizing infrastructure and software as well as website quality, strengthening teachers, strengthening online education monitoring, and building a mental model of online teaching.
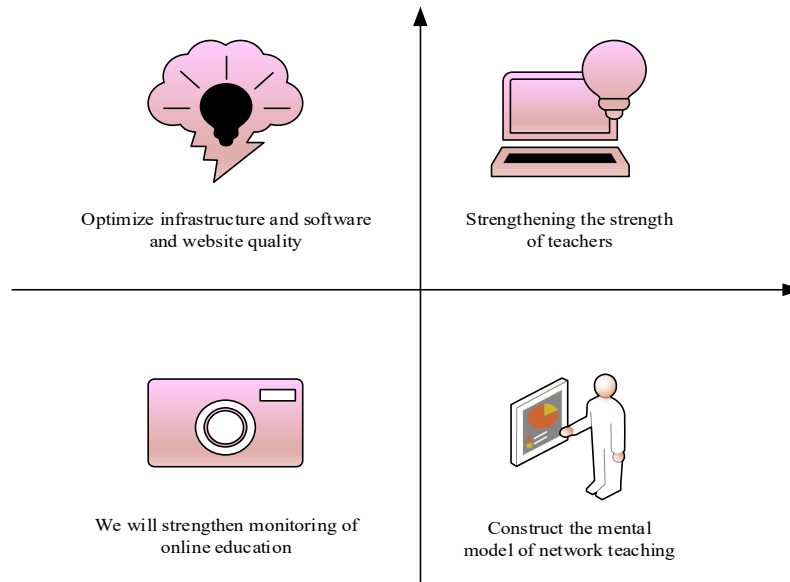
Figure 2: Strategies for optimizing online education

(1) Optimize infrastructure, software and website quality

Through economic development and policy subsidies to improve the network teaching infrastructure, a number of excellent network education platforms can be developed to ensure the stability of network transmission, reduce delay, and provide material support and network support for network education. To develop high-quality online education courseware, courseware developers should pay attention to combining educational theory and psychological theory when making courseware. The courseware should be rich in content, able to highlight the key points, able to play the role of cultivating students' creative thinking and at the same time give consideration to students' autonomous learning ability. In addition, when playing network courseware, network teachers should reasonably choose multimedia forms to promote learners' understanding and mastery of the curriculum. In terms of software and website quality, developers should pay attention to the quality of software and websites, and teaching institutions must pay attention to their quality and interactivity when selecting software and websites.

(2) Strengthening teachers

Teachers are one of the main participants in education and one of the important driving forces for the development of education. The popularization and development of network education form put forward requirements for teachers' ability. Under this environment, teachers should change the traditional education concept, abandon the misunderstanding of the network, and clarify the significance and role of network education. Teachers should actively learn new educational knowledge and network knowledge, organically combine educational knowledge and network knowledge, and flexibly apply network educational knowledge to the form of network education. In addition, based on the perspective of school administrators, school administrators should strengthen the online education technology training for teachers to provide opportunities for teachers to improve the level of online teaching.

(3) Strengthen network education monitoring

Before class: This paper takes school education as an example. Teachers should transmit the information about pre-class courses to the teaching supervisor. The teaching supervisor shall timely detect whether the pre-opening courses meet the conditions for opening courses, and report the courses that meet the conditions for opening courses and those that fail to meet the conditions to the Academic Affairs Office to ensure the normal development of online classroom work. After the class starts: the Academic Affairs Office can irregularly check the online education situation, ask teachers for information related to online teaching, or use background data to analyze the online teaching situation. Teachers can effectively monitor students' online learning behavior through the following ways, limit students' page turning speed, and require them to read in a reasonable time. It can put forward requirements for playing learning videos. Students are not required to sign in regularly. Students are required to upload class notes to the education platform after learning.

(4) Constructing the mental model of network teaching

The application of artificial intelligence is conducive to promoting human-computer interaction in online education [15]. In order to improve the human-computer emotional interaction effect of the network education system, this paper studies the mental model. The traditional Belief Desire Intention (BDI) model includes belief, desire and intention. Belief refers to the basic cognition of the mental model subject to the world. Desire is a state that the subject of mental model expects to achieve, which can be regarded as the goal of the subject. Intent is a desire that the subject of mental model most expects or is most suitable for completing. Under the background of network teaching, based on the BDI model, this paper proposes the Basic features Emotional and cognitive abilities Belief Desire Intention (BEBDI) model. It is expected to establish a more intelligent human-computer emotional interaction system, as shown in Figure 3.

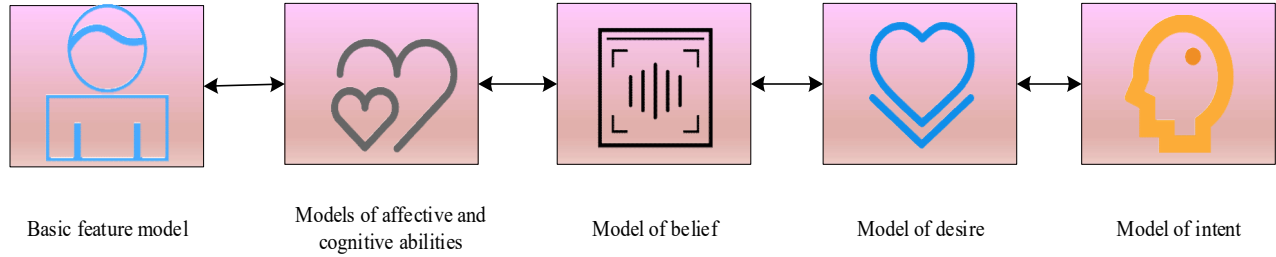| Basic feature model | Models of affective and cognitive abilities | Model of belief | Model of desire | Model of intent |

Figure 3: BEBDI mental model

Basic feature model: the content of the basic feature model includes the basic information characteristics of learners, including the registration information of the network platform, the real information of the teaching participants, the gender of the subject, the age of the subject and the education background of the subject. The model of emotion and cognitive ability includes personality characteristics, interest, motivation, emotional behavior and cognitive ability. Belief model: for learners, the belief model can reflect the learners' mastery of the learned knowledge, including learning and evaluation. Learning does not refer to students' learning of specific knowledge, but refers to various learning methods. Evaluation refers to learners' evaluation of various learning methods such as text learning and video learning. For the teachers, the belief model of the teachers includes the registration information of the learners' network platform and the evaluation information of the students. Desire model: in the learner's desire model, there is only one item of learning objectives, that is, learners can achieve a desired learning state through online learning to meet their own learning needs. The teacher's wish model includes the learner's online registration information and teaching objectives. The teaching goal of the teacher is relative, that is, the goal that the teacher needs to achieve for the individual learner. Intention model: for learners, it only includes the content of teaching process, and for teachers, it includes the content of online registration information of learners and teaching process.

The teaching methods and strategies existing in the mental model of the teacher can be regarded as the initial intention of the learner. When the content in the learner's emotional and cognitive ability model changes, the teacher's mental model would change its own intention model and give students a new teaching strategy process to adapt to the current state of learners. For example, when learners are disgusted with text learning, teachers would change their own intentions through analysis and change audio learning, video learning and other learning methods for learners. The teaching strategy process recorded in the learner's intention model is helpful to maintain the emotional stability of learners, so that learners can improve their positive emotional input level and thus improve their learning efficiency and effectiveness. For example, after the teacher endows the students with a new teaching strategy process, that is, after changing the learning method for the learners, the human-computer emotional interaction system would record this information and ask the learners whether to change the learning method before the learners have emotional fluctuations.

IV. Brief Analysis of Affective Computing in the Context of Online Education

First, it can collect the facial expression and facial pose data of online learners. It is necessary to use machine and manual means to remove unqualified data before data annotation. The emotion of annotation is joy, disgust, depression, confusion and calm, and the data set is divided. Then the convolutional neural network model can be selected for image feature extraction. Finally, multimodal data fusion is carried out. Set the output result of online learners' facial expression model as i^f, and its expression formula is:

$$i^f = \left\{ i_0^f, i_1^f, i_2^f, i_3^f, i_4^f \right\}$$

(1)

Among them, 0 represents joy, 1 represents disgust, 2 represents depression, and 3 represents confusion. Set the output result of the online learner's face pose model as i^g, and its expression formula is:

$$i^g = \left\{ i_0^g, i_1^g, i_2^g, i_3^g, i_4^g \right\} \tag{2}$$

The recognition accuracy of multi-source data fusion model is:

$$\upsilon = a_n * i^f + a_m * i^g \tag{3}$$

$$\upsilon = \sum_{p=0}^{p=4} b_n i_p^f + \sum_{q=0}^{q=4} b_m i_q^g \tag{4}$$

Among them, b_n, b_m are the weight of different emotions.

V. Evaluation of Application Needs of Mental Model of Online Teaching

Firstly, this paper investigates the students in H school who are carrying out online education, including four classes, Q, W, E and R. There are 54 in Class Q, 61 in Class W, 57 in Class E and 59 in Class R. This paper mainly focuses on the level of positive emotional attitude investment, learning efficiency, and satisfaction with human-computer interaction system. Then this paper invited four experts to evaluate the BEBDI network teaching mental model, and called them Expert D, Expert F, Expert V and Expert N. The basic characteristics of students are shown in Table 1.

Table 1: Basic characteristics of students

	Class Q	Class W	Class E	Class R
Mean age	20.54	21.04	20.54	20.37
Mean of grade	75.68	80.24	76.85	78.14
Male students	36	41	28	34
Female students	18	20	29	25

As shown in Table 1, the average age of students in Class Q is 20.54, and the average score is 75.68. There are 36 male students and 18 female students. The average age of students in Class W is 21.04, and the average score is 80.24. There are 41 male students and 20 female students. The average age of students in Class E is 20.54, and the average score is 76.85. There are 28 male students and 29 female students. The average age of students in Class R is 20.37, and the average score is 78.14. There are 34 male students and 25 female students. It can be seen from the data that the age data of the students in the four classes are close to the performance data, which is conducive to reducing experimental errors.

(1) The level of students' positive emotional input

This paper investigates the level of students' positive emotional input and divides it into three levels: high, medium and low, as shown in Figure 4.
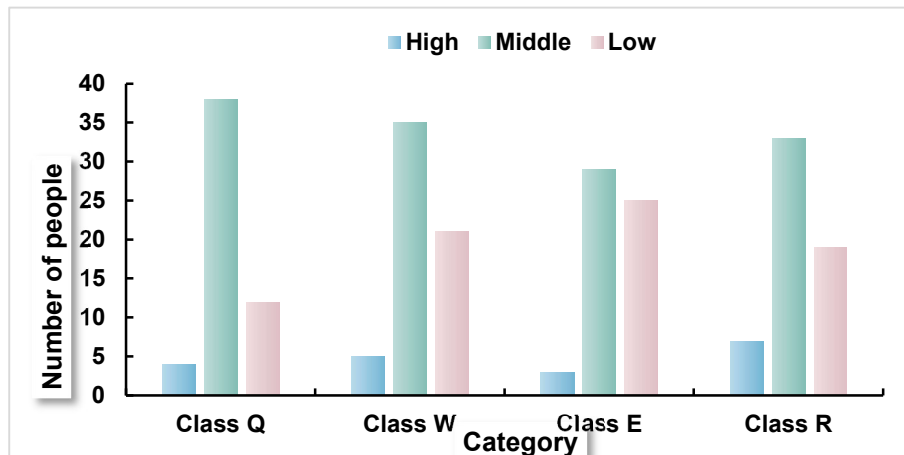

Figure 4: Student's level of positive emotional engagement

As shown in Figure 4, on the whole, most students think their level of positive emotional input is medium. From the specific data, 4 students in Class Q think their level of positive emotional input is high, and 38 students think their level of positive emotional input is medium. 12 people think their level of positive emotional input is low. Five students in Class W think their level of positive emotional input is high. 35 people think their level of positive emotional input is medium, and 21 people think their level of positive emotional input is low. Three students in Class E think their level of positive emotional input is high, 29 think their level of positive emotional input is medium, and 25 think their level of positive emotional input is low. Seven students in Class R think their level of positive emotional input is high, and 33 students think their level of positive emotional input is medium. 19 people think their level of positive emotional input is low. It can be seen from the data that a total of 212 students in the four classes think their level of positive emotional input is not high, accounting for 91.77% of all respondents.

(2) Student learning efficiency

This paper investigates students' views on their own learning efficiency, and divides it into three standards: high, medium and low, as shown in Figure 5.
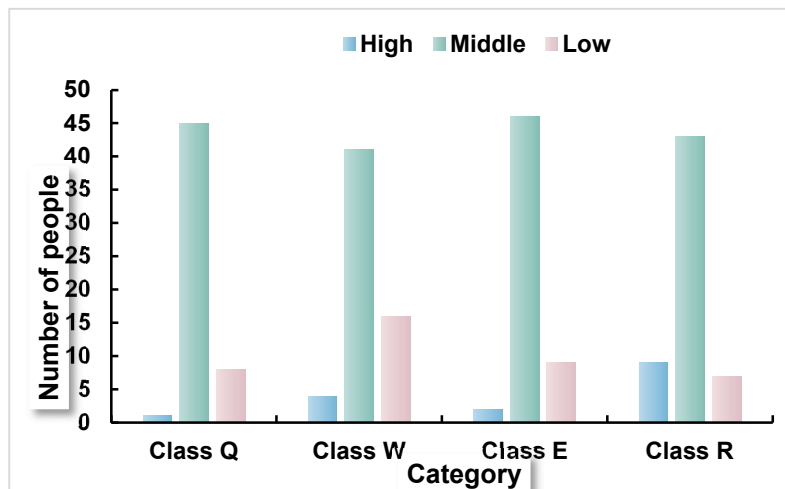

Figure 5: Student learning efficiency

As shown in Figure 5, on the whole, most students think their efficiency is medium. From the specific data, only one student in Class Q thinks their learning efficiency is high, and 45 students think their efficiency is medium. Eight people think their efficiency is low. Four students in Class W think their efficiency is high, 41 think their efficiency is medium, and 16 think their efficiency is low. Two students in Class E think their efficiency is high, 46 think their efficiency is medium, and 9 think their efficiency is low. Nine students in Class R think their efficiency is high, 43 think their efficiency is medium, and 7 think their efficiency is low. It can be seen from the calculation that 215 students in the four classes think that their efficiency in online learning is not high enough, and the proportion of these students is 93.07%.

(3) Student satisfaction with human-computer interaction system

This paper investigates students' satisfaction with the human-computer interaction system, as shown in Figure 6.
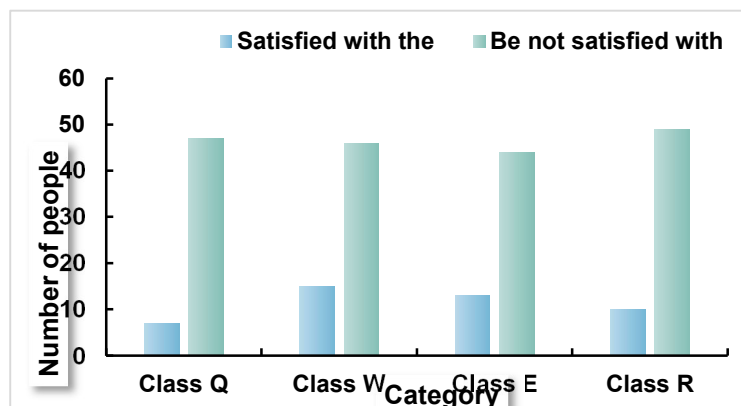

Figure 6: Student satisfaction with human-computer interaction system

As shown in Figure 6, on the whole, most students are not satisfied with the human-computer interaction system. From the specific data, 7 students in Class Q are satisfied with the human-computer interaction system in online education, and 47 students are not satisfied with the human-computer interaction system. There are 15 students in Class W who are satisfied with the human-computer interaction system in online education, and 46 students who are not satisfied with the human-computer interaction system. 13 students in Class E are satisfied with the human-computer interaction system, and 44 students are not satisfied with the human-computer interaction system. 10 students in Class R are satisfied with the human-computer interaction system, and 49 students are not satisfied with the human-computer interaction system. From the data, it can be calculated that 186 students in four classes are dissatisfied with the human-computer interaction system in online education, accounting for 80.52%. This shows that the human-computer interaction system in online education still needs to be optimized, and the construction of the mental model of online teaching is conducive to making the human-computer interaction system more intelligent and emotional.

(4) Experts' evaluation on mental model of network teaching

This paper records the experts' evaluation scores on the feasibility and effectiveness of the BEBDI online teaching mental model, as shown in Figure 7.
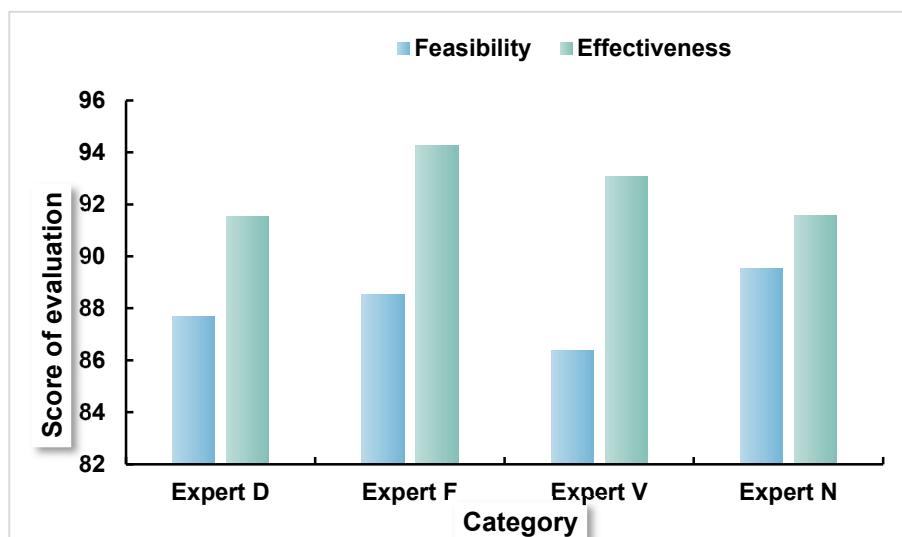

Figure 7: Expert evaluation of the mental model of online teaching

As shown in Figure 7, expert D scored 87.69 on the feasibility of the mental model of online teaching and 91.52 on the effectiveness of the mental model of online teaching. Expert F scored 88.54 on the feasibility of the mental model of online teaching and 94.26 on the effectiveness of the mental model of online teaching. Expert V scored 86.37 on the feasibility of the mental model of online teaching and 93.07 on the effectiveness of the mental model of online teaching. Expert N scored 89.54 on the feasibility and 91.58 on the effectiveness of the online teaching mental model. The average feasibility evaluation score of the four experts for the mental model of online teaching is 88.04, and the average effectiveness evaluation score for the mental model of online teaching is 92.61.

VI. Conclusions

This paper first summarized the problems in online education, such as insufficient teachers, excessive dependence on students' self-control and lack of effective supervision, which was not conducive to the establishment of harmonious classroom relations. Secondly, this paper put forward some countermeasures to optimize network education, such as strengthening the teaching staff, strengthening the monitoring of network education and constructing the mental model of network education. After analyzing BDI mental model, this paper proposed BEBDI mental model, which included basic feature model, emotion and cognitive ability model, belief model, etc. Then it introduced affective computing in the context of network education, and finally analyzed and evaluated the application of the mental model of network education. The conclusions are that most students believed that their own positive emotional input level was not high and their own efficiency was not high in the online education environment. Most students were not satisfied with the human-computer interaction system of online education. Experts believed that the mental model of online teaching was feasible and effective.

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