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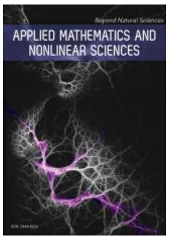

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Research on the reform and effect evaluation of three-dimensional motion animation blended teaching based on fuzzy evaluation model

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Abstract

This paper combines the teaching of a 3D animation course with the blended teaching mode and constructs a framework for the design of 3D animation blended teaching reform. Based on the fuzzy comprehensive evaluation algorithm, we adopt qualitative and quantitative methods to determine the evaluation index system of teaching reform, divide the course teaching objectives, teaching content, learning resources, online learning and teaching design and classroom organization into five first-level indexes, establish the weights of the evaluation index system, and complete the construction of the fuzzy comprehensive evaluation system of 3D animation blended teaching. Examine the design and teaching effects of 3D animation that blends learning from different dimensions, and examine the correlation between learners' multi-dimensional recognition of teaching reform and its learning impact. By combining the weights of each index, the fuzzy comprehensive evaluation results are obtained by determining the affiliation degree of each index using the fuzzy statistical method. The operation results show that the fuzzy comprehensive evaluation scores of the five first-level indicators of teaching reform are 0.754546, 0.69943, 0.638926, 0.66888, and 0.5966. It can be seen that the comprehensive evaluation results of the five aspects have achieved good results. The evaluation of teaching reform's effects can be targeted and feasible using a fuzzy comprehensive evaluation model.

Keywords: Fuzzy comprehensive evaluation; Fuzzy statistical method; Three-dimensional animation; Blended teaching.
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1 Introduction

In contemporary college students, in the context of electronic information technology, the skilled use of electronic devices for learning is a general trend, and online and offline hybrid teaching modes are also commonly used in teaching. Three-dimensional animation design course mainly explains the process and skills of three-dimensional modeling and three-dimensional animation production and teach students relevant knowledge about three-dimensional animation design and production [1-3]. The construction of 3D models is mainly accomplished with the assistance of computer software [4]. The course demands a high level of theoretical knowledge and practical skills from students, who must be able to master various operations of modeling software and associated parameter settings. In addition, the course is a cross-cutting comprehensive course; students not only need to master computer-related skills but also need to master a certain degree of aesthetic knowledge and, at the same time, have a high degree of spatial imagination [5-6].

With the rapid development of information technology, some new technical means continue to appear, and students working in the field of three-dimensional modeling need to have a strong learning ability [7]. In order to develop students' self-learning abilities, higher education teachers must provide relevant teaching resources in the teaching process [8]. At present, the relevant policies point out that the deep integration of information technology and educational resources should be carried out, the quality of online education should be continuously improved, the relevant resources and service standard system should be comprehensively established, and a more sound networked, digital, personalized and lifelong education system should be initially constructed. Blended learning and fuzzy evaluation models are combined to evaluate the impact of the teaching reform of a 3D animation course in this context.

Xu, L. pointed out that the development of 3D technology has promoted the construction of face models in 3D animation, but the facial appearance established needs to be further optimized due to the inconsistency of expression and facial muscle movement in detail. Based on this, a simulation model of character expression in the framework of 3DS Max is proposed and facial muscle movement is modeled based on the relationship between the bones and muscles of the head [9]. Kumarapu, L. et al. proposed a supervised multi-person 3D pose estimation and animation framework for 3D animation of human motion, i.e., the effect of a given input RGB video sequence. The pipeline of the system consists of various modules, which mainly include multi-person 2D pose estimation, depth mapping estimation, 2D pose to 3D pose conversion, human trajectory prediction and human pose tracking [10].

Shi, X. argues that the development of information technology provides a new development direction for art and design, among which 3D animation modeling is a new multimedia technology based on computer technology. The research aims to realize the recognition and classification of 3D models and designs and proposes a new network model, which is based on a capsule network using vector neurons to store feature space information. In order to test the effectiveness of this network model, three methods are selected for performance comparison. [11]. Liu, J. et al. analyzed and discussed the optimization model and mobile model of animation art design and pointed out that in order to solve the problem that user migration cannot be perceived, a content-based mobile edge animation design mechanism is proposed. Users' perception of nodes, animation design speed, and residence time in small areas can all be calculated comprehensively by this mechanism [12]. Li, Q. et al. proposed a particle swarm optimization algorithm based on the automatic control of group animation behavior in order to improve the autonomy and intelligence of group animation behavior. The global optimal solution is converged to by the evolution time of PSO again when the surrounding environment changes 10 times, as demonstrated by the experimental results. The particle swarm optimization algorithm is significantly better than the other two algorithms in terms of population diversity in the state of automatic control of the movement of individuals and crowd animation [13].

Deng, X. et al. pointed out that the emergence of VR technology requires a virtual environment based on high-tech computer technology but is able to provide people with different sensory experiences. In order to improve students' learning interest, virtual reality technology is combined with experimental teaching to explore the application effect of VR technology in the experimental teaching of animation art [14]. Ma, Z. et al. believe that the traditional teaching content of animation professional training needs to be adapted to the current market environment and keep in line with the market reality. Starting from the needs of the animation industry, the professional competence of animation undergraduates was analyzed, and the problems of the animation professional training and teaching system were explored [15]. Fang, N. et al. focused on analyzing the problems that need to be solved by the students when learning computer simulation and animation. Based on the analysis of activity data from 24 student participants, it was concluded that computer simulation and animation are more helpful in understanding and helping students solve problems encountered during the learning process compared to the traditional textbook style [16]. Zhang, Z. et al. demonstrated that it is difficult for educators to write virtual character animations that are consistent with reality. The study developed a methodology for creating animations that utilize human-computer interaction and intelligent algorithms, which was utilized in the experimental teaching of mixed reality [17]. Liu, L. et al. specifically analyzed the impact of the development of new media on the development of animation, which includes two main parts: the first is the change of publishing media, and the second is the change of the scale of the order of the change and the diversity of the publishing channels and dissemination. The study also involves teaching about the process of new media animation production, utilizing the concept of strengthening specialization in the curriculum and applying assessment criteria to effectively analyze students' mastery of animation theory [18]. Chen, R. R. et al. point out that in the era of new media, the talent cultivation of animation education is moving towards the goal of high-end talents. Based on the model singularity of the design model of the model-based system engineering animation research platform, a structure-behavior aggregation state machine was developed, and the application effect of using this state machine method was analyzed [19].

Based on the needs of higher education talent cultivation, this paper divides the 3D animation course into three phases: before, during and after class, designing the "five-one" teaching program, and integrating the framework of 3D animation blended teaching design. The fuzzy comprehensive evaluation method is selected, combined with the reform design of three-dimensional animation hybrid teaching, the evaluation index system is clarified, and the fuzzy comprehensive evaluation mathematical model of three-dimensional animation hybrid teaching is established. Among them, the 3D animation blended teaching is specifically divided into five first-level indicators and 17 second-level indicators for course teaching objectives, teaching content, learning resources, online learning, teaching design and classroom organization. Using example data and combining quantitative analysis methods to analyze the design and teaching effect of 3D animation blended teaching, the correlation analysis between 3D animation blended teaching and teaching effect is carried out to explore the correlation between the learners' multidimensional recognition of teaching reform and learning effect. Based on the qualitative analysis indexes, the fuzzy statistical method is used to determine the grade of each evaluation index, and the final fuzzy comprehensive evaluation results of 3D animation blended teaching reform are obtained by arithmetic.

2 Method

2.1 Design of Blended Teaching Reform for 3D Animation Courses

Blended teaching is a method of teaching that blends online independent learning with offline face-to-face instruction. With the development of informationization construction in colleges and universities and the deepening of teaching reform, the promotion of blended teaching has become a teaching mode that is jointly explored and widely applied by all professional disciplines.

According to the needs of higher education talent cultivation, the blended teaching mode is adopted for 3D animation teaching, and the specific implementation process is shown in Figure 1. Give full play to students' initiative and personality, improve students' learning interests in multiple ways and from multiple angles, and form a curriculum system adapted to the needs of the industry. The blended teaching design of 3D animation aims to cultivate excellent students with high comprehensive quality who are active in thinking, united and collaborative, courageous in expression, good at doing things, and diligent in self-study. The course introduces a blended teaching mode, establishes teaching resources before, during and after class, as well as corresponding teaching methods and assessment methods, and designs a student-led "five-one" teaching program. That is to say, watching a microclass, completing a task, conducting a demonstration, carrying out a discussion and realizing an improvement so that the information-assisted teaching method can be carried out throughout the blended teaching before, during and after the whole course.

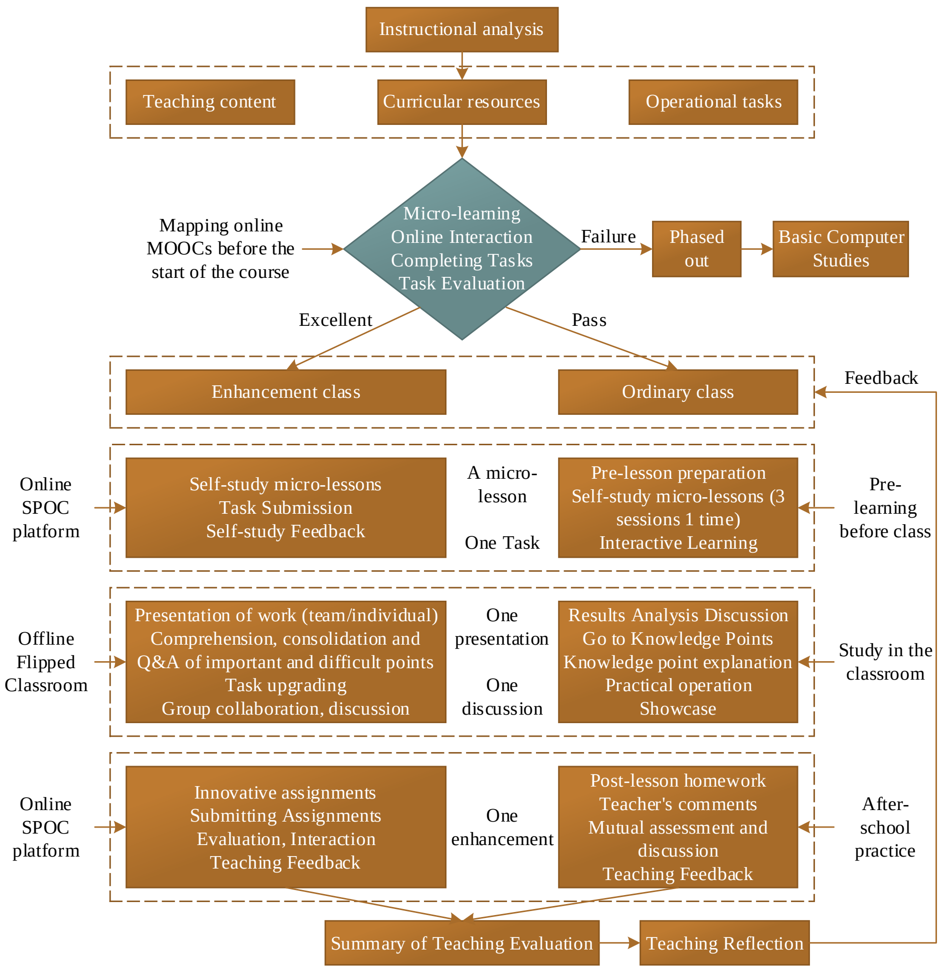

Figure 1. 3d animation hybrid teaching implementation process

2.2 Mathematical model of the fuzzy comprehensive evaluation methodology

Let U be the set of certain objects, called the domain, which can be stylized continuous or discrete. u denote the elements of U, denoted $U=\{u\}$.

Define 1:

Any mapping μ_F, i.e., $\mu_F: U \to [0,1]$, of an interval from an argument domain U to [0,1] determines U a fuzzy subset F, μ_F called the affiliation function or degree of affiliation of F. That is, μ_F denotes the degree or rank to which u belongs to a fuzzy subset F. In the argument domain U, a fuzzy subset can be represented as the set of ordinal couples of an element u with its affiliation function $\mu_F(u)$, denoted as:

$$F=\{(u,\mu_F(u)) \mid u \in U\} \tag{1}$$

If U is continuous, the fuzzy set F can be denoted as:

$$F=\int_U \mu_F(u)/u \tag{2}$$

If U is discrete, the fuzzy set F can be written as:

$$\begin{aligned} F &= \mu_F(u_1)/u_1+\mu_F(u_2)/u_2+\cdots\cdots+\mu_F(u_n)/u_n \\ &= \sum \mu_F(u_i)/u_i, \qquad i=1,2,\cdots\cdots,n \end{aligned} \tag{3}$$

Definition 2:

A fuzzy set is said to be a branched set of a fuzzy set F if the fuzzy set is the set consisting of all elements u in the argument domain U that satisfy $\mu_F(u)>0$. When u satisfies $\mu_F=1.0$, then this fuzzy set is said to be a fuzzy singularity.

Definition 3:

Let A and B be two fuzzy sets in the domain U with affiliation functions μ_A and μ_B, respectively, then for all $u \in U$, the following operations exist:

1) The concatenation of A and B is denoted as $A \cup B$ and its affiliation function is defined as:

$$\mu_{A\cup B}(u)=\mu_A(u)\vee\mu_B(u)=\max\{\mu_A(u),\mu_B(u)\} \tag{4}$$

2) The intersection of A and B is denoted as $A \cap B$ and its affiliation function is defined as:

$$\mu_{A\cap B}(u)=\mu_A(u)\wedge\mu_B(u)=\min\{\mu_A(u),\mu_B(u)\} \tag{5}$$

3) The complement of A is denoted as $\bar{A}$ and its transfer function is defined as:

$$\mu_{\bar{A}}(u) = 1 - \mu_A(u) \tag{6}$$

Definition 4:

If $A_1 A_2, \cdots\cdots, An$ is a fuzzy set in the thesis domain, $U_1, U_2, \cdots\cdots, U_n$ respectively, then the direct product of these sets is a fuzzy set in the product space $U_1 \times U_2 \times \cdots\cdots \times Un$ with an affiliation function:

$$\begin{aligned} \mu_{A_1 \times \ldots\ldots A_n}(u_1, u_2, \cdots, u_n) &= \min\{\mu_{A1}(u_1), \cdots\cdots, \mu_{An}(u_n)\} \\ &= \mu_{A1}(u_1)\mu_{A2}(u_2)\cdots\cdots\mu_{An}(u_n) \end{aligned} \tag{7}$$

Definition 5:

If U, V is two non-empty fuzzy sets, a fuzzy subset R of its direct product $U \times V$ is called a fuzzy relation from U to V and can be expressed as follows:

$$U \times V = \{((u, v), \mu_R(u, v)) \mid u \in U, v \in V\} \tag{8}$$

Definition 6:

If R and S are fuzzy relations in $U \times V$ and $V \times W$ respectively, then the composite $R \circ S$ of R and S is a fuzzy relation from U to W, denoted:

$$R \circ S = \left\{ \left[(u, w); \sup_{v \in V} (\mu_R(u, v) * \mu_S(v, w) \right] u \in U, v \in V, w \in W \right) \tag{9}$$

Its affiliation function is:

$$\mu_{R \circ S}(u, w) = \vee_{v \in V} (\mu_R(u, v) \wedge \mu_S(u, v)), (u, w) \in (U \times W) \tag{10}$$

The * sign in Eq. (9) can be any of the operators within the trigonometric paradigm, including fuzzy intersection, algebraic product, bounded product, and straight product.

Definition 7:

A fuzzy set F with real number R as its domain, if its affiliation function satisfies:

$$\max_{x \in R} \mu_F(x) = 1 \tag{11}$$

Then F is a normal fuzzy set. If for any real number $x, a < x < b$, there is:

$$\mu_F(x) .. \min\{\mu_F(a), \mu_F(b)\} \tag{12}$$

Then F is a convex fuzzy set. If F is both normal and convex, then F is said to be a fuzzy number.

Definition 8:

A linguistic variable can be defined as the multivariate group $(x,T(x),U,G,M)$. where x is the variable name. $T(x)$ is the lexical set of x, i.e., the set of language-valued names. U is the thesaurus, and G is the syntactic rule that produces the name of the language value. M is the syntax rule relating the meaning of each linguistic value. Each linguistic value of a linguistic variable corresponds to a fuzzy number defined in the argument domain U. The set of basic words of linguistic variables relates fuzzy concepts to precise values, enabling the quantification of qualitative concepts as well as the qualitative fuzzification of quantitative data.

2.2.1 Single-level fuzzy comprehensive evaluation algorithm

1) Determine the set of evaluation factors expressed in equation (13):

$$U=\{u_1,u_2\ldots\ldots,u_m\} \tag{13}$$

Where for $u_i, i=1,2,\ldots,m$ is the evaluation factor, m is the number of individual factors at the same level, and this set constitutes the framework of the evaluation.

2) Determine the set of evaluation results expressed in equation (14):

$$V=\{v_1,\ldots,v_n\} \tag{14}$$

where $v_j, j=1,2,\ldots,n$ is the evaluation result and n is the number of elements, i.e., the number of grades or the number of rubric grades. This set specifies the range of choices for the evaluation outcome for a given evaluation element. The elements of the result set can be either qualitative or quantitative scores.

3) Determine the affiliation matrix, which is represented by equation (15):

Suppose that for the i rd evaluation factor u_i, a single factor evaluation is performed to obtain a fuzzy vector with respect to v_j:

$$R_i=\left(r_i,r_{i2},\ldots,r_{im}\right), i=1,2,\ldots,m; j=1,2,\ldots,n \tag{15}$$

4) Determine the set of weights expressed in equation (16):

$$W=\left(w_1,\ldots,w_n\right) \tag{16}$$

Where $w_i, i=1,2,\ldots,n$ denotes the importance of factor $u_i, i=1,2,\ldots,n$, i.e., the weight assigned to $u_i, i=1,2,\ldots,n$, satisfying equation (17):

$$\sum_{i=1}^{n} Wi=1, 0\le Wi\le 1 \tag{17}$$

5) Get the final evaluation result B:

The synthesis of the weight vector A and judgment matrix R is the final evaluation result of the object as in equation (18):

$$B = W\square R = (b_1, b_2, \ldots, bn) \tag{18}$$

which satisfies equation (19):

$$bj = \sum_{i=1}^{n} Wi\square Rij,\ j = 1, 2, \ldots, n \tag{19}$$

2.2.2 Multi-level fuzzy comprehensive evaluation algorithm

1) Determine the hierarchical relationship between factors

2) Establish the weight set

First of all, establish the weight set of factor class A. According to the importance of each type of factor, give each factor class the corresponding weight. Let the weight of factor $u_i, i = 1, 2, \ldots, l$ of category i be $w_i, i = 1, 2, \ldots l$, then the weight set of this factor category is equation (20):

$$A = (w_1, w_2, \ldots, w_n) \tag{20}$$

Next, the set of factor weights is established Ai. In each category of elements, each factor is assigned a corresponding weight according to the importance of each factor. Let the weight of the j th factor $u_{ij}, i = 1, 2, \ldots, l; j = 1, 2, \ldots m$ in the category i be $w_{ij}, i = 1, 2, \ldots, l; j = 1, 2, \ldots m$, then the set of factor weights is expressed by equation (21):

$$A_i = (w_{i1}, w_{i2}, \ldots, w_{im}), i = 1, 2, \ldots l \tag{21}$$

3) Establishment of evaluation result set V

This step has the same significance as the establishment of evaluation results set in single-level fuzzy comprehensive evaluation [20-21].

It is expressed by equation (22):

$$V = (v_1, v_2, \ldots, v_n) \tag{22}$$

4) Conducting a comprehensive evaluation of the lowest-ranking factors

That is, the comprehensive evaluation is conducted according to the factors in a certain category. Let the $i, i = 1, 2, \ldots, l$ class of the $j, j = 1, 2, \ldots, m$ element of the comprehensive evaluation, the evaluation object belongs to the evaluation results of the $k, k = 1, 2, \ldots, n$ element of the degree of affiliation is $r_{ijk}, i = 1, 2, \ldots l; j = 1, 2, \ldots, m; k = 1, 2, \ldots, n$, then the comprehensive evaluation of the single-factor affiliation matrix expressed in the formula (23):

$$R_i = \begin{pmatrix} r_{i11} & r_{i12} & \cdots & r_{ikk} \\ r_{i21} & r_{i22} & \cdots & r_{i2k} \\ \cdots & \cdots & \cdots & \cdots \\ r_{im1} & r_{im2} & \cdots & r_{imk} \end{pmatrix}, i = 1, 2, \ldots l \tag{23}$$

Thus, the fuzzy comprehensive evaluation matrix for the factors of category $i, i = 1, 2, \ldots, l$ is represented by equation (24):

$$\begin{aligned} B_i = A_i \circ R_i &= \begin{pmatrix} w_{i1} & w_{i2} & \cdots & w_{im} \end{pmatrix} \circ \begin{pmatrix} r_{i11} & r_{i12} & \cdots & r_{i1k} \\ r_{i21} & r_{i22} & \cdots & r_{i2k} \\ \cdots & \cdots & \cdots & \cdots \\ r_{im1} & r_{im2} & \cdots & r_{imk} \end{pmatrix} \\ &= \begin{pmatrix} b_{i1} & b_{i2} & \cdots & b_{im} \end{pmatrix}, i = 1, 2, \ldots, n \end{aligned} \tag{24}$$

5) Conducting a fuzzy comprehensive evaluation of factors at the next lowest level

The lowest level of fuzzy comprehensive evaluation is only a synthesis of the factors in a class, and in order to consider the combined effects of the factors, a synthesis between the classes must also be performed.

When the comprehensive evaluation of factors between classes is performed, the evaluation performed is a single-factor evaluation, and the single-factor evaluation matrix shall be the lowest level fuzzy comprehensive evaluation matrix:

$$B = \begin{pmatrix} B_1 \\ B_2 \\ \cdots \\ B_l \end{pmatrix} = \begin{pmatrix} A_1 & \circ & R_1 \\ A_2 & \circ & R_2 \\ & \cdots & \\ A_l & \circ & R_l \end{pmatrix} = \begin{pmatrix} b_1 & b_2 & \cdots & b_l \end{pmatrix} \tag{25}$$

2.3 Establishment of Fuzzy Comprehensive Evaluation System for Blended Teaching of 3D Animation

2.3.1 Data sources

This paper utilizes the web-based course management platform system in School S to issue questionnaires applicable to students and teachers of 3D animation majors about the evaluation of 3D animation blended courses, respectively. The questionnaires were regularly distributed at the end of each semester, and both 3D animation majors and teachers were asked to fill out the questionnaires for students involved in the blended teaching course. The 3D animation blended course evaluation was able to obtain some data about the students and teachers by collecting and organizing questionnaires. For the aspect of the expert survey, the school teachers contact the expert teachers of other universities so as to get the expert evaluation data.

A total of 482 questionnaires were collected in this survey, of which 478 were valid. By analyzing the data, we get α coefficient equal to $0.972 > 0.9$, and KMO value is 0.976, greater than 0.9, which indicates that the overall reliability and validity of the questionnaire are good and has a certain degree of credibility.

2.3.2 Determination of fuzzy integrated evaluation indicators

The evaluation of 3D animation blended teaching effectiveness includes five parts: 3D animation course teaching objectives, 3D animation teaching content, 3D animation learning resources, online learning and teaching design and classroom organization. The corresponding specific evaluation indicators are qualitative. A fuzzy comprehensive evaluation is performed on teaching objectives, teaching content, learning resources, online learning, teaching design, and classroom organization in this paper. Based on the corresponding fuzzy comprehensive evaluation results and the weights of teaching objectives, teaching content, learning resources, online learning, instructional design and classroom organization, the linear weighting method is used to obtain the evaluation results of 3D animation blended teaching effectiveness. The specific steps are as follows:

1) Determine the fuzzy comprehensive evaluation index U

Evaluation indicators are evaluated comprehensively using a 3D animation blended teaching effect evaluation index system.

$$\begin{aligned} U &= \langle U_1, U_2, U_3, U_4, U_5 \rangle \\ &= \left\langle \begin{matrix} Teaching\ goals, Teaching\ content, Learning\ resources, \\ Online\ learning, Teaching\ design\ and\ classroom\ organization \end{matrix} \right\rangle \end{aligned} \tag{26}$$

Among them, U_i consists of secondary indicators, respectively. U_1, U_2, U_3, U_4, and U_5 are instructional objectives, content, learning resources, online learning and instructional design and classroom organization, respectively.

Teaching objectives U_1:

$$U_1 = \{Knowledge\ teaching, ability\ training, quality\ improvement\} \tag{27}$$

Teaching objectives include three aspects: transfer of knowledge of 3D animation, ability development, and quality enhancement.

Teaching content U_2:

$$U_2 = \left\{ \begin{matrix} Design\ teaching\ content\ around\ the\ teaching\ target, \\ Clear\ the\ students'\ self\text{-}taught\ content, \\ Highlight\ the\ students'\ practical\ ability\ and\ innovation\ ability \end{matrix} \right\} \tag{28}$$

The teaching content consists of three parts, respectively: designing the teaching content around the teaching objectives, clarifying the content of students' self-study as the main content, and highlighting the cultivation of students' practical ability and innovation abilities.

Learning Resources U_3:

$$U_3 = \left\{ \begin{array}{l} \textit{Curriculum standards for online teaching platforms}, \\ \textit{Teaching resources update timely}, \\ \textit{Expand the resources of sexual learning}, \\ \textit{Teachers share teaching resources} \end{array} \right\} \tag{29}$$

Learning resources consist of four parts: curriculum standards within the online teaching platform, timely updating of teaching resources, the richness of extended learning resources, and co-construction and sharing of teaching resources by teachers in the course group.

Online learning U_4:

$$U_4 = \left\{ \begin{array}{l} \textit{Design around teaching goals}, \\ \textit{Use the network teaching platform to guide students to study} \end{array} \right\} \tag{30}$$

Online learning is broken down into two components: designing around instructional objectives and guiding students through the online teaching platform.

Instructional design and classroom organization U_5:

$$U_5 = \left\{ \begin{array}{l} \textit{Focus on the course and arrange the content of the course}, \\ \textit{Classroom teaching is clear}, \\ \textit{Effective application of modern information technology}, \\ \textit{Reasonable control of teaching}, \\ \textit{Focus on inspiration and discussion} \end{array} \right\} \tag{31}$$

Teaching design and classroom organization consist of focusing on course priorities, arranging the content of lectures in a targeted manner, clear thinking in classroom lectures, effective application of modern information technology, reasonable control of teaching sessions, and focusing on inspiration and discussion.

2) Determine the evaluation set of indicators V

$$\begin{aligned} V &= \{V_1 V_2 V_3 V_4 V_5\} \\ &= \{\textit{Out of line}, \textit{Worse}, \textit{Medium}, \textit{Good}, \textit{Excellence}\} \end{aligned} \tag{32}$$

3 Result and discussion

3.1 Determination of weights of fuzzy evaluation index system

The evaluation of a blended teaching course is a comprehensive evaluation involving multiple factors with multiple uncertainties, which is difficult to directly analyze qualitatively by quantitative standards, and it is not easy to compare between different disciplines and different teaching methods. In this paper, the fuzzy comprehensive evaluation model is chosen to carry out a fuzzy comprehensive evaluation of the factors that are difficult to analyze accurately and quantitatively in order to seek a more realistic evaluation result. To ensure the scientific nature of fuzzy comprehensive evaluation, it is crucial to select the right evaluation indicators. The evaluation system of the blended course is equipped with a total of five first-level indicators, which are course teaching objectives, teaching content, learning resources, online learning and teaching design and classroom organization, and there are 17 corresponding second-level indicators under the first-level indicators. The evaluation index system is established through the use of both qualitative and quantitative methods.

The rating index system's weights are depicted in Table 1. The first-level indicators of the 3D animation blended teaching evaluation index system are five parts: course teaching objectives, teaching content, learning Xi resources, online learning Xi, teaching design and classroom organization, and the weight coefficients are 0.24465, 0.20145, 0.18939, 0.13776 and 0.22675, respectively. The secondary indicators had their weights calculated separately. Among them, the three-dimensional animation blended teaching design and classroom organization is mainly divided into five secondary indicators: focusing on the key points of the course, arranging the teaching content in a targeted manner, having clear classroom teaching ideas, effectively applying modern information technology, reasonably controlling the teaching process, focusing on inspiration and discussion, and encouraging students to think independently, with weight coefficients of 0.25331, 0.18836, 0.21045, 0.21528 and 0.1326 respectively.

Table 1. Rating system weight

Primary indicator	Weighting	Secondary indicator	Weighting
Course teaching objectives	0.24465	Teaching of knowledge	0.28642
		Ability culture	0.43671
		Quality improvement	0.27687
Teaching content	0.20145	Design teaching content around the teaching target	0.29253
		Organize the knowledge point, make clear the student self-study mainly content	0.37725
		Highlight the students' practical ability and innovation ability	0.33022
Learning resources	0.18939	Curriculum standards for online teaching platforms	0.31564
		Timely update of regular teaching resources	0.36385
		Expand the resources of sexual learning	0.20457
		The curriculum group builds and Shared the teaching resources	0.11594
Online learning	0.13776	Design online learning activities around the teaching target	0.54474
		Use the network teaching platform to guide students to study	0.45526
Teaching design and classroom organization	0.22675	Focus on the course and arrange the content of the course	0.25331
		Classroom teaching is clear	0.18836
		Effective application of modern information technology	0.21045
		The teaching link is reasonable	0.21528
		Encourage students to think independently	0.13260

3.2 Evaluation of satisfaction with blended teaching of 3D animation

The evaluation results of the 3D animation blended teaching design are shown in Table 2. The statistics show that among the 478 3D animation students, 278 of them are satisfied with the clarity of the learning objectives of the 3D animation blended teaching design, accounting for more than half of them. Only 55 individuals perceived the learning objectives as unclear and did not reflect the fundamentals of 3D animation teaching. In the evaluation of 3D animation blended teaching design, the highest satisfaction level is the logical rationality of 3D animation resources, accounting for

0.6046. The satisfaction level of 3D animation blended teaching design in the five aspects of the clarity of learning objectives, the richness of the course content arrangement, the logical rationality of the resources, the degree of satisfaction with the animation effect and the satisfaction with the interface design are all maintained at more than 50%, which indicates that the arrangement of 3D animation blended teaching design still needs to be optimized and improved. The arrangement requires further optimization and improvement.

Table 2. 3D animation hybrid teaching design evaluation results

	Content and proportion		
	Satisfaction	General	Discontent
Learning goal clarity	278(0.5816)	145(0.3033)	55(0.1151)
The content of the course is enriched	245(0.5126)	175(0.3661)	58(0.1213)
Resource logic	289(0.6046)	136(0.2845)	53(0.1109)
Animation effect satisfaction	275(0.5753)	128(0.2678)	75(0.1569)
Interface design satisfaction	268(0.5607)	137(0.2866)	73(0.1527)

3.2.1 Evaluation of teaching satisfaction

The teaching effect of 3D animation blended teaching, is analyzed from four dimensions, which are stimulating the interest in 3D animation, helping to understand and deepen the knowledge, improving learning efficiency, and improving independent learning ability. The results of the data analysis of the blended teaching effect are shown in Table 3. Among them, in the three parts of learning interest, helping to understand and deepen knowledge and learning efficiency, all 26 people think that the existing blended teaching effect of 3D animation does not reach the goal and does not help the learning of 3D animation. Over 50% of 3D animation students believe that the current blended teaching method of 3D animation can stimulate their learning interest, according to 0.7385 percent of students. Only 0.5962 students feel very helpful when it comes to helping to understand and deepen their knowledge of 3D animation, which is less than half of the total of 285.

Table 3. Hybrid teaching effect data analysis results

	Content and percentage				
	Totally unhelpful	Not very helpful	General	Compare to	Very helpful
It inspired interest in 3d animation	26 (0.0544)	12 (0.0251)	35 (0.0732)	52 (0.1088)	353(0.7385)
Help understand and deepen knowledge	26(0.0544)	27(0.0565)	45(0.0941)	95(0.1987)	285(0.5962)
Improve learning efficiency	26(0.0544)	10(0.0209)	67(0.1402)	79(0.1653)	296(0.6192)
Improve your ability to learn	12(0.0251)	45(0.0941)	63(0.1318)	69(0.1444)	289(0.6046)

3.2.2 Correlation analysis of 3D animation blended teaching and teaching effectiveness

The correlation analysis of the dimensions of blended teaching and teaching effectiveness is shown in Table 4. There is a significant positive correlation ($p<0.01$) between the four dimensions of the blended teaching platform and the 3D animation instructional design and classroom organization, with correlation coefficients of 0.574, 0.641, 0.758, and 0.859, respectively. It can be found that blended teaching supports learning and has the highest correlation coefficient with students' learning gains. The students' learning gains will increase as the learning support provided by 3D animation blended instruction becomes stronger. This is because, in the virtual learning space and environment, the interactive function provided by the blended teaching platform can closely connect the learning community, which is conducive to students' in-depth understanding of 3D animation construction principles.

Table 4. Analysis of the various dimensions of online learning and teaching effect

Dimension	Teaching target goals	Teaching content	Learning resources	Online learning	Teaching design and classroom organization
Teaching target	1				
Teaching content	0.635**	1			
Learning resources	0.574**	0.706**	1		
Online learning	0.645**	0.657**	0.742**	1	
Teaching design and classroom organization	0.574**	0.641**	0.758**	0.859**	1

3.2.3 Correlation analysis between multidimensional recognition of teaching reforms and learning outcomes

Table 5 shows the cross-analysis results that show how satisfied people are with various aspects of 3D animation resources and how they encourage learning interest.

Cross-analysis results on the satisfaction of different learners with 3D animation teaching resources and stimulating their interest in 3D animation knowledge are presented in the table. Fisher's test is used because there exists a certain unit with an expectation value of less than 5.

Analysis of the results in the table yields that the probability of significance of the overall quality of the 3D animation resources, the arrangement of the content of the resources and the animation effects they present are 0.006, 0.012 and 0.004 respectively, all of which are less than 0.05, which indicates that there is a significant correlation between the learners' satisfaction with these three aspects of the 3D animation resources and the stimulation of the learners' interest in learning this course.

Among those who are satisfied with the quality of the resources, 0.7753 of them all think that the 3D animation resources have stimulated their learning interest in learning 3D animation knowledge to some extent. The level of interest of learners in this knowledge is greatly affected by the quality of the resources, as indicated.

Table 5. Analysis of the satisfaction and interest of the three 3d animation

	Satisfaction	It inspired interest in 3d animation					x^2	P
		1	2	3	4	5		
3d visual resource quality	Satisfaction	25	12	14	76	100	19.082	0.006
	General	24	12	16	85	21		
	Discontent	12	21	13	19	28		
Learning objectives of teaching resources	Clarity	16	10	33	78	89	10.053	0.193
	General	13	26	30	36	72		
	Inaccuracy	14	9	15	22	15		
3d visualization resource content	Enrichment	25	29	36	75	82	16.258	0.012
	General	17	10	64	66	29		
	Incongruity	10	15	8	7	5		
3d visualization courseware logic	Reasonableness	35	40	66	88	97	8.637	0.285
	General	16	20	34	38	20		
	Out of line	4	6	8	4	2		
3d visualization courseware animation	Satisfaction	38	15	67	84	82	20.741	0.004
	General	8	7	53	45	45		
	Discontent	12	3	5	6	8		
3d visualization courseware interface	Coordinate	38	22	63	75	91	14.125	0.056
	General	8	24	47	45	16		
	Incongruity	6	12	1	14	16		

In summary, the recognition of 3D animation blended teaching reform in terms of teaching design and teaching effect is not more than 0.75. Especially in terms of teaching design of 3D animation blended teaching reform, the satisfaction in five aspects, namely, the setting of learning objectives, the arrangement of course content, the logical reasonableness of the resources, the satisfaction with animation effect, and the satisfaction with the interface design, is not more than 0.61. Targeted improvement of the teaching effect of 3D animation blended teaching reform is necessary. The improvement of the teaching effect of 3D animation blended teaching reform is necessary.

3.3 Analysis of the results of the fuzzy comprehensive evaluation of teaching reforms

The comprehensive evaluation indexes of three-dimensional animation teaching reform are quantified through the collection and processing of data based on the above analysis. On the basis of determining the weights of the indicators, the fuzzy comprehensive evaluation method is applied to carry out a comprehensive evaluation of the five aspects of 3D animation blended teaching reform.

To determine their association with the set of rubrics, qualitative indicators were categorized using fuzzy statistics or level-by-level estimation. The fuzzy statistics consisted of asking the evaluation experts to evaluate the set of rubrics using the five grades assigned to them. The five evaluation grades are unqualified, poor, medium, good and excellent. The grade is assigned to each evaluation indicator, and then the frequency m_{ij} of the evaluation grade V_j of each indicator is counted accordingly, and the degree of affiliation r_{ij} of each indicator is calculated:

$$r_{ij} = m_{ij} / f \tag{33}$$

Where m_{ij} indicates the frequency of U_i belonging to V_j, and f indicates the number of experts involved in the evaluation.

A single-factor fuzzy evaluation relative to the indicator U_i can be obtained:

$$R_i = \left(r_{i1}, r_{i2}, r_{i3}, r_{i4}, r_{i5}\right) \tag{34}$$

For quantifiable indicators, the fuzzy distribution function of the indicator is determined according to its specific nature. Then, according to the actual indicator values corresponding to the indicator affiliation diagram, the corresponding degree of affiliation can be derived. This results in a one-factor evaluation matrix R_i for each quantitative indicator.

According to the comprehensive evaluation index system listed in subsection 2.3, there are 17 indicators, and for the qualitative indicators in the index system, the expert scoring method is adopted, and 10 experts in the field of education reform are extracted to evaluate and score them. The set of rubric levels are unqualified, poor, moderate, good and excellent, and the corresponding evaluation scores are (0-0.2), (0.2-0.4), (0.4-0.6), (0.6-0.8) and (0.8-1). This set of rubrics also serves as a basis for cross-referencing the final evaluation results. The quantitative indicators in the indicator system undergo processing and digitization to the [0, 1] interval after taking the original value.

The degree of affiliation is obtained through arithmetic, and the fuzzy comprehensive evaluation results are obtained by combining the weights of each index, and its specific data are shown in Table 6. Five classes in this school are selected to calculate the fuzzy comprehensive evaluation results of the five first-level indicators of 3D animation blended teaching reform, which are teaching objectives, teaching content, learning resources, online learning and teaching design and classroom organization. Among them, the fuzzy comprehensive scores of instructional design and classroom organization are 0.250678, 0.21356, 0.205, 0.178, 0.15354, which are higher than the other four aspects, indicating that the 3D animation blended teaching reform can effectively improve instructional design and classroom organization.

The fuzzy comprehensive evaluation scores of the five first-level indicators of 3D animation blended teaching reform are 0.754546, 0.69943, 0.638926, 0.66888, 0.5966. The comprehensive evaluation results for the five aspects have had a positive effect. There are 4 good results and 1 medium result. Analysis of the process and results of the calculation can be found in the current class 5 in the process of 3D animation blended teaching, instructional design and classroom organization still need to be improved.

Table 6. Fuzzy comprehensive evaluation results

Teaching reform	Class 1	Class 2	Class 3	Class 4	Class 5
Teaching target	0.044923	0.06024	0.04152	0.05486	0.04824
Teaching content	0.140227	0.1078	0.11229	0.14157	0.13456
Learning resources	0.115821	0.12536	0.09478	0.12235	0.10684
Online learning	0.202897	0.19247	0.185336	0.17210	0.15342
Teaching design and classroom organization	0.250678	0.21356	0.205	0.178	0.15354
3d animation hybrid teaching reform fuzzy comprehensive evaluation score	0.754546	0.69943	0.638926	0.66888	0.5966
The final conclusion of the fuzzy comprehensive evaluation of teaching reform	Good	Good	Good	Good	Medium

4 Conclusion

This paper constructs a framework of 3D animation blended teaching design, forms a teaching reform combining online independent learning and offline face-to-face teaching, and analyzes the effect of this teaching reform by using a fuzzy comprehensive evaluation model.

The 3D animation blended teaching design is divided into five parts, namely, course teaching objectives, teaching content, learning resources, online learning and instructional design and classroom organization, and the 3D animation blended teaching fuzzy comprehensive evaluation system is established. The final fuzzy evaluation level for the five indicators is 4 good and 1 medium, based on the fuzzy evaluation level for evaluating the effect of blended teaching reform. 3D animation blended teaching reform has a relatively good impact on teaching, but there are still some issues with the implementation of teaching design and classroom organization.

Targeting the existing problems of teaching reform can be achieved based on the fuzzy comprehensive evaluation of 3D animation blended teaching reform. According to the teaching design and classroom organization to be improved, it should be based on the teaching objectives of 3D animation. Using 3D animation resources, enriching the teaching design, and optimizing classroom organization can be achieved by combining it with the online learning mode.

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