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Abstract:

With the rapid development of information technology and the constant change of college education model, traditional classroom teaching methods have been unable to meet students' needs for individuality, flexibility and interaction. Cognitive fuzzy learning system (CFLS), as a new intelligent teaching tool combining Fuzzy Cognitive Map, FCM) and cognitive load theory, provides a new idea for classroom teaching design by dynamically analyzing classroom data and adjusting teaching strategies in real time. This study constructs a dynamic classroom design model based on CFLS, and systematically discusses the application effect of CFLS in college classroom teaching through questionnaire survey, model experiment and classroom application. The results show that CFLS can significantly improve the flexibility and adaptability of classroom design, and promote the double improvement of students' learning effect and teachers' classroom satisfaction. At the same time, CFLS shows good adaptability in different disciplines, and its real-time feedback mechanism can effectively support personalized teaching, adjustment of learning progress and optimization of teaching interaction. Although CFLS has obvious application advantages, this study also found that its adaptability and feedback mechanism in complex classroom scenes need to be further improved. This study not only verifies the potential of CFLS in modern teaching, but also provides practical reference for the construction of intelligent classroom teaching mode in the future.

Keywords: cognitive fuzzy learning system; Classroom teaching design; Higher education; Individualized teaching

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1. Introduction

With the rapid development of information technology and the continuous change of education mode, traditional teaching methods have been difficult to meet the needs of contemporary college students for personalized and diversified learning [1]. Cognitive Fuzzy Learning System (CFLS), as a new teaching system combining fuzzy cognitive map (FCM) and cognitive load theory, has gradually become an important tool to improve the quality of education. Wei and Jiang (2024) proposed that CFLS can dynamically adjust teaching strategies and personalize teaching content according to students' cognitive status, thus improving learning effect [2]. This method has achieved good application results in many educational fields, which provides new ideas for future classroom teaching design.

The research on classroom design in colleges and universities has made remarkable progress in recent years, focusing on the innovation of teaching mode, teaching method and evaluation system [3, 4]. The traditional teaching mode is gradually replaced by a more flexible and interactive teaching mode [5, 6]. With the progress of information technology, new teaching modes such as flip classroom and mixed teaching have been widely used in colleges and universities. O'Flaherty and Phillips (2015) reviewed the application of flip-classroom, emphasizing that the combination of extracurricular learning and classroom interaction can help to improve students' participation and learning effect [7]. Further research by Kazanidis et al. (2019) found that flip classroom can improve students' academic performance and training satisfaction when designing courses, especially in curriculum design and the use of teaching media [8].

In terms of teaching methods, fuzzy cognitive map (FCM), as a part of cognitive fuzzy learning system (CFLS), has been applied to the dynamic adjustment and personalized design of classroom teaching [9]. Through the fuzzy cognitive map, students' cognitive state can be combined with the learning process, and the teaching content can be adjusted accurately [10]. Han et al. (2018) research shows that teachers' teaching effectiveness and teaching support directly affect students' academic performance, while supportive teaching strategies can promote students' cognitive development and learning effect [11]. Obada et al. (2023) studied the teaching of bioengineering course based on hybrid online learning, and showed that introducing flexible teaching methods into teaching design can better meet the learning needs and development of students [12].

In terms of evaluation system, Wang (2023) used the method of grey relational analysis to discuss the evaluation of mixed teaching based on fuzzy cognitive map, and thought that CFLS could not only evaluate the effect of online and offline mixed teaching, but also provide strong data support and optimization scheme for curriculum design [13]. Singh and Kaur (2023) put forward that cognitive load theory and autonomous learning are of great significance to the improvement of teaching quality, and the internationalization trend of university teaching also puts forward new challenges and requirements for classroom design [14].

However, there are still some shortcomings in the current research on classroom design in colleges and universities [15]. First of all, most of the research focuses on the theoretical discussion of teaching modes and methods, and lacks the systematic application research of CFLS in practical teaching [16]. Although fuzzy cognitive map has been applied in some disciplines, its application research in interdisciplinary teaching design is still weak [17]. Singh and Suknunan (2023) pointed out that although instructional design is gradually internationalized, how to use cognitive fuzzy learning system efficiently in multicultural background still needs further study [18]. The teaching evaluation function of CFLS has not been fully exerted, and how to provide continuous learning feedback and optimization in a dynamic and complex teaching environment is still an important direction for future research.

From the above research, it can be seen that cognitive fuzzy learning system, as a cutting-edge teaching design tool, has great application potential in college classroom design, but its actual effect and application framework still need further empirical research and discussion. Based on this, this paper intends to further study the practical application of cognitive fuzzy learning system in college classroom design, explore its flexible application methods in different disciplines, and analyze the promotion of CFLS to personalized teaching, learning progress adjustment and teaching interaction in classroom design.

2. Materials and Methods

2.1 Data collection and sample selection

2.1.1 Sample selection and research object

The sample selection of this research is based on the specific research purpose, aiming at deeply discussing the practical application effect of cognitive fuzzy learning system (CFLS) in the classroom design of colleges and universities. The research object is undergraduates and their courses in a university. The reasons for choosing the undergraduate group are: this group is large in scale and widely representative, which can reflect the typical classroom design practice; At the same time, the core position of classroom teaching design in undergraduate education in the teaching process makes it a key field of research and has high research value.

Selection criteria of research objects:

Discipline background: The research covers many disciplines, ensuring that the applicability and application effect of CFLS in classroom design can be evaluated from different disciplines. The selected disciplines include humanities, science and engineering, social sciences, etc. to ensure the diversity and comprehensiveness of the research samples. Through interdisciplinary comparative analysis, we can discuss how the cognitive fuzzy learning system can be flexibly adjusted according to the characteristics of different disciplines.

Teacher participation: This study selects teachers who have certain teaching experience and are willing to participate in and support the research. Teachers' rich teaching experience is helpful to provide more in-depth insights, and teachers' ability to flexibly adjust classroom design and understand and implement personalized design is very important for the application of cognitive fuzzy learning system. Teachers with high participation can better apply CFLS in the teaching process, which reflects the actual effect of the system.

Student groups: In each subject, 30 to 50 undergraduates are randomly selected as research samples. The selection of students is based on the basic characteristics such as grade, gender and major, so as to ensure the representativeness and diversity of the samples. In this way, we can get universal conclusions and ensure the reliability and validity of the data. The selected students will accept different teaching designs in the classroom and provide feedback data to analyze the influence of CFLS on students' learning effect.

Class size and teaching form: The research objects include large classes and small classes, aiming to explore the potential influence of class size on the implementation effect of cognitive fuzzy learning system. By choosing different classes, we can compare the adaptability and performance of CFLS in large and small class teaching environment. In addition, curriculum design should combine traditional face-to-face teaching with modern technical means (such as online learning platform, interactive discussion tools, etc.) to implement mixed teaching. In this way, we can test the adaptability and effect of CFLS in various teaching modes and evaluate its practical application in modern teaching environment.

In order to ensure the representativeness and universality of the data, this study plans to select a certain number of student samples from each course, usually 30 to 50 students. Choosing this sample size can fully cover the diversity of classroom teaching and ensure that the collected data has high statistical reliability and effectiveness. At the same time, selecting multiple courses for research can increase the generalization of the results and facilitate the discussion of the applicability of cognitive fuzzy learning system in different teaching situations.

2.1.2 Data sources and collection methods

The data sources of this study mainly include questionnaire survey, classroom observation, teacher interview and student feedback, etc., and combine quantitative and qualitative research methods to comprehensively evaluate the practical application effect and influence of cognitive fuzzy learning system (CFLS) in college classroom design.

(1) Questionnaire survey is one of the main data collection methods in this study, aiming at understanding students' and teachers' feelings about the application of cognitive fuzzy learning system in classroom design and its teaching effect. The questionnaire design is divided into two parts:

Student questionnaire: mainly discusses students' cognition and experience of classroom design, including learning participation, knowledge mastery, learning motivation, teaching interaction and so on. The question design in the questionnaire is based on the key elements of classroom teaching design, such as learning progress adjustment, personalized teaching, teaching interaction, etc., covering the feedback of students in different disciplines and teaching forms.

Teachers' questionnaire: It aims to understand teachers' practice and feedback in the application of cognitive fuzzy learning system, especially the evaluation of flexibility, adaptability and teaching support of teaching design. The teacher questionnaire also involves the setting of classroom teaching objectives, the adjustment of teaching strategies and the management of learning progress.

(2) At the same time, by directly observing the teaching process, we collect the actual operation of teachers and students' learning performance when applying the cognitive fuzzy learning system. The key points of observation include:

Teaching design and implementation: how can teachers adjust teaching content and progress according to students' feedback, and whether cognitive fuzzy learning system can effectively support personalized teaching.

Classroom interaction: the frequency and quality of interaction between teachers and students, and between students, and observe whether there is sufficient interaction to promote students' knowledge mastery and cognitive development.

Student participation: whether students' enthusiasm and participation in the classroom can enhance their learning motivation and sense of participation through CFLS.

All the students and teachers involved in the study will sign the informed consent form before the start of the study to ensure that the research process meets the ethical requirements. The research will strictly keep the personal information and survey data of the participants confidential to ensure the privacy and rights of the participants are protected.

2.1.3 Data collection and descriptive statistics

In this study, 180 student questionnaires and 30 teacher questionnaires were collected, covering multiple academic backgrounds, classroom sizes and teaching forms, so as to comprehensively evaluate the practical application effect of cognitive fuzzy learning system (CFLS) in college classroom design. Descriptive statistics on the basic information of students and teachers are shown in Table 1- Table 2 and Figures 1- 2.

Table 1.

Statistics of students' basic information

Category	Option	Number	Percentage
Grade	Year 1	65	36.10%
	Year 2	57	31.70%
	Year 3	58	32.20%
Gender	Male	95	52.80%

	Female	eighty-five	47.20%
Discipline	Humanities	58	32.20%
	STEM	60	33.30%
	Social Sciences	62	34.40%
Class Size	Large Class	130	72.20%
	Small Class	50	27.80%
Teaching Format	Traditional Classroom	75	41.70%
	Blended Learning	105	58.30%

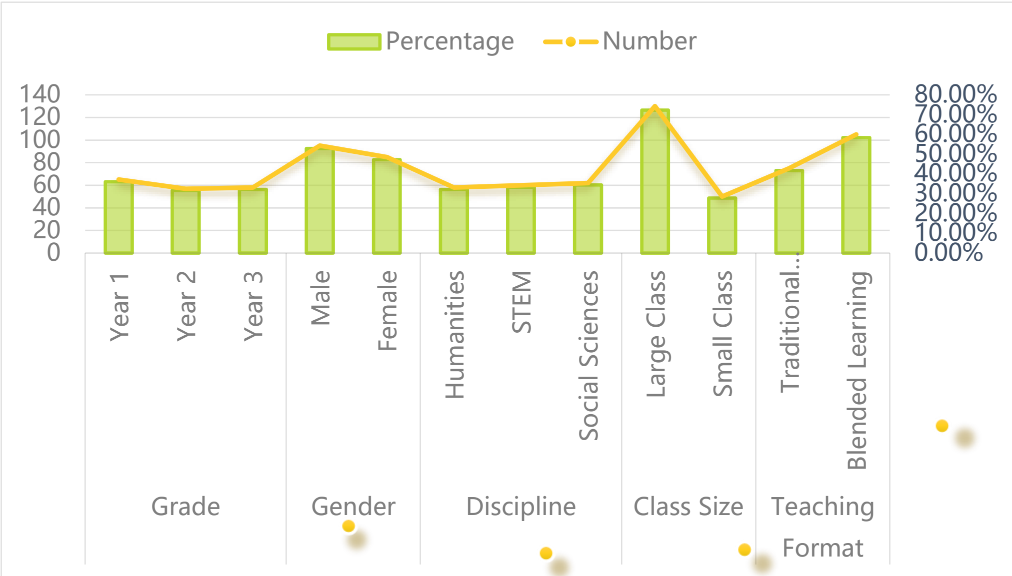

Figure 1. Statistical diagram of students' basic information

Table 2

By analyzing Table 1 and Figure 1, it is found that the students' samples are relatively uniform in grade distribution, with 36.1% students from grade one, 31.7% students from grade two and 32.2% students from grade three respectively, covering undergraduates at different learning stages. In terms of gender, boys accounted for 52.8% and girls accounted for 47.2%, and the gender distribution of the sample was nearly balanced. On the professional background, students come from humanities (32.2%), science and engineering (33.3%) and social science (34.4%), which shows the diversity of disciplines. In the distribution of class size, large class students account for 72.2%, small class students account for 27.8%, and large class samples are more, which is in line with the actual distribution of college classrooms. In terms of teaching forms, students in blended teaching account for 58.3%, while students in traditional classroom teaching account for 41.7%, reflecting the diversity of current classroom teaching forms.

Table 2
Statistics of teachers' basic information

Category	Option	Number	Percentage	Category	Option	Number	Percentage
Gender	Male	18	60%	Course Type	Classroom Teaching	22	73.30%
	Female	twelve	40%		Online Teaching	eight	26.70%
Teaching Experience	1-5 Years	seven	23.30%	Teaching Format	Traditional Classroom	13	43.30%
	6-10 Years	twelve	40%		Blended Learning	17	56.70%
	Over 10 Years	11	36.70%	Teaching Level	Moderate Experience	14	46.70%
Discipline	Humanities	nine	thirty percent		High Experience	16	53.30%
	STEM	11	36.70%	Class Size	Large Class	16	53.30%
	Social Sciences	10	33.30%		Small Class	14	46.70%

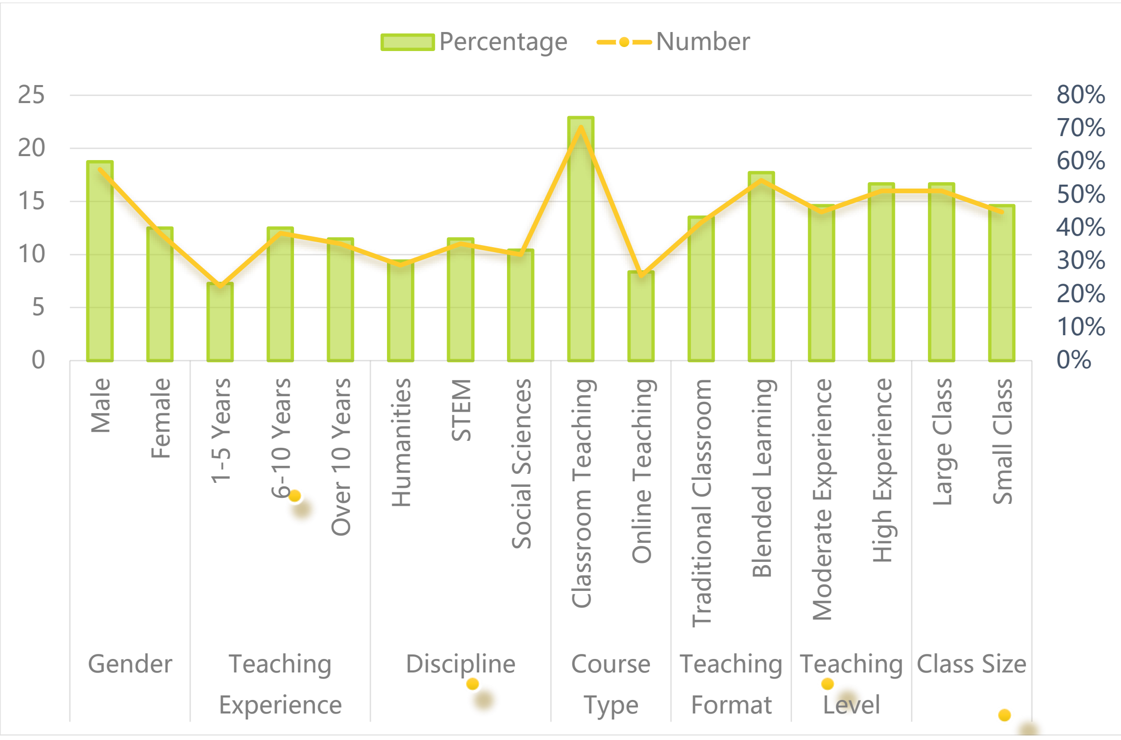

Figure 2. Statistical diagram of teachers' basic information

As can be seen from Table 2 and Figure 2, male teachers account for 60% and female teachers account for 40%. The distribution of teaching years is relatively balanced, accounting for 23.3% in 1-5 years, 40% in 6-10 years and 36.7% in more than 10 years. The subject background covers humanities (30%), science and engineering (36.7%) and social science (33.3%). In the teaching form, 56.7% teachers choose mixed teaching, and 43.3% choose traditional classroom teaching; 73.3% are mainly classroom teaching, and 26.7% are mainly online teaching. In terms of teaching experience, medium experience accounts for 46.7% and high experience accounts for 53.3%. 93.3% of teachers hold qualification certificates, 53.3% teach in large classes and 46.7% teach in small classes.

Descriptive statistics of the research samples show that both students and teachers have diversity and representativeness. These data provide reliable basic support for the follow-up study of the application effect of cognitive fuzzy learning system in college classroom design, and can reflect the actual situation in different classroom sizes, teaching forms and subject backgrounds, ensuring that the research results have a certain wide applicability.

2.2 Cognitive fuzzy learning system model construction

Cognitive fuzzy learning system (CFLS) is a dynamic learning support tool that combines Fuzzy Cognitive Map, FCM) and fuzzy reasoning logic [19]. The system dynamically evaluates the teaching effect by modeling the key factors in classroom design (such as students' cognitive state, learning participation, classroom interaction, etc.), and puts forward optimization suggestions.

2.2.1 Definition of cognitive fuzzy learning system model

The core of CFLS is the method of causal relationship modeling and state updating based on fuzzy cognitive map, which is used to simulate the complex interaction between various factors in the classroom [20]. As a modeling tool based on graph theory, fuzzy cognitive map's nodes represent system variables (such as students' learning state), and the edge weights between nodes represent the strength of causality between variables.

(1) System nodes and causality

The he model's input variables include factors such as students' learning progress, classroom interaction quality, and knowledge mastery level, while the output variable is classroom optimization suggestions. Specifically, assume the system consists of n variable nodes, with a weight matrix representing the causal relationship strength between the nodes. The weight values range from [-1, 1]:

$w_{ij} > 0$: Indicates that node i has a promoting effect on node j.

$w_{ij} < 0$: Indicates that node i has an inhibiting effect on node j.

(2) System status update

The system state $S_t = \{s_1, s_2, ..., s_n\}$ represents the state value of each node at time t, and the state update is completed by the following formula (1).

$$S_{t+1}(v_j) = f(\sum_{i=1}^{n} w_{ij} \cdot S_t(v_i) + b_j) \quad (1)$$

Where: w_{ij} indicates the weight v_i from node to node; b_j is the offset value of the node v_j ; F(x) is the activation function.

2.2.2 Cognitive fuzzy learning system model architecture design

For the research of fuzzy reasoning system, CFLS model architecture includes three main levels: input level, fuzzy reasoning level and output level.

The input layer receives students' feedback data (such as classroom satisfaction, learning effect score, etc.) and fuzzifies it. For example, the original grade is divided into three fuzzy language variables: low, medium and high, and the formula for calculating the membership degree is (2).

$$\mu_A(x) = \begin{cases} 0, x \le a \\ \dfrac{x-a}{b-a}, \ a < x < b \\ 1, x \ge b \end{cases} \tag{2}$$

Where, $\mu_A(x)$ represents the membership degree of data X in fuzzy set A, and a and b are the boundary values of fuzzy set.

Fuzzy reasoning layer: the fuzzy reasoning layer infers the input data through the fuzzy rule base. The reasoning result is calculated as Formula (3) by weighted average.

$$y = \frac{\sum_{i=1}^{n} \mu_{A_i} \cdot w i}{\sum_{i=1}^{n} \mu_{A_i}} \tag{3}$$

The function of fuzzy reasoning layer is to transform complex classroom feedback data into interpretable reasoning results, which can be used to guide the optimization of teaching design.

Output layer: fuzzy reasoning results are transformed into specific classroom optimization suggestions through deblurring. The following formula (4) is adopted for deblurring.

$$y* = \frac{\sum_{i=1}^{n} y_i \cdot \mu_{B_i}}{\sum_{i=1}^{n} \mu_{B_i}} \tag{4}$$

Among them:

$y*$: Deblurring result; y_i: Possible output values; μ_{B_i} : Membership degree.

2.2.3 Realization process of cognitive fuzzy learning system model

The implementation process of CFLS includes the following steps:

(1) Data input and fuzzification

Students' feedback and classroom data are input into the model and transformed into fuzzy language variables through fuzzy functions.

(2) State updating and weight optimization

Referring to the fuzzy cognitive map optimization method in [20], the system optimizes the weight matrix w as shown in Formula (5) by the following formula.

$$w_{ij}^{(t+1)} = w_{ij}^{(t)} - \eta \frac{\partial L}{\partial w_{ij}} \tag{5}$$

Where: η is the learning rate; L is the loss function, which is used to measure the error between the reasoning result and the actual feedback.

(3) Reasoning and deblurring

The model uses fuzzy rule base reasoning to get classroom design optimization suggestions, and outputs specific teaching adjustment plans after deblurring.

(4) Feedback and iterative optimization

The system adjusts the model parameters (such as weight matrix and bias term) according to the actual teaching feedback to improve the adaptability of the model in the dynamic classroom environment.

2.3 College classroom teaching design based on cognitive fuzzy learning system

As an intelligent classroom support tool, cognitive fuzzy learning system (CFLS) can dynamically analyze students' learning feedback and adjust teaching strategies in real time, which provides a brand-new design idea for classroom teaching in colleges and universities. The classroom teaching design based on CFLS focuses on constructing a student-centered, interactive and dynamic teaching model. This section expounds its specific application from three aspects: teaching objectives and design principles, design and implementation of classroom activities, and learning feedback and evaluation mechanism.

2.3.1 Teaching objectives and design principles

Classroom design based on CFLS, its teaching objectives mainly focus on the following aspects: to meet the learning needs of different students through personalized teaching design. CFLS can dynamically capture students' cognitive status and classroom participation, and provide differentiated teaching resources for students with different cognitive levels. CFLS supports real-time adjustment in the teaching process, and teachers can dynamically optimize teaching content and progress according to system feedback, thus improving classroom efficiency. CFLS emphasizes classroom interaction, and stimulates students' interest and initiative in learning by enhancing communication between teachers and students. Finally, through the data-driven evaluation and feedback mechanism, CFLS can continuously optimize teaching strategies and improve students' learning effectiveness.

In terms of design principles, CFLS emphasizes student-centered and fully respects students' subjectivity in the learning process. For example, by systematically analyzing students' cognitive state, we can recommend suitable learning tasks and resources for students, so that they can get the best results in their own learning path. Based on the principle of data-driven, CFLS makes scientific decisions on teaching activities by using classroom data to ensure the scientificity and operability of the design. At the same time, CFLS is flexible and can be adjusted adaptively according to the characteristics of different disciplines, teaching objectives and students' needs. In terms of interaction, CFLS emphasizes the multi-dimensional interactive forms of classroom activity design, such as group discussion and case analysis, so as to maximize the sense of participation and interaction in the classroom.

2.3.2 Design and implementation of classroom activities

The design of classroom activities based on CFLS is dynamic and diversified, aiming at providing different students with activities suitable for their cognitive level and learning needs. CFLS can support group learning activities. By systematically analyzing students' cognitive level, learning interest and historical performance, teachers can divide students into groups with similar or complementary learning abilities, thus promoting cooperative learning within groups. For example, in a mixed teaching class, the system can separate students with good learning foundation from those who need extra help, and realize complementarity through collaborative learning. For students with weak foundation, CFLS can push supplementary learning resources suitable for their level.

Task-driven learning is one of the important teaching methods supported by CFLS. Classroom task design should be as close to the real scene as possible, which is open and challenging, and can guide students to explore and apply what they have learned independently in the process of completing the task. For example, in science and engineering courses, teachers can design engineering problem situations, so that students can work together to complete tasks, while CFLS dynamically analyzes the progress and participation of each group in the process, providing tips and suggestions for students or groups that need extra support.

In the process of classroom implementation, CFLS can run through the whole teaching process. Before class, the teacher systematically analyzes the students' historical learning data to understand the students' mastery of knowledge points and the difficulties of the course content, so as to make a targeted teaching plan. In the classroom, the system monitors students' learning status and classroom participation in real time, generates dynamic feedback, and helps teachers adjust teaching progress. For example, when the system detects that the understanding of a certain knowledge point is low, the system will prompt the teacher to explain the content in more detail. After class, CFLS will generate a study report according to the students' task completion, which will help teachers understand the classroom effect and provide a basis for subsequent teaching.

2.3.3 Learning feedback and evaluation mechanism

Learning feedback and evaluation mechanism is one of the core links of classroom design based on CFLS, and it is also an important guarantee to ensure teaching effect and students' learning quality. CFLS provides multi-level feedback support for students, teachers and classroom managers through real-time monitoring and dynamic analysis of classroom data.

CFLS can provide students with personalized learning feedback. For example, the system can generate a personalized learning report for each student according to the students' classroom participation, task completion and knowledge points, and clarify the students' advantages and areas for improvement. Students can learn about their learning progress and adjust their learning plans through these feedbacks. At the same time, the system can also recommend supplementary materials or learning tasks for students to help them make up for the weak links.

CFLS provides multi-dimensional classroom evaluation data for teachers. For example, the system can generate the participation curve of students in the classroom and help teachers identify which knowledge points students have mastered better and which knowledge points need to be further consolidated. The system can also analyze students' performance in classroom activities, such as the contribution in group discussion and the correct rate of answering questions. These evaluation data can help teachers better understand the teaching effect, find the shortcomings in classroom design, and provide the basis for the next classroom optimization.

CFLS constructs a complete feedback closed-loop mechanism. In the teaching process, CFLS helps teachers adjust their teaching strategies through real-time feedback; After the teaching, the system integrates and analyzes the classroom data, which provides the direction for teaching improvement. For example, the system can prompt teachers which teaching links need to be optimized and which students need extra attention. Through the feedback closed-loop mechanism, CFLS not only improves the accuracy of classroom design, but also realizes the continuous improvement of teaching.

3. Results and Discussion

3.1 Research results

3.1.1 Analysis of the results of the questionnaire survey

This study collected 180 students and 30 teachers' evaluation on the application effect of cognitive fuzzy learning system (CFLS) in college classroom design through questionnaire survey. The following is the analysis of the results of the questionnaire survey of students and teachers, as shown in Figure 3 and Tables 3-6.

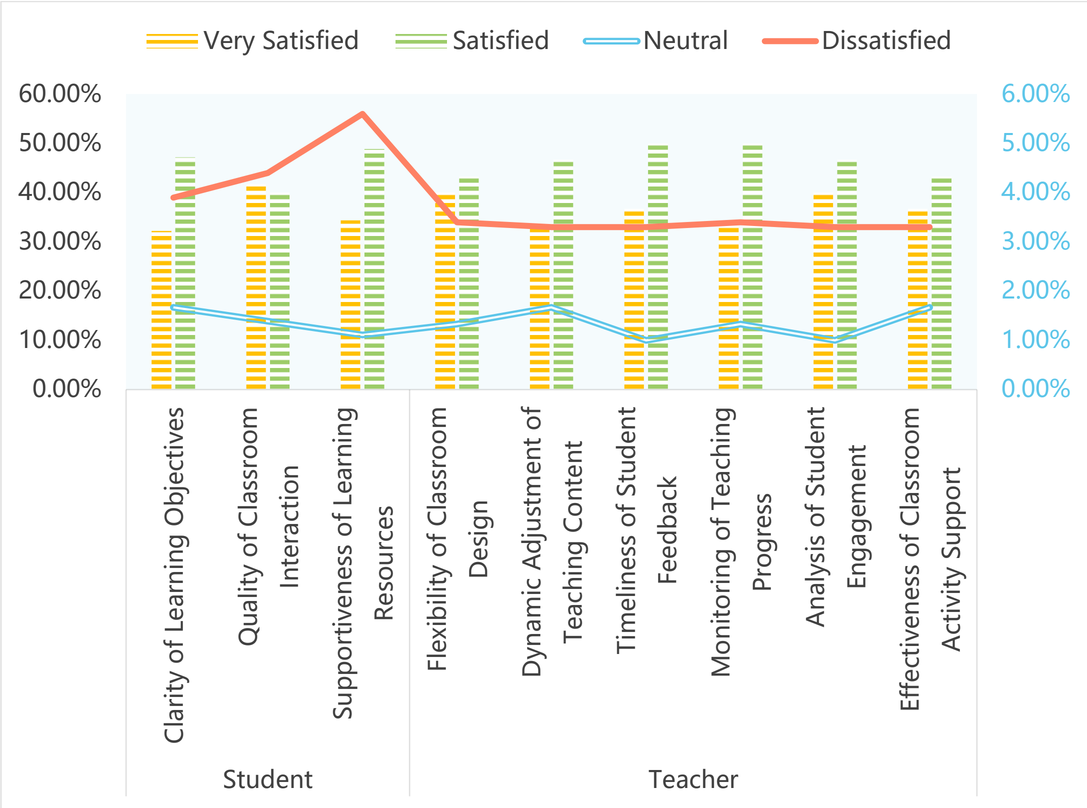

Figure 3. Statistics of the proportion of teachers and students in the survey

Table 3
Student satisfaction with classroom design

Dimension	Very Satisfied	Satisfied	Neutral	Dissatisfied
Clarity of Learning Objectives	58	eighty-five	30	seven
Quality of Classroom Interaction	75	seventy-two	25	eight
Supportiveness of Learning Resources	62	88	twenty	10

As can be seen from Table 3 and Figure 3, most students are satisfied or very satisfied with the classroom design based on CFLS, especially in the quality of classroom interaction (81.7% students are satisfied) and the support of learning resources (83.3% students are satisfied). A small number of students asked for improvement in the clarity of teaching objectives and the support of learning resources, and 3.9% and 5.6% students expressed dissatisfaction respectively.

Table 4
Students' evaluation of classroom participation

Dimension	Option	Number	Percentage
	Frequently	50	27.80%
Frequency of Asking Questions	Occasionally	95	52.80%
	Rarely	35	19.40%

Participation in Group Discussions	Very Active	48	26.70%
	Active	82	45.60%
	Neutral	40	22.20%
	Inactive	10	5.60%
Frequency of Classroom Interaction	High	60	33.30%
	Moderate	eighty-five	47.20%
	Low	35	19.40%

Table 4 shows that, although most students indicated that the participation of classroom interaction and group discussion was high (more than 70% students were active or very active), there were still 19.4% students who thought that the frequency of classroom interaction was low, which indicated that the CFLS system needed to further improve the supporting effect of interaction in some scenes.

Table 5
Teacher Evaluation of CFLS Application Effectiveness

Dimension	Very Satisfied	Satisfied	Neutral	Dissatisfied
Flexibility of Classroom Design	twelve	13	four	one
Dynamic Adjustment of Teaching Content	10	14	five	one
Timeliness of Student Feedback	11	15	three	one

In Table 5 and Figure 3, teachers have a high evaluation on the flexibility of classroom design, the dynamic adjustment of teaching content and the timeliness of students' feedback, among which the satisfaction ("very satisfied" and "satisfied") exceeds 80% in all dimensions. However, some teachers still put forward suggestions for improvement, thinking that there is still room for improvement in dynamic adjustment and timeliness of student feedback.

Table 6
Teacher evaluation of classroom support effectiveness

Dimension	Very Satisfied	Satisfied	Neutral	Dissatisfied
Monitoring of Teaching Progress	10	15	four	one
Analysis of Student Engagement	twelve	14	three	one
Effectiveness of Classroom Activity Support	11	13	five	one

Table 6 and Figure 3 show that teachers are highly satisfied with the classroom support of CFLS, among which the monitoring of teaching progress and the analysis of students' participation are more than 80% satisfied, and the support effect of classroom activities is also recognized by teachers (80% satisfied). A few teachers think that the supporting effect of classroom activities still needs to be optimized, especially the adaptability in complex classroom activities.

3.1.2 Analysis of model experiment results

In order to evaluate the practical application effect of cognitive fuzzy learning system (CFLS) in classroom teaching design, this study conducted a model experiment. By simulating the performance of the system in different teaching scenarios, this paper analyzes its role in optimizing classroom design, dynamically adjusting teaching content and improving students' learning effect. The following are the key data and analysis of the experimental results:

Table 7
Optimization effects of CFLS on classroom teaching design

Optimization Dimension	Pre-Test (Without CFLS)	Post-Test (With CFLS)	Improvement Rate
Student Classroom Engagement Score	3.2 (out of 5)	4.1 (out of 5)	28.10%
Teacher Classroom Satisfaction Score	3.5 (out of 5)	4.3 (out of 5)	22.90%
Frequency of Classroom Interaction (times/class)	twelve	twenty	66.70%
Utilization Rate of Teaching Resources	65%	85%	30.80%

As can be seen from Table 7, CFLS significantly optimizes the effect of classroom teaching design. After the application of CFLS, students' participation in class increased from 3.2 to 4.1, an increase of 28.1%. Teachers' scores on classroom satisfaction increased by 22.9%. At the same time, the number of classroom interactions has increased from 12 to 20, and the utilization rate of teaching resources has increased from 65% to 85%. This shows that CFLS can improve students' participation and teachers' satisfaction and enhance teaching effect by dynamically optimizing classroom design.

Table 8
Performance of CFLS in dynamically adjusting teaching content

Indicator	Pre-Test (Without CFLS)	Post-Test (With CFLS)	Improvement Rate
Knowledge Mastery Rate (%)	68%	82%	20.60%
Satisfaction with Difficult Content Explanation	3.4 (out of 5)	4.2 (out of 5)	23.50%
Matching Rate of Learning Progress	70%	88%	25.70%

As can be seen from Table 8, CFLS has performed well in dynamically adjusting the teaching content. Students' mastery of knowledge points increased from 68% to 82%, and the satisfaction score of difficult content explanation increased from 3.4 to 4.2. In addition, the matching degree of learning progress has increased from 70% to 88%. This shows that CFLS can effectively help students better grasp knowledge points and improve learning efficiency by dynamically analyzing classroom feedback and adjusting teaching content.

Table 9
Effects of CFLS on student learning outcomes

Student Performance Dimension	Pre-Test (Without CFLS)	Post-Test (With CFLS)	Improvement Rate
Average Classroom Test Score (points)	75	83	10.70%
Assignment Completion Rate (%)	78%	92%	17.90%
Learning Motivation Score	3.3 (out of 5)	4.1 (out of 5)	24.20%

Table 9 shows that CFLS has significantly improved students' learning effect. After the application of CFLS, the average score of students' classroom test increased from 75 to 83, and the completion rate of homework increased from 78% to 92%. In addition, the score of students' learning initiative has increased from 3.3 to 4.1. This shows that CFLS can effectively stimulate students' learning motivation and improve the learning effect.

The experimental results show that CFLS has achieved remarkable results in classroom teaching design, dynamic adjustment of teaching content and improvement of students' learning effect. Specifically, CFLS optimizes classroom design and improves students' participation, knowledge mastery and academic performance by monitoring classroom feedback and students' cognitive status in real time. At the same time, teachers' satisfaction with the classroom has also been significantly improved, and the frequency of classroom interaction and the utilization rate of teaching resources have been greatly improved. These data further verify the application potential of CFLS in modern teaching and provide an important reference for future educational innovation.

3.1.3 Classroom teaching effect analysis

Further evaluate the teaching effect of cognitive fuzzy learning system (CFLS), and analyze it from the aspects of teacher satisfaction and overall classroom teaching efficiency. As shown in Tables 10 and 11.

Table 10
Impact on teacher satisfaction

Teacher Satisfaction Dimension	Pre-Test (Without CFLS) (out of 5)	Post-Test (With CFLS)	Improvement Rate
Flexibility of Classroom Design	3.5	4.3	22.90%
Effectiveness of Teaching Content Adjustment	3.4	4.2	23.50%
Timeliness of Handling Student Feedback	3.6	4.4	22.20%

The application of CFLS has significantly improved teachers' satisfaction with the flexibility of classroom design, the adjustment of teaching content and the timeliness of student feedback processing. Teachers believe that CFLS provides more accurate classroom data support, which enables them to make rapid adjustments in the teaching process and improves teaching efficiency and classroom effect.

Table 11

Improvement in overall classroom efficiency

Classroom Efficiency Dimension	Pre-Test (Without CFLS)	Post-Test (With CFLS)	Improvement Rate
Frequency of Classroom Interaction (times/class)	twelve	twenty	66.70%
Utilization Rate of Teaching Resources	65%	85%	30.80%
Classroom Activity Score	3.2 (out of 5)	4.1 (out of 5)	28.10%

The average number of classroom interactions has increased from 12 to 20, with an increase of 66.7%; The utilization rate of teaching resources has increased from 65% to 85%, and the classroom activity score has also increased from 3.2 to 4.1. These data show that CFLS can effectively improve the overall classroom efficiency and provide a more dynamic learning environment for teachers and students by optimizing classroom design and promoting teacher-student interaction.

From the above analysis, it can be seen that the application of CFLS is remarkable in improving teachers' satisfaction and overall classroom efficiency. Specifically, teachers' satisfaction with the adjustment of teaching content and classroom management has been significantly improved, and the frequency of classroom interaction and resource utilization have been optimized. These results show that CFLS provides strong support for classroom design and teaching practice in colleges and universities, and it is a teaching tool with wide application prospects.

3.2 Discussion

3.2.1 Summary of research questions

This study focuses on the performance of cognitive fuzzy learning system (CFLS) in the design and application of classroom teaching in colleges and universities, and summarizes the following main research problems and their solutions by combining data analysis and experimental results:

The integration of CFLS in classroom design: This paper discusses how CFLS, as an innovative teaching tool, can optimize classroom design by dynamically adjusting teaching content, improving students' participation and promoting personalized learning. The results show that CFLS can effectively overcome the limitations of traditional classroom design, such as fixed teaching methods and insufficient adaptability to students' needs.

Influence on students' learning and teachers' satisfaction: This study focuses on the double influence of CFLS on students and teachers. For students, CFLS has significantly improved academic performance, learning initiative and classroom participation; For teachers, CFLS improves the flexibility of classroom design, the ability to adjust teaching content and the timeliness of student feedback processing.

Challenge of interdisciplinary application: Although CFLS has shown remarkable potential in many disciplines such as liberal arts, science and engineering, social sciences, etc., the research found that its adaptability among different disciplines still has certain challenges. In particular, how to finely adjust the system according to the teaching characteristics of different disciplines needs further in-depth study.

Construction of real-time feedback and continuous optimization mechanism: Research shows that the existing classroom feedback mechanism is insufficient, and CFLS can provide a dynamic feedback closed loop for continuous optimization of teaching strategies. However, in the highly dynamic and complex classroom environment, CFLS still needs to be further improved to give full play to its real-time feedback and optimization potential.

3.2.2 Research Enlightenment and Suggestions

Based on the research results, this study puts forward the following important inspirations and practical suggestions to promote the in-depth application of CFLS in colleges and universities:

Strengthening individualized teaching support: CFLS has obvious advantages in supporting individualized learning, and can dynamically adjust teaching content by analyzing students' feedback. Advanced data analysis technology, such as machine learning algorithm, should be further introduced in the future application to further optimize the allocation of teaching resources and the accuracy of teaching strategies, so as to better meet the learning needs of different students.

Expand the interdisciplinary application scope: Although CFLS shows good adaptability in multidisciplinary fields, it is necessary to develop more flexible configuration schemes according to the characteristics of different disciplines. For example, for science and engineering courses, the system can focus on supporting the decomposition of complex knowledge points and the integration of diversified teaching resources; For liberal arts courses, we can pay more attention to the optimization of classroom interaction and the improvement of students' cognitive participation.

Improve the accuracy and adaptability of real-time feedback: CFLS has obvious advantages in real-time feedback and optimization mechanism, but it still needs to be further improved in dynamic classroom environment. It is suggested that the accuracy of system feedback should be improved by optimizing the data collection and analysis process, and the linkage between feedback and instructional design adjustment should be strengthened to ensure the efficiency and immediacy of feedback mechanism.

Strengthen teacher training and guidance on system application: the effective application of CFLS can not be separated from the support and participation of teachers. Therefore, it is suggested that colleges and universities provide systematic training for teachers, help teachers to be familiar with the functions and usage of the system, and improve their teaching design ability. At the same time, in the process of system promotion, a professional team should be set up to provide teachers with continuous technical support and guidance to help them make full use of the advantages of CFLS in classroom practice.

Constructing comprehensive evaluation and promotion mechanism: In the process of promoting CFLS, a comprehensive evaluation system should be established to quantify the application effect of the system in different teaching scenarios. Through the long-term tracking and evaluation of classroom teaching quality, we can continuously optimize the functional design of CFLS, and provide data support and practical experience for the promotion of other universities.

4. Conclusion

This study focuses on the application of cognitive fuzzy learning system (CFLS) in classroom teaching design in colleges and universities, and systematically discusses its potential in optimizing classroom teaching design, improving teaching effect and promoting teaching interaction. The main conclusions of the study are as follows:

First, CFLS can significantly optimize the classroom teaching design in colleges and universities. Traditional classroom teaching design is often limited by a fixed model, and it is difficult to dynamically adapt to students' diverse learning needs. However, CFLS dynamically models the key factors in the classroom (such as students' cognitive state, learning progress and classroom interaction) through fuzzy cognitive maps, which can realize real-time adjustment of teaching content and teaching strategies. The model experiment and classroom application results of this study show that CFLS has excellent adaptability in personalized teaching design, classroom interaction optimization and learning progress adjustment, which provides strong support for the flexibility and pertinence of classroom design in colleges and universities.

Secondly, CFLS has played a significant role in improving students' learning effect. Through questionnaire survey and experimental analysis, it is found that students' learning initiative, classroom participation and knowledge mastery have been significantly improved in classroom teaching with CFLS. For example, classroom test scores, homework completion rate and learning motivation scores have all improved significantly after the application of CFLS, which shows that the system can effectively stimulate students' interest in learning and help them better master the learning content. This shows that CFLS can provide students with more targeted learning support through accurate classroom data analysis and real-time feedback mechanism.

Thirdly, the research shows that the application of CFLS is not only beneficial to students, but also significantly improves teachers' satisfaction. Teachers' feedback data shows that CFLS is excellent in dynamic adjustment of teaching content, timeliness of feedback processing and flexibility of classroom design. Through classroom observation, it is found that CFLS can improve the interaction frequency between teachers and students and significantly improve the utilization efficiency of teaching resources. These characteristics not only improve the overall efficiency of the classroom, but also provide more accurate decision support for teachers in complex teaching environment.

Fourthly, the interdisciplinary adaptability of CFLS has been preliminarily verified in this study. Through the application in different disciplines such as liberal arts, science and engineering and social sciences, it is found that CFLS can flexibly adjust the teaching design according to the characteristics of disciplines, showing strong versatility. However, the study also found that the teaching needs of different disciplines are quite different, which requires the system to further optimize the configuration according to specific scenarios in practical application.

Fifthly, the closed-loop mechanism of classroom feedback based on CFLS is studied and constructed, and its effectiveness is verified. By monitoring classroom data in real time and generating dynamic feedback, CFLS can provide teachers with classroom optimization suggestions, which significantly improves the accuracy and adaptability of classroom teaching. This feedback closed-loop mechanism not only contributes to the continuous optimization of teaching design, but also provides technical support for the long-term improvement of teaching quality.

To sum up, CFLS, as a cutting-edge intelligent teaching tool, shows its great potential and wide applicability in classroom teaching design in colleges and universities. The results show that CFLS can effectively improve the flexibility and efficiency of classroom teaching and provide teachers and students with a higher quality teaching experience. However, this study also points out that the adaptability of CFLS in complex teaching scenarios still needs to be further improved, especially in the dynamic classroom, which can be used as the next research plan.

Ethics approval and consent to participate

Not Applicable.

Consent for publication

Not Applicable.

Availability of data and material

The datasets used and/or analysed during the current study available from the corresponding author on reasonable request.

Competing interests

The authors have declared that no competing interests exist.

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Authors' contributions

Mingfang Zhou, Yongping Wei, Yameng Bai wrote the main manuscript text, prepared figures, tables and equations. All authors reviewed the manuscript.

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