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Research Article

Design of Teaching Effect Evaluation Algorithm of Flipped Classroom Based on Fuzzy Comprehensive Evaluation

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The flipped classroom model has become an essential path of teaching improvement in the colleges and institutions of higher education across the Republic of China as a direct result of the extensive assimilation of information technology and education courses that have taken place in this era of mobile Internet. Simultaneously, in order to react to the desire for the construction of new liberal arts and the training of talents serving society, a fuzzy comprehensive evaluation (FCE) algorithm is proposed to assess the teaching effect of flipped classrooms. This is done with the intention of meeting the requirements of both the construction of new liberal arts and the training of talents who can serve society. We divided the people who were going to be the subjects of this teaching into two groups: (i) one to serve as the experimental group; and (ii) the other to serve as the control group. We then supplemented the lessons for each group using either flipped classroom teaching or traditional teaching methods, depending on which group they were in. After that, the results based on the fuzzy comprehensive assessment reveal that the teaching method of the flipped classroom can successfully raise students' ability for autonomous learning as well as cultural creativity and practice. Furthermore, it can also increase the quality of teaching in the classroom. The learning effect is superior to that of the conventional instructional approach, and as such, it is deserving of further promotion. The evaluation can successfully grade the teaching effect of the classroom, which provides growth for a novel notion for the evaluation of the teaching influence of the flipped classroom.

1. Introduction

The flipped classroom teaching model [1–3] is a new teaching approach that was tested out and promoted at Woodland Park High School in Colorado, United States of America. It has gained significant attention from educators both in the United States and in other countries of the world. In fact, students use their own time outside of class to view instructional videos and other materials that have been provided by their teachers in advance [4]. The name is given to the more in-depth examination of the material being taught in the classroom, which may take the form of exercises, group discussions, or other types of activities [5]. Because academics in both the United States and other countries have conflicting opinions regarding the flipped classroom method of instruction, numerous academics in the field of education have participated in in-depth investigations into the topic's efficacy [6]. According to a number of study papers, the instructional influence of the flipped classroom teaching style in college physics classes is noticeably superior to that of the traditional teaching mode [7–9]. A controlled experiment on the teaching effect of undergraduate physics courses is one of the most influential pieces of research that has been done on the teaching effect of flipping the classroom in this nation. The findings indicate that, after two flipped courses, the experimental group's students made considerably more progress than the control group's students did. This was the case even though both groups were taught the same material and the teaching objectives were the same.

The capacity of the teacher using the flipped classroom to instruct is a direct factor in determining the teaching effect [10–13]. According to the findings of the research, the teaching video, the learning task package, and the classroom activity organization are the direct features that disturb the teaching influence of the flipped classroom. These findings are consistent with the research conclusions reached by other domestic scholars. The implementation of nontraditional instructional techniques poses the problem of rethinking course curricula for teaching professionals. The preparation of instructional materials has taken a significant amount of time and effort on the part of teachers. The results of certain questionnaires indicate that students are pleased with the preclass preparation and teaching mode used by the teachers. This finding suggests that the concepts behind the flipped classroom teaching style can significantly boost students' concentration in learning and improve their ability to learn on their own. As a result, hastening the cultivation of flipped classroom teaching ability among teachers is an imperative assurance for boosting the efficiency of flipped classroom teaching. Moreover, the use of the flipped classroom methodology as a teaching strategy is an important component that encourages independent student learning and has an impact on the effectiveness of instruction.

The teaching effects of flipped classrooms can be significantly improved by directing students to assume responsibility for their own education; encouraging students to use their creativity to acquire knowledge; and developing students' capacity for self-directed study. According to the results of the study, neither the awareness nor the capabilities of today's pupils have considerably increased, and the current state of affairs regarding autonomous learning is not favorable. The students face a number of challenges, the most significant of which is that the time they have available for flipped learning before class is severely limited due to the fact that the new teaching approach is incompatible with it [13]. Because of the significant amount of work that is expected from them academically, some students have voiced their opinion that it is not advisable to implement the flipped classroom teaching mode on a more regular basis. The flipped classroom should place an emphasis on teaching students according to their aptitude and concentration, as well as helping pupils who have a poorer ability to learn on their own independently [14].

Establishing the evaluation index system [15, 16] is a challenging task. Each of these indicators needs to be completed in order to guarantee impartiality, fairness, independence, and integrity, and the process is fairly convoluted. In the course of the construction process, the evaluation standards of numerous practice indicators for instructors as evaluation standards can better satisfy the demands of teachers and can easily be changed into standard practice for teachers. However, this pure form of individual teachers is influenced by the teachers themselves, but it is difficult to obtain sufficient effective samples at the same time, considering that there may be difficulties and deviations in the effective teaching behaviors described by teachers in classroom teaching. In fact, this makes it a tedious and challenging task to take a broad view of the effectiveness of singular teachers. The term assessment refers to all of the methods by which academic staff members make judgements regarding a student's progress throughout the whole learning process and within a specific unit of study.

Assessment is an essential component of both learning and teaching. Evaluations are carried out with the intention of providing a continuous process of planning, measuring, analyzing the outcomes, and employing the findings to arrive at well-informed decisions, which should ideally lead to some sort of advancement. Evaluation of the learning experience as well as the instructor's own performance is a component of any course or teaching evaluation. In other words, it can be broken down into two components. It is the job of teachers to evaluate their students' progress in learning and to assign reasonable grades. The department of staff management at a university is the one responsible for conducting teaching evaluations. The department can evaluate the quality and efficacy of teaching in order to monitor the teaching process and acquire data from specific aspects. This will enable the department to provide feedback to instructors in the future that will help them improve their own teaching. The major contributions of the research presented in this work are as follows: (1) A fuzzy comprehensive evaluation (FCE) algorithm is proposed in order to respond to the requirements of the construction of new liberal arts and the training of talents for societal service, as well as to evaluate the teaching effect of flipped classrooms. (2) A single-layer fuzzy evaluation model along with a multilayer fuzzy evaluation model is suggested.

The left behind part of the paper is arranged as follows. In Section 2, we deliberate the state-of-the-art methods and rivals in the related works. In Section 3, the research design and the methodology are presented. Furthermore, the two models are also demonstrated in this section. Simulation experiments and the attained outcomes are discussed in subsequent Section 4. Lastly, in Section 5, we provide a summary of our research and discuss some future research directions.

2. Related Work

Evaluating the informatization teaching ability of teachers in a way that is objective and accurate [17, 18], is one of the key tasks that must be completed in order to stimulate the growth of informatization teaching in the Republic of China, and the research on this topic has significant practical significance [19]. Numerous investigations into this topic have been carried out by academics in the past. Some researchers have developed an evaluation method for teachers' ability to teach informatization based on smart classrooms [20, 21], and they have provided some plausible proposals for the evaluation of teachers' capacity to teach informatization in higher vocational institutions. Some academics have undertaken studies on the standard of instructors' ability to teach informatization, and this provides a certain theoretical basis for additional research that may be conducted. The informatization teaching skills of teachers have been evaluated using a set of evaluation indexes that have been established by a few researchers and are rather comprehensive. After conducting research on the comprehensive evaluation method for teaching informatization in colleges and universities, a number of academics came to the conclusion that the evaluation results obtained using the radar map comprehensive analysis method are not only objective and accurate but also offer a number of distinct benefits. Some researchers use the TPACK theoretical model to conduct research with examples and evaluate the informatization teaching capacity of educators based on their findings [22, 23]. They are of the opinion that the present crop of preservice teachers has a poor level of technical ability, and they believe that there are still gaps in the integration of technology and content instruction. Some researchers have constructed a three-dimensional foreign language teaching evaluation system in accordance with the informatization teaching mode. They have also clarified the evaluation objectives of the evaluation system, and they are of the opinion that the system possesses the benefits of being comprehensive, objective, scientific, and accurate. Researchers have examined the efficacy of teaching information technology in vocational institutions, as well as the standards for evaluating it and the techniques for putting it into practice effectively.

Evaluating a teacher's performance is one of the most efficient ways to boost the overall quality of instruction, and it also plays a significant part in making administration in educational institutions of higher learning more robust. A large number of researchers have done work linked to teaching assessment in their studies. One use of data mining that sees use is in the evaluation of the effectiveness of classroom instruction [24]. Some academics utilize decision trees to assess the level of instruction provided by colleges and universities, with the ultimate goal of raising the overall standard of instructor training. To achieve more accurate results from the evaluation, some academics employ support vector machines using both the default settings and chosen parameters. Rough sets are a method that some academics use to acquire information about the employment situation and the quality of teaching in colleges and institutions of higher education. An evaluation model is established, and the applicable rules are reviewed. This helps to ensure that the evaluation level is improved as much as possible.

The FCE technique is a mathematical method that uses the thinking and methods of fuzzy mathematics to thoroughly evaluate items that are difficult to properly identify in the real world [25–27]. It should be noted that this particular method was initially developed by the University of California, Berkeley. The application of certain scholars in the teaching of a comprehensive assessment of fuzzy evaluation. A novel teaching performance evaluation framework that is based on the fuzzy AHP and FCE approaches has been presented by several academics. The novel evaluation technique first finds the evaluation index system's components and subfactors and then employs the degree analysis fuzzy AHP method to calculate the weights of the factors and subfactors that were determined in the previous step. The proposed teaching performance evaluation framework that is based on the fuzzy AHP and FCE methodologies is illustrated by a case application by some academics.

The field of study known as fuzzy mathematics is one that makes use of associated mathematical procedures in order to deal with and address a variety of hazy things and occurrences. In both our professional and personal lives, there are some challenges that can be challenging to accurately convey using numerical terms. It is possible that using a vague number to describe it will be more socially acceptable. It is possible to interpret it in a number of different ways. Since Moorel proposed the concept of interval numbers in the 1960s, scholars have always paid attention to the application and research of interval numbers. This is due to the fact that the selection of attribute weights needs to make the lower limit of the widespread attribute cost of every structure the smallest possible, and the upper limit of the complete attribute significance of every system needs to be maximized. A planning model is established by using the weighting method, and the attribute weights are determined by the attribute weighting method. Some academics employ the Hausdorff distance in order to ascertain the attribute value of the interval number as well as the degree of closeness of the ideal interval number. Additionally, the Hausdorff distance formula is utilized in order to ascertain the relative importance of the related attributes. According to the research of a few academics, the multiattribute decision-making issue of the intermission quantity can be solved by describing the positive and negative superlative interval numbers of the interval number and employing the relative closeness as a factor in determining how much weight to give each interval attribute. The operation can be made more straightforward by converting the attribute weights into numerical values. The multiattribute decision-making problem with scheme preference was explored by some academics, and one of them offered a way to compute attribute weights based on the interval number separation degree formula.

In order for colleges and institutions of higher education to effectively implement the national education policies and procedures, consolidate the fundamental task of building morality and cultivating people, and simultaneously further progress and increase the level of teaching work, a comprehensive assessment of their teaching conditions is required. This assessment must be carried out in order for schools and institutions of higher education to effectively implement the national education policies and procedures. It is necessary, at this time, to evaluate the teaching quality of each college according to the scores that were given by the experts because the scores that were given by the experts were frequently fuzzy numbers (such as interval numbers) as a result of the various uncertainties that were present in the actual situation. There is currently no standardized approach to the teaching of evaluation anywhere in the world, including in the United States. Methods such as AHP, PCA, utility function, FCE, and so on are examples of the most frequently used mathematical analysis techniques [28, 29]. Every approach comes with its own set of perks. The extent of its use as well as any restrictions it may have. The AHP contains significant amounts of subjectivity, and the ranking is fairly arbitrary.

The principal component analysis method does not provide a clear explanation of what it means. The utility function method and the FCE method both rely on subjectivity when deciding how much weight to give to each factor [30]. As a result of the unpredictability of the comprehensive evaluation of teaching, a mathematical model that is based on the dispersion maximization method has been established in order to determine the weight vector group of attributes [31]. This model seeks to eliminate, to the greatest extent possible, the subjectivity associated with determining the weight vector and possesses some degree of objectivity. This method uses interval numbers as an example. A teaching evaluation model in a fuzzy environment is provided, and a decision method based on an interval number weight vector group is proposed. This provides a new evaluation method for teaching the evaluation model in a fuzzy environment. Take interval numbers as an example. Providing [32, 33].

3. Research Design

3.1. Data Sources. Figure 1 displays the flow chart that corresponds to the algorithm. The comparison of the final exams and questionnaires that were administered at the end of the course by a school in Shanghai provides the source for our data. The test set consists of eighty percent of the total data, while the training set consists of twenty percent of the total data [29]. Our evaluation model of the flipped classroom teaching effect, which is based on the model for comprehensive evaluation, is created in this manner.

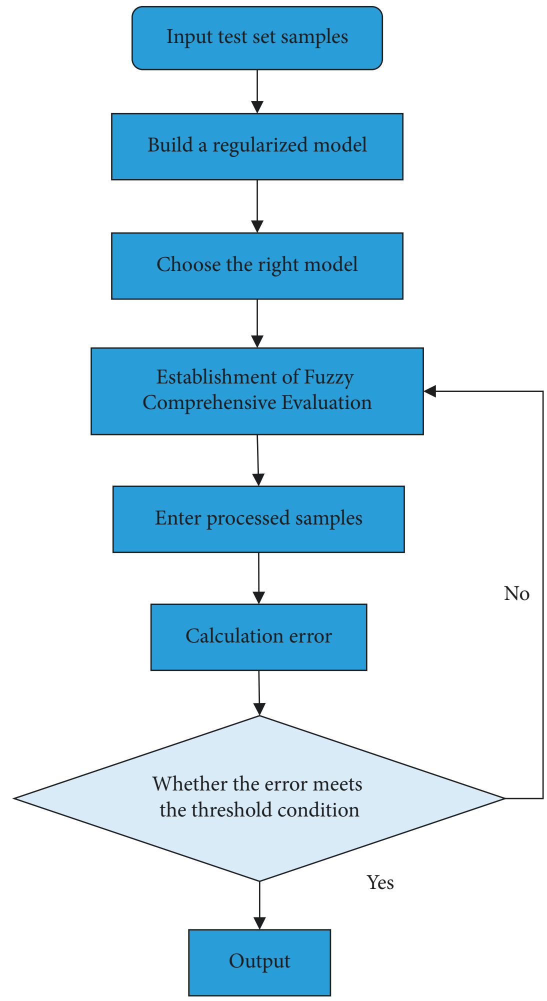

Figure 1: The algorithm flowchart.

3.2. Analysis Based on the AHP-FCE Method. Utilizing the membership degree theory found in fuzzy mathematics, one can quantitatively evaluate those complex multifactor schemes that are difficult to define using precise mathematical relationships. This is what is meant by FCE. To a large extent, the quality of the FCE is determined by the extent to which the calculation of the index weight is objective and scientific. This occurs during the process of determining the membership degree of each factor in the process of calculating the membership degree of each factor. When compared to the method of subjective qualitative determination of weights, AHP, which is a qualitative and quantitative multifactor decision-making method, is capable of making the calculation of index weights of fuzzy factors more objective and scientific. This is in contrast to the method of subjective qualitative determination of weights.

3.2.1. Single-Layer Fuzzy Evaluation Model. The following is a detailed description of the process that constitutes the single-layer fuzzy evaluation model:

(i) Step 1: obtain the factor set $S = \{s_1, s_2, \ldots, s_n\}$ associated with classroom instruction.

(ii) Step 2: the next step is to build up the $P = \{p_1, p_2, \ldots, p_m\}$ judgment set.

(iii) Step 3: evaluation of a single factor. The result of the ith evaluation of a single component is that the fuzzy relationship between S and P is $(g_{i1}, g_{i2}, \ldots, g_{im})$, and the evaluation matrix for all n factors looks like this as given in

$$G = \left(g_{ij}\right)_{n\times m}. \tag{1}$$

(iv) Step 4: carry out an exhaustive analysis and have the weight set $W = (w_1, w_2, \ldots, w_n)$, whereas the w_i indicates the relative importance of each factor i, which is illustrated using

$$\sum_{i=1}^{n} w_i = 1\left(w_i \geq 0\right)w_i. \tag{2}$$

The following formula, as demonstrated using equation (3), is a list of the results from the comprehensive evaluation:

$$A = W \cdot G = \left(w_1, w_2, \ldots w_n\right) \cdot \left(g_{ij}\right)_{n\times m} = \left(a_1, a_2, \ldots a_n\right). \tag{3}$$

Among the above equation (3), the generalized fuzzy synthesis operator is denoted by the letter "·" and is illustrated using

$$a_j = \sum_{i=1}^{n} w_i g_{ij} \, (j = 1, 2, \ldots, m). \tag{4}$$

3.2.2. Multilevel Fuzzy Evaluation Model. Following the design of the evaluation index system for the teaching impact of the mathematics network live broadcast, the teaching effect of the live broadcast classroom is evaluated with the assistance of the multilevel fuzzy evaluation model.

The following is a rundown of the particular steps involved in the multilevel fuzzy evaluation model:

Step 1: perform the calculations and collect the final result of the full evaluation. A_{ij} of the lower subtarget in accordance with the model of evaluation with a single layer I is the number of the criterion layer, and j is the number of the evaluation index that is contained within the same criterion layer.

Step 2: the second step is to reestablish the fuzzy matrix G_i. The formula for this step is as follows using

$$G_i = \begin{bmatrix} A_{i1} \\ A_{i2} \\ \cdots \\ A_{ik} \end{bmatrix} = \begin{bmatrix} a_{i_1 1} & a_{i_1 2} & \cdots & a_{i_1 m} \\ a_{i_2 1} & a_{i_2 2} & \cdots & a_{i_2 m} \\ \cdots & \cdots & \cdots & \\ a_{i_k 1} & a_{i_1 m} & \cdots & a_{i_1 m} \end{bmatrix}, \tag{5}$$

where k is the number of assessment indications that can be potentially found in layer i of them all.

Step 3: comprehensive assessment of a single layer, assuming that the weight set of the i-layer evaluation index is denoted by the symbol $W_i = (w_{i1}, w_{i2}, \ldots w_{ik})$, the following formula, as shown in equation (6), is an example of the comprehensive evaluation result for this layer:

$$A_i = W_i \cdot G_i = (w_{i1}, w_{i2}, \ldots w_{ik}) \cdot \begin{bmatrix} a_{i_1 1} & a_{i_1 2} & \cdots & a_{i_1 m} \\ a_{i_2 1} & a_{i_2 2} & \cdots & a_{i_2 m} \\ \cdots & \cdots & \cdots & \\ a_{i_k 1} & a_{i_1 m} & \cdots & a_{i_1 m} \end{bmatrix}$$
$$= (b_{i1}, b_{i2}, \ldots b_{im}). \tag{6}$$

Step 4: conduct an all-encompassing analysis of the overall objective, beginning with the most fundamental component and working your way up through the layers. The following formula, which is illustrated in equation (7), is a list of the outcomes of the comprehensive examination of the overall goal:

$$A_i = (b_{01}, b_{02}, \ldots b_{0m}). \tag{7}$$

3.3. Evaluation Indicators. As metrics for determining the accuracy of the model, we make use of the accuracy, precision, recall, and $F1$ metrics. These indicators are widely used in artificial intelligence and machine learning research to quantify the prediction outcomes. The following equation (8) is the formula for determining the accuracy rate:

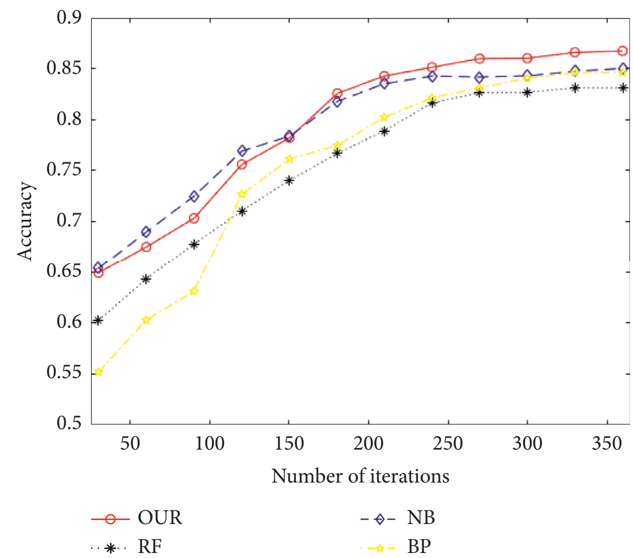

FIGURE 2: Accuracy of various approaches at different iterations.

$$Acc = \frac{TP + TN}{TP + TN + FP + FN}, \tag{8}$$

where TP denotes the true false and TN stands for true negative. Similarly, FP and FN characterize false positive and false negative, respectively. The following equation is the formula for determining the precision rate:

$$Pre = \frac{TP}{TP + FP}. \tag{9}$$

The following equation is the formula for determining the recall rate:

$$Rec = \frac{TP}{TP + FN}. \tag{10}$$

The following equation is the formula for determining the $F1$:

$$F1 = \frac{2 \times Pre \times Rec}{Pre + Rec}. \tag{11}$$

Besides these metrics, researchers have also used the MAPE (mean absolute percentage error) and RMSE (root mean square error) indicators to demonstrate the usefulness and accuracy of the prediction outcomes [23].

4. Experiments and Results

We will refer to the fuzzy algorithm as "OUR algorithm" for the sake of making the comparison between the following algorithms as simple as possible. We will also compare the random forest algorithm (RF), the Naïve Bayes algorithm (NB), and the BP neural network algorithm (BP) with the proposed approach.

As can be seen in Figure 2, we obtained varying degrees of success. When compared to the other five classification

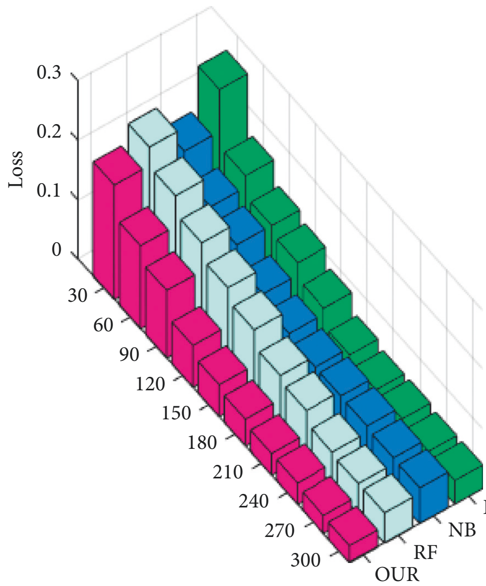

Figure 3: The loss for various approaches at different iterations.

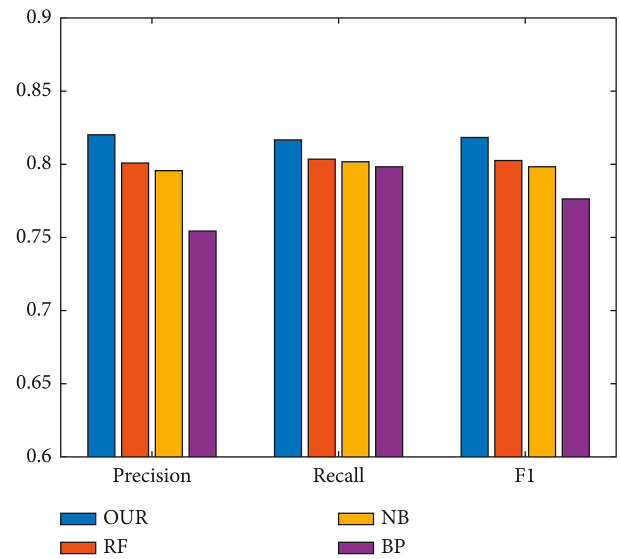

Figure 4: The precision, recall, and $F1$ metric values under dissimilar algorithms.

prediction algorithms that were tested, it is clear that the accuracy of the OUR method is superior to that of the others. This demonstrates that the OUR methodology is still quite successful in determining the impact that flipped classroom instruction has had on student learning. The efficacy of various assessment methods allows for the impact of interventions to be determined. It is during the iterative process that the correctness degree of the BP mechanism improves at the fastest possible rate. However, after the number of iterations hits 250, the growth rate begins to gradually slow down. During the iterative process, the accuracy of the RF algorithm continuously improves until it reaches its peak, at which point it is ranked last. When it was all said and done, the accuracy of the NB algorithm came in second.

Figure 3 depicts the loss that occurred while the procedure was being iterated. During the iterative process, we are able to observe that the algorithm loss of the OUR algorithm is always reducing, and as a result, it is currently the lowest value among the four different loss values. In contrast to the BP method, the initial loss is the one that is the highest, but as the iterative process continues, the parameter fitting gets better and better, which results in the model loss growing smaller and smaller, and the final loss is the one that is the second highest. As the number of repetitions grows, there is a gradual reduction in the amount of data lost by both the NB method and the RF algorithm. However, the end outcome is not as excellent as the data lost by the OUR algorithm. The precision, recall, and $F1$ metric values under diverse algorithms are shown in Figure 4.

We compared the OUR method with the RF algorithm, the NB algorithm, and the BP algorithm with regard to precision, recall, and $F1$ metric value, as is illustrated in Figure 4. Because the OUR method has the highest precision rate, recall rate, and $F1$ metric value, it is clear that there are no issues with the algorithm's stability. This can be noticed by looking at the figure. It is able to provide an accurate analysis of the flipped classroom's instructional effectiveness.

When it comes to conventional methods of education, the teachers themselves are frequently portrayed as the main characters in the classroom. Students are mostly responsible for listening and taking notes in the classroom, while professors are primarily responsible for delivering lectures. There is very little participation from students overall. The drawbacks of this form of instruction are readily apparent, despite the fact that it is helpful in fostering the development of teaching practices. An interest in learning, imperfect comprehension, generally unchangeable thought patterns, and so on. Students are given the opportunity to acquire knowledge that is relevant to their classes in advance by watching videos at home before coming to class. It should be noted that the majority of the time spent in class is devoted to the memorization, application, and exploration of material. The primary modes of instruction are exploratory and expanding activities, role-based debates, group discussions, and so on.

Communication between students as well as communication with students and the implementation of the flipped classroom teaching style in classroom instruction is beneficial for teachers because it targets students' knowledge blind spots as well as their needs and interests, and it guides students to engage in self-directed learning in a manner that is more scientific and rational. Students can be given greater initiative through the use of layered teaching, which can also inspire students' excitement for learning, actualize the creation of high-level thinking, encourage the integration of knowledge, and eventually enhance knowledge integration. The teaching impact evaluation model of flipped classrooms, which is based on fuzzy comprehensive assessment, can assist educators in devoting more of their consideration to the refinement of students' elementary literacy and the training of students in fundamental abilities.

5. Conclusions, Limitations, and Future Work

To summarize the findings, the flipped classroom teaching style, which is grounded in FCE, has achieved good implementation results in classroom teaching, and it has effectively stimulated students' learning interests and learning abilities. In fact, this was accomplished through the implementation of a comprehensive assessment. This teaching approach, which is focused on solving real-world problems, places an emphasis on the integration of a wide range of academic fields, and makes extensive use of the newest and latest generations of information technology, is able to successfully implement the student-centered teaching method, provide students with a greater variety of learning resources and opportunities, encourage students to engage in self-directed learning, and result in improved academic performance. We have confidence that the recommended approach is a novel approach to flipped classroom education that should be considered for use in institutions of higher learning.

There are a few issues associated with the methods of evaluating humans. For instance, the findings of the evaluation of the teaching quality are extremely subjective and unscientific, and the accuracy of the evaluation is very poor. As a result, the results of the evaluation cannot effectively reflect the actual teaching level of teachers. With the rise of the Internet and other forms of information technology, the question of how to employ information technology in a manner that is both scientifically and precisely correct in assessing the quality of instruction has been brought to the forefront. In an effort to find solutions to these issues, we have been making an effort to implement the fuzzy comprehensive assessment approach into the practical teaching evaluation of computer majors. Several datasets were gathered while classes were being taught, sparing university administration the additional labor that would have been required. After that, the data from the index are entered into the fuzzy comprehensive model in order to produce the outcomes of the scientific research. We are able to properly evaluate the teaching effect of the classroom by utilizing an evaluation algorithm that is based on FCE. This allows us to assist schools in objectively evaluating the classroom in which teachers are positioned. In the future, we will address these issues while proposing evaluation algorithms that are based on FCE.

Data Availability

The data used to support the findings of this study are available from the corresponding author upon request.

Conflicts of Interest

The authors declare that they have no conflicts of interest.

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