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Research on the Online Examination and Assessment Mode of Design Courses Based On Fuzzy Hierarchy Comprehensive Evaluation Method

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Abstract:

In order to improve the scientificity and objectivity of the assessment of design courses, an online examination and assessment mode of design courses based on Fuzzy Hierarchy Comprehensive Evaluation method is proposed. The evaluation hierarchy structure and evaluation index weight of design courses are constructed by Analytic Hierarchy Process, and the Fuzzy Comprehensive Evaluation method is adopted for the assessment of each Evaluation index. Based on the algorithm of Fuzzy Hierarchy Comprehensive Evaluation Method, this paper constructs an online assessment platform, which uses the advantages of information technology to improve the productivity of design course assessment and reduce the workload of assessment, and can be used in online or offline classes. Through the comparative experiment in the actual classes, this model can improve the perception of the scientificity, objectivity and consistency of the assessment of design courses, increase the overall satisfaction with design courses, and the assessment results can comprehensively and objectively demonstrate the design ability of the course participants.

Keywords*: Design Courses, Examination and Evaluation Mode, Fuzzy Hierarchy Comprehensive Evaluation Method, Design course assessment, Online assessment.*

I. INTRODUCTION

Assessment is a very important link in the process of higher education. In 2018, the Ministry of Education of China issued the Opinions on Accelerating the Construction of High-level Undergraduate Education and Improving Talent Training Ability in an All-round Way, which pointed out that it is necessary to strictly assess the course process, scientifically and reasonably design the course assessment contents and methods according to the course characteristics, and put forward the application of modern information technology achievements in education and teaching to reform the teaching assessment mode[1]. The Opinions on First-class Undergraduate Courses issued by the Ministry of Education of China in 2019 requires strict assessment and evaluation, and advocates diversified assessment and evaluation[2].

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Scientific, objective and comprehensive curriculum assessment is a means for teaching management institutions and teachers to evaluate teaching quality, test teaching effect and diagnose teaching problems, which can play a role in discovering students' own shortcomings, stimulating learning enthusiasm and guiding their efforts[3-4]. Design courses are comprehensive and practical, which mainly cultivate students' ability to solve problems creatively by using design thinking. The design solution process has a long continuity, the design results are diversified, and there is no quantifiable standard answer, which brings certain difficulties to the assessment of design courses[5]. Especially under the influence of COVID-19 pandemic, online teaching and online and offline mixed teaching mode are widely used, and online teaching also brings challenges to the assessment of design courses. The purpose of this study is to improve the scientificity, objectivity and consistency of the assessment of design courses, give full play to the effectiveness of assessment to guide students' learning, this paper puts forward an online assessment mode of design courses based on fuzzy comprehensive hierarchy process, constructs an assessment index system of design courses based on fuzzy comprehensive hierarchy process, and constructs an online assessment platform of design courses with the help of information technology. This model can realize the scientificity, objectivity, comprehensiveness and consistency of the assessment of design courses, and has high feasibility. Through the comparative experiment in teaching practice, the application of this model in design courses can improve students' perception of the scientificity and comprehensiveness of the assessment process, the objectivity and consistency of the assessment results, and the usefulness of the assessment.

II. PROBLEMS IN ASSESSMENT OF DESIGN COURSES

2.1 The Proportion Distribution of Formative Assessment and Final Assessment of Design Courses is Unreasonable

Formative assessment is an assessment of students' learning process, while final assessment is a comprehensive assessment at the end of the course[6]. For design courses, design process and design results are equally important. Design process is a process for students to solve design problems, which reflects students' mastery of theoretical knowledge and design innovation ability. The assessment of design process can find out the problems in students' design process in time, play a role in guiding and correcting deviations, and finally affect design results[7]. However, at present, the proportion and energy invested in formative assessment of design courses are relatively low, while the proportion and energy invested in final assessment are relatively high, which makes it difficult to find problems in students' design process in time. After the problems are found in final assessment, the course has ended, and the guiding function of assessment to students is weakened. Some scholars have realized this problem and put forward the scheme of staged assessment[8]. However, the traditional staged assessment, on the one hand, lacks scientific division of stages, and on the other hand, it will multiply the workload of teachers, which is difficult to strictly implement in actual teaching.

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2.2 There is a Lack of Scientificity and Rationality in Setting Assessment index of Design Course

Design is a creative activity with a certain subjective, and the design output is a multi-element complex balanced by many factors. The evaluation and assessment of the design process and results shall also be multi-dimensional. In teaching practice, the teachers will set up and design the assessment index according to their own experience, but the division of the index and the setting of the index weight have certain subjectivity and lack of scientific basis.

2.3 The Consistency and Objectivity of Design Curriculum Assessment are Relatively Low

Because of the complexity and diversity of design process and results, in addition, due to the influence of teachers' cognition and preference on design, it is difficult to ensure consistency and objectivity in the assessment of design courses. The main performance is that for the assessed students as a whole, it is difficult to ensure the consistency of evaluation standards between students from beginning to end in the whole evaluation and assessment process. For individual students, teachers inevitably integrate subjective factors in the assessment process, which makes it difficult to ensure the objectivity of assessment. Some scholars are also aware of this problem, and put forward that teachers, enterprise experts and students should participate in the assessment together, and improve the consistency and objectivity by increasing the number of evaluators[9]. However, it is necessary to coordinate the course progress and the time arrangement of enterprise experts, which will bring about the problems of long assessment cycle and low assessment efficiency. It can also improve the consistency by evaluating the design results many times, but it will also reduce the efficiency of assessment and increase the workload of teachers.

Based on the above analysis, the reform of evaluation and assessment of design curriculum needs to cover the whole process of design and develop scientific and reasonable assessment indexes with the support of certain theory. With the help of modern information technology, it breaks through the limitation of time and space, and introduces multiple evaluators to participate in the evaluation and assessment of the whole process of design, so as to improve the objectivity and consistency of the assessment. The application of information technology can also reduce the workload of teachers' assessment, improve the efficiency of curriculum assessment, and make the comprehensive, scientific and reasonable evaluation and assessment of design curriculum more feasible.

III. ON-LINE ASSESSMENT MODE OF DESIGN COURSE BASED ON FUZZY HIERARCHY PROCESS

In order to solve the above problems, based on many years of teaching and assessment practice of design courses, this paper proposes an online assessment mode of design courses based on fuzzy hierarchy process. Based on the curriculum syllabus, the assessment index system and index weight are constructed by using the analytic hierarchy process to make the assessment of design courses scientific and reasonable. Although the assessment system constructed by the fuzzy comprehensive assessment method is objective, the assessment process is relatively complicated and involves a large amount of calculation. If this method

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is applied in the design courses, a large amount of extra work will be brought and the feasibility will be reduced. In order to solve this problem, the online evaluation and assessment platform is constructed in this paper. With the help of the advantages of information technology, it generates the assessment algorithm template, calculates and analyzes the assessment data, realizes multi person asynchronous evaluation, improves the objectivity and consistency of the assessment of design courses, reduces the workload of the assessment of design courses, improves the efficiency of the assessment, and makes the comprehensive, scientific and objective assessment of design courses more feasible, It is also applicable to online teaching. The flow of this mode is shown in Figure 1, and the specific implementation process is as follows.

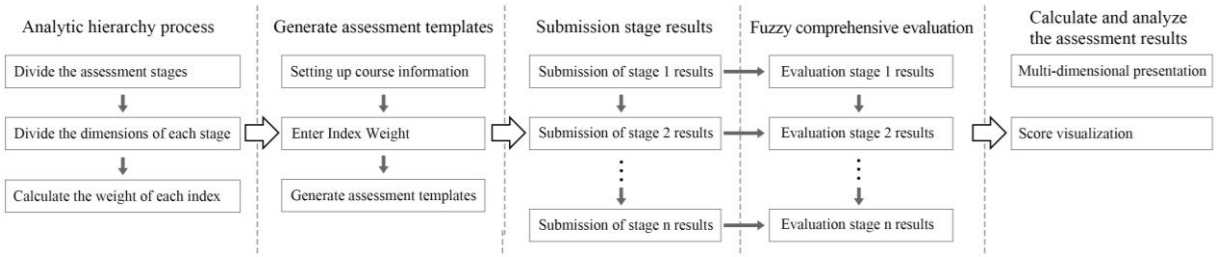

Fig 1: Online Assessment process of design courses based on fuzzy hierarchical synthesis method

3.1 Constructing the Evaluation Index System of Design Courses Based on Fuzzy Comprehensive Hierarchy Evaluation Method

Fuzzy comprehensive evaluation method combines the advantages of analytic hierarchy process and fuzzy comprehensive evaluation method [10], the analytic hierarchy process can hierarchy and organizes complex problems and form a scientific and comprehensive evaluation hierarchy[11]. The fuzzy comprehensive evaluation method is based on fuzzy mathematics, which can quantify people's subjective judgment and form a relatively objective evaluation of subjective problems[12]. The characteristics of fuzzy comprehensive hierarchy evaluation method make it very suitable for the assessment of design courses. The steps and algorithms of constructing the evaluation system of design courses by fuzzy comprehensive hierarchy evaluation method are as follows.

3.1.1 Determine the Assessment Hierarchy of the Course

According to the course schedule and design process, design courses can be divided into several stages at first. The design stage is the first-level index of design course assessment, $S=(S_1, S_2, S_3, \cdots, S_n)$. Each design stage has its objectives, which can be divided into several assessment dimensions. The assessment dimensions of each stage are the second-level index of design course assessment, $D= (D_1, D_2, D_3, \cdots, D_m)$. According to the syllabus and training objectives, the teachers in the teaching and research section use the way of focus discussion to preliminarily divide the assessment stages of the course and the assessment dimensions of each stage. Then the Delphi method is used to determine the assessment stages of the course and the assessment dimensions of each stage. The assessment hierarchy of design courses is shown in

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Figure 2.

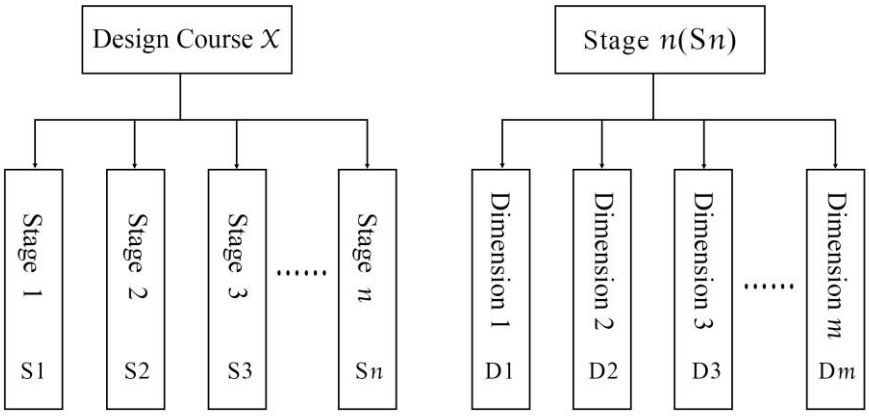

Fig 2: Evaluation hierarchy of design courses

3.1.2 Index weight calculation

The weights of each stage and its dimensions of design courses are determined by analytic hierarchy process, and the steps are as follows.

(1) Constructing judgment matrix

Compare the importance of assessment indexes at the same level in pairs, and give corresponding values according to the importance gap between the two indexes. In this study, 1~9 scales are used to construct the judgment matrix, and the evaluation criteria of the judgment matrix are shown in Table 1. Delphi method is used to obtain the judgment matrix of each assessment stage and assessment dimension in each stage.

TABLE I. Explanation of comparison and assignment of judgment matrix indexes

Index compared	Value	Value description
A_i - A_j	1	Two indexes are equally important
A_i - A_j	3	A_i is slightly more important than A_j
A_i - A_j	5	A_i is obviously more important than A_j
A_i - A_j	7	A_i is more important than A_j
A_i - A_j	9	A_i is extremely important than A_j
A_i - A_j	2, 4, 6, 8	The importance is in the middle of adjacent values
A_j- A_i	1/3, 1/5, 1/7 ,1/9 1/2, 1/4, 1/6, 1/8	Reverse comparison results of two indexes

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(2) Weight calculation and consistency test

Firstly, the product M_i of each row index of the judgment matrix is calculated.

$$M_i = \prod_{j=1}^{n} a_{ij}, \quad i = 1, 2, 3 \ldots n \tag{1}$$

(a_{ij} denotes row i column j elements in the judgment matrix)

Then, the geometric mean of M_i is calculated.

$$\overline{w}_i = \sqrt[n]{M_i} \tag{2}$$

Finally, normalize $\overline{w}_i$.

$$w_i = \frac{\overline{w}_i}{\sum_{j=1}^{n} \overline{w}_j} \tag{3}$$

The obtained feature vector W=(w_1, w_2, w_3, ... w_n) is the weight of each indicator in the judgment matrix.

(3) Consistency test

According to the requirement of AHP, the consistency of judgment matrix needs to be detected by consistency ratio, which is C.R.=C.I./R. I., where R.I. is the average consistency index, which is related to the order of judgment matrix and can be obtained by looking up the table. C.I. is the consistency index, and the calculation formula is:

$$C.I. = \frac{\lambda_{max} - n}{n-1} \tag{4}$$

λ_{max} is the largest characteristic root, and the calculation formula is:

$$\lambda_{max} = \sum_{i=1}^{n} \frac{(AW)_i}{(nw_i)} \tag{5}$$

It is generally believed that if the value of C.R. is less than 0.1, the consistency of the judgment matrix is acceptable, and if C.R. > 0.1, the judgment matrix needs to be readjusted.

Through the above algorithm, we can calculate the weights of each stage of design courses and the weights of assessment dimensions in each stage.

3.1.3 Course grade calculation

When calculating course scores, with the progress of the course, the scores of each assessment stage are calculated one by one, and then the total assessment scores of the course are calculated. The fuzzy comprehensive method is used to evaluate the stages of the course. Firstly, the comment set V= {v_1, v_2, v_3, ... , v_m} and the score P=(p_1, p_2, p_3, ... , p_m) represented by each grade in the comment set are

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determined. The more grades of the comment set are divided, the finer the assessment is, but the lower the assessment efficiency is. The grade number of the comment set can be set according to the characteristics of students and courses.

A plurality of evaluators evaluate each dimension of stage S_i, and construct a subset of membership degree R_j, $R_j=(r_{j1}, r_{j2}, r_{j3}, ..., r_{jm})$ of the j-th dimension of stage S_i corresponding to the membership degree of each comment in the comment set, where r_{jk}=(the j-th dimension selects the number of v_k grades in the comment set V) / the total number of evaluators, k=(1, 2, 3,. .. , m). Thus, the evaluation membership matrix R of stage S_i is obtained.

$$R = \begin{bmatrix} R_1 \\ R_2 \\ \cdots \\ R_n \end{bmatrix} = \begin{bmatrix} r_{11} & \cdots & r_{1m} \\ r_{21} & \cdots & r_{2m} \\ r_{n1} & \cdots & r_{nm} \end{bmatrix} \quad (6)$$

The weighted average operator is used to calculate the fuzzy comprehensive evaluation vector Z=B*R of stage S_i, where $B=(w_1, w_2, \ldots, w_n)$is the weight vector of each dimension in stage S_i.

The score algebraic value of stage S_i is $G=Z*P^T$, where P= (P_1, P_2, P_3, ⋯, P_m) is the score value represented by the evaluation grade of the comment set.

The total grade algebra value of the course is $T=W*F^T$, where $W=(w_1, w_2, \ldots, w_n)$is the weight vector of each stage of the course, and F= (g_1, g_2, ..., g_n,) is the algebraic value of the assessment scores for each stage of the course.

Through the fuzzy comprehensive hierarchy evaluation method, the design courses are divided into assessment stages, each assessment stage is divided into assessment dimensions, and the weights of assessment indexes at each level are calculated, so as to realize the all-round assessment of design courses. The assessment indexes and weights are scientific and reasonable. But at the same time, it can be seen that the assessment process involves many steps and a large number of calculations, which is inefficient and heavy in workload.

3.2 Construction of Online Assessment Platform for Design Courses

Based on the fuzzy comprehensive hierarchy evaluation algorithm, an online assessment platform for design courses is constructed, which automatically calculates and analyzes the assessment data, improves the assessment efficiency, reduces the workload of teachers, and can adapt to the online teaching of design courses. The online assessment platform has realized the functions of collection and exhibition of design results, evaluation and assessment, calculation and analysis, visual presentation of assessment results, interaction and so on. The specific evaluation and assessment modes are as follows.

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3.2.1 Generate assessment template

After the expert Delphi method obtains the assessment hierarchy and index weight of the course, the hierarchy information and index weight of the design course are input into the online assessment platform, as shown in Figure 3, and the system automatically generates the evaluation template of the design course, as shown in Figure 4, which reduces the assessment workload and improves the assessment efficiency.

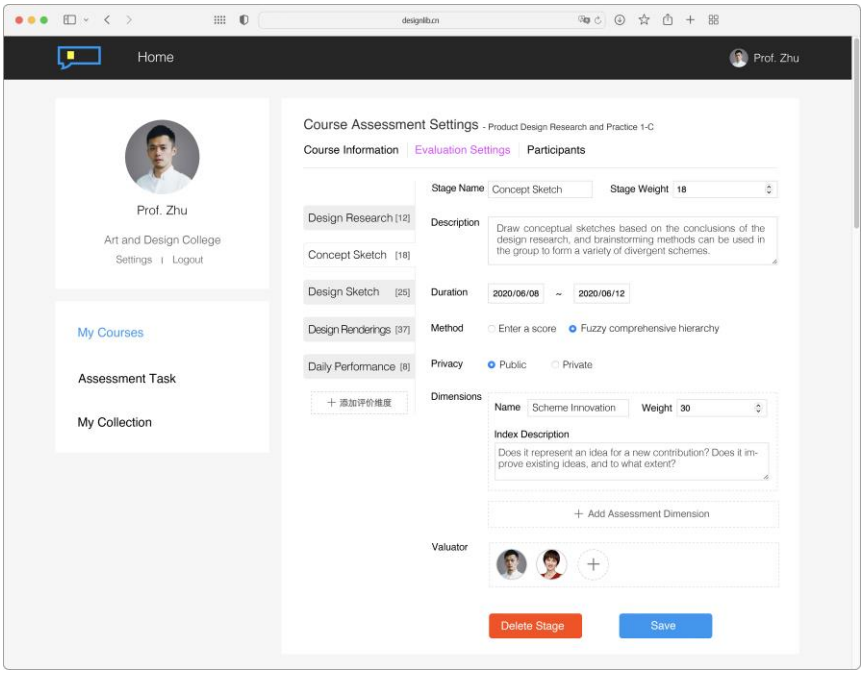

Fig 3: Setting Appraisal Indexes

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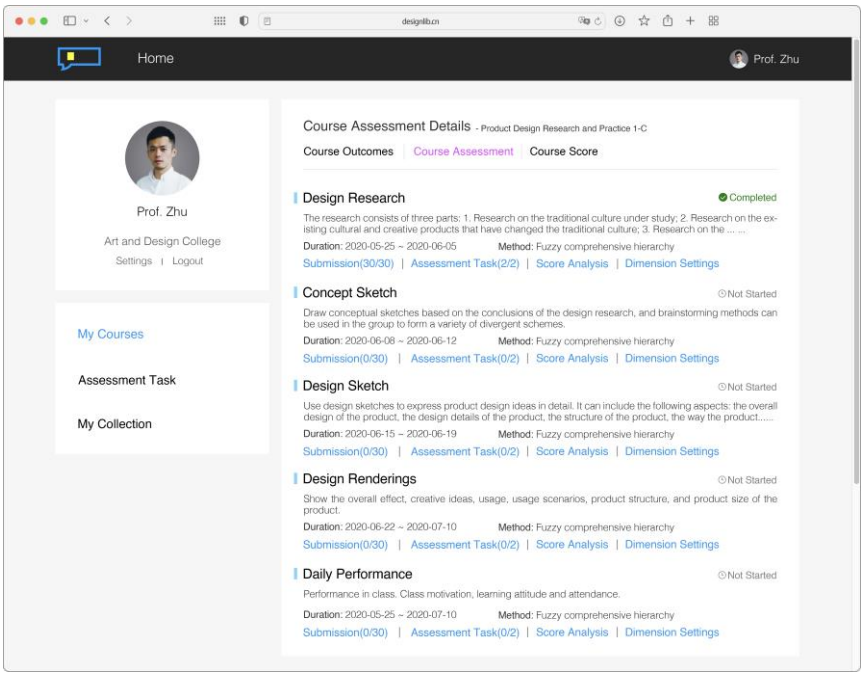

Fig 4: Generating Assessment Template

3.2.2 Collection and display of stage design results

According to the assessment stage division and course progress, students can upload stage results and generate stage results display, as shown in Figures 5 and 6.

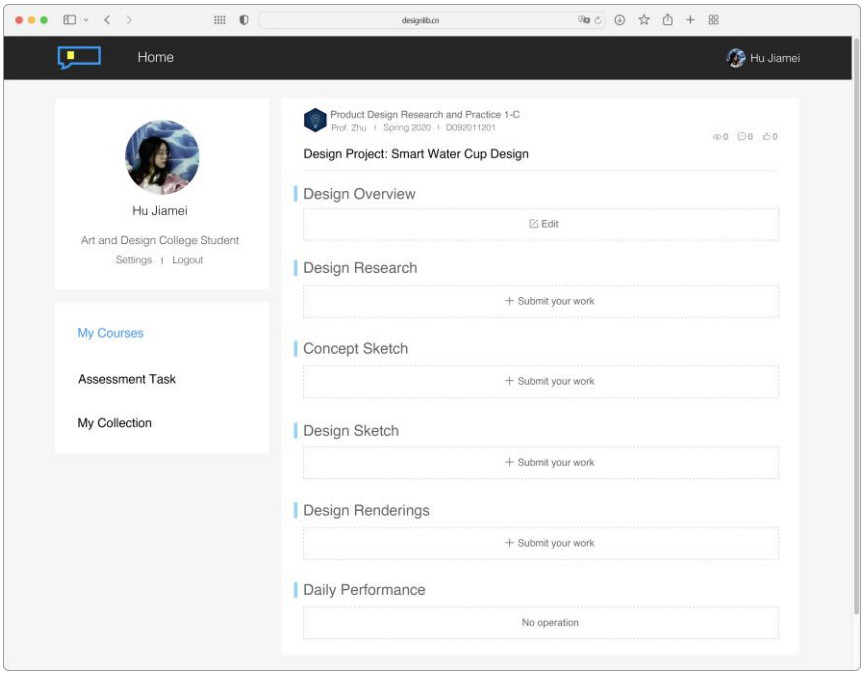

Fig 5: Upload stage design results

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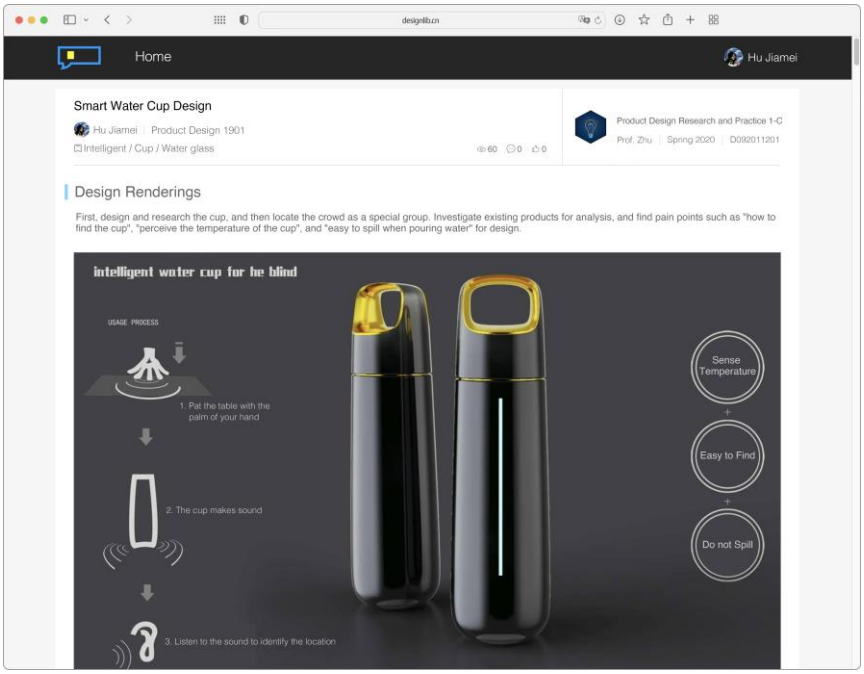

Fig 6: Design results display

3.2.3 Assessment

Multiple evaluators can be set up in the assessment process. Generally, enterprise experts, peer teachers and students can be invited to participate in the assessment at the same time. The system will automatically generate the content that the evaluators needs to evaluate, as shown in Figure 7. During the assessment, the system displays the stage design results and comment set. After observing the stage design results, the assessor can select the corresponding assessment grade and add suggestions for the design results, as shown in Figure 8.

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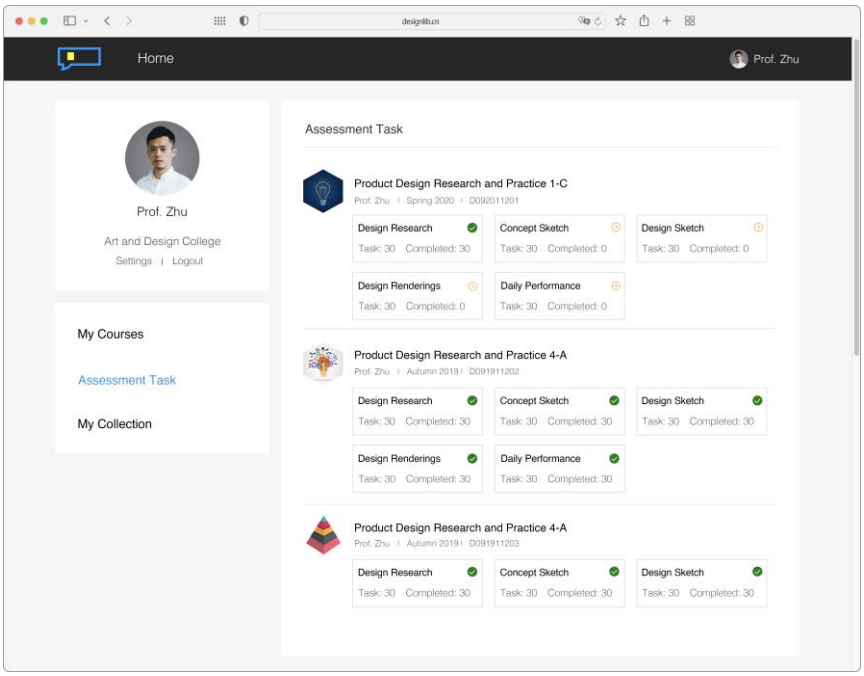

Fig 7: Assessment task

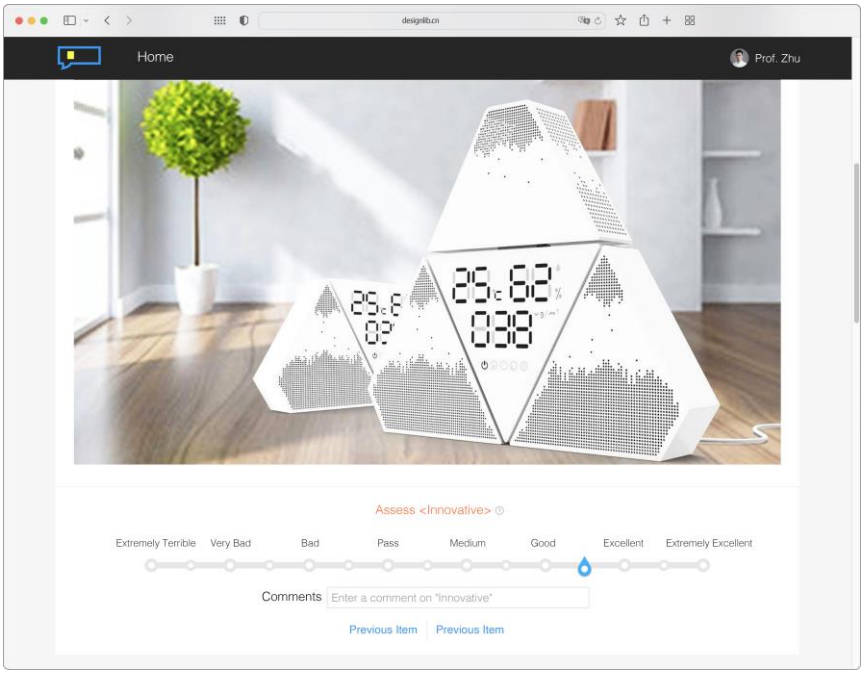

Fig 8: Assess stage design works

3.2.4 Visualization of appraisal results

After a stage assessment, the system will automatically calculate the results according to the fuzzy

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hierarchical synthesis algorithm, and present the assessment results in a visual form. Students can view their own assessment results immediately, know their own shortcomings, and make up for shortcomings in the next stage. Teachers can view the overall assessment of students and adjust the teaching emphasis in the next stage according to the assessment results. After the assessment of all design stages is completed, the assessment data of the whole course is systematically calculated and analyzed, and the assessment results of the course are displayed in a three-dimensional and all-round way in a visual form. Students can analyze their gains and weaknesses in the course, observe excellent designs, and clarify their efforts. Teachers can know the problems existing in students' learning process according to the analysis results of students' overall assessment, and adjust teaching methods in the next teaching process. The student-side assessment results are shown in Figure 9, and the teacher-side assessment results are shown in Figure 10. In addition, in order to protect students' privacy, the assessment results are invisible to the outside, and students can only view their own assessment results.

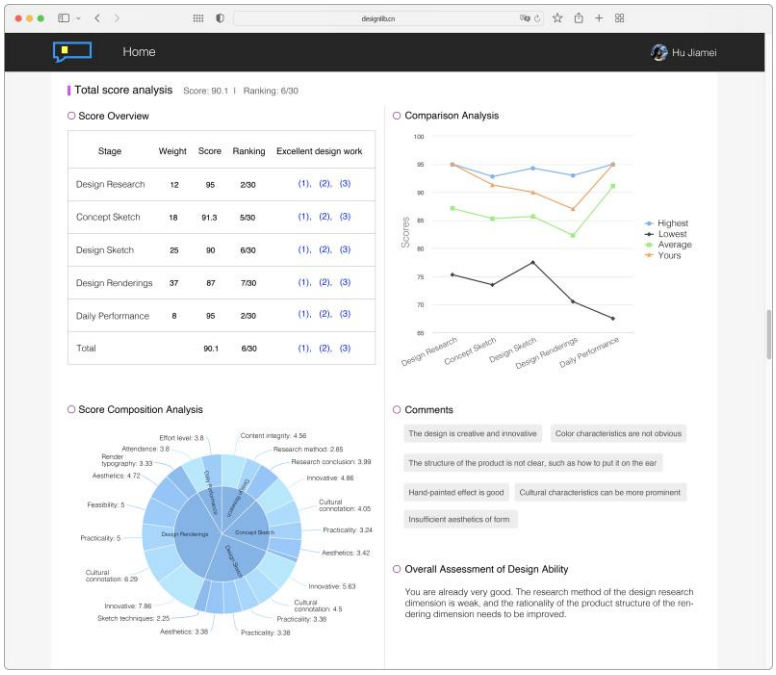

Fig 9: Example of presentation of student-side assessment results

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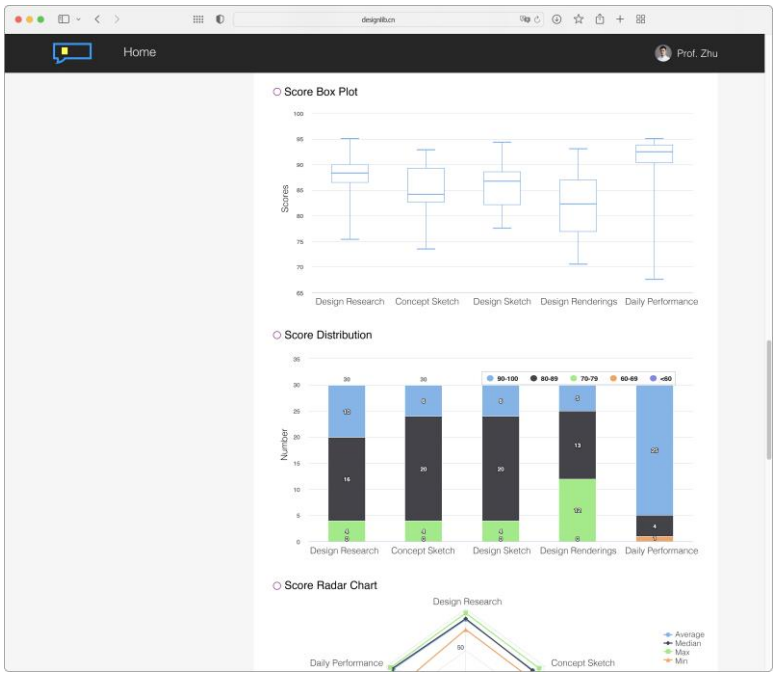

Fig 10: Example of presentation of teacher-side assessment results

The online assessment platform of design courses, with the help of computer data calculation and analysis ability, reduces the workload of design courses assessment by fuzzy comprehensive hierarchy evaluation method, ensures the scientificity and rationality of design courses assessment and improves the assessment efficiency; And multiple evaluators can be introduced to participate in the assessment asynchronously, which improves the objectivity and consistency of the design course assessment; The assessment results can be presented in real time and visually, which is beneficial for teachers and students to find out the problems in the teaching and learning process in time. In addition, after the course assessment, the design results will be published on the platform, which can also be used as a platform for online exhibition of students' design results.

IV. EFFECT TEST

In order to validate the superiority of the evaluation model, a comparative experiment was conducted on two courses, "Product Design Research and Practice 1-B" and "Product Design Research and Practice 1-C" of Grade 19 product design major. There are 30 students majoring in product design in Grade 19. "Product Design Research and Practice 1-B" and "Product Design Research and Practice 1-C" are design practice courses with similar courses and the same teachers. The course "Product Design Research and Practice 1-B" adopts the traditional assessment method. After the course is finished, students fill out the learning satisfaction questionnaire. "Product Design Research and Practice 1-C" adopts the fuzzy comprehensive hierarchy online assessment platform proposed in this study to evaluate and assess. After the course, students fill in the learning satisfaction questionnaire. Twenty-seven paired valid

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questionnaires were collected from two questionnaires. Import the questionnaire data into SPSS 25.0, using the method of paired sample T test, the results are shown in Table 2. The data analysis shows that the assessment model proposed in this paper is superior to the original assessment model in four aspects: scientificity and comprehensiveness of the assessment process, objectivity of the assessment results, help to learning and overall satisfaction, and the difference is significant, which shows that the assessment model proposed in this study has certain advantages. In addition, the instructor also said that the evaluation and assessment mode proposed in this paper is standardized, organized, scientific and objective, and the workload of assessment has not increased significantly with the help of online assessment platform.

TABLE II. T test results of paired samples

	Item	**Pairing difference** New assessment mode - Original assessment mode		
		Average	t value	Sig. (two tails)
Scientific and comprehensive assessment process	1. The way of evaluating the results of this course is reasonable	0.407	2.383	0.025
	2. The index setting of the course achievement evaluation is scientific	0.556	3.606	0.001
	3. The index setting of the course achievement evaluation is comprehensive	0.333	2.082	0.047
Objectivity of assessment results	4. The results of the grade evaluation accurately reflect my actual learning level	0.556	2.850	0.008
	5. The result of the course achievement evaluation is objective	0.370	2.294	0.030
Help to study	6. After seeing the results of the grade evaluation, I can clearly understand my shortcomings in the study of this course	0.630	3.533	0.002
	7. After seeing the results of the grade evaluation, I can clearly understand what I am good at in this course	0.370	3.058	0.005
	8. After seeing the results of the performance evaluation, I can clearly know the direction of my efforts	0.519	2.657	0.013
	9. The results of the grade evaluation are helpful to my future study	0.630	3.136	0.004
Overall satisfaction	10. Overall satisfaction with the course and assessment process	0.444	3.606	0.001

V. CONCLUSION

Scientific and objective evaluation and assessment of design courses is of great significance to school teaching management institutions, teachers and students. The online evaluation and assessment

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mode of design courses based on the fuzzy hierarchical comprehensive evaluation method proposed in this study. On the one hand, the assessment hierarchy of design courses and the weights of assessment indexes at each level are determined by the analytic hierarchy process, which improves the scientific evaluation of design courses. On the other hand, an online assessment platform for design courses is built on the basis of the fuzzy hierarchical comprehensive assessment method. With the help of information technology, an assessment template is generated to realize the assessment algorithm, reduce the amount of manual calculation, and improve the assessment efficiency, reduces the workload of teachers, and the online assessment platform can simultaneously introduce corporate designers and students to participate in the assessment asynchronously, which improves the consistency and objectivity of assessment; in addition, this model can be used in both offline and online teaching scenarios. The superiority of this model is verified in actual teaching practice. The evaluation and assessment mode proposed in this study provides a feasible reference for the reform of design course assessment.

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