Research Article

Evaluation of Multimedia Classroom Teaching Effectiveness Based on RS-BP Neural Network

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Received 3 March 2022; Revised 31 March 2022; Accepted 28 April 2022; Published 13 May 2022

Academic Editor: Xuefeng Shao

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With the popularization of information technology, multimedia teaching has been widely used in universities as a new form of classroom teaching. In this paper, based on the classroom process, 12 evaluation indexes are initially obtained from three dimensions of “courseware, classroom teaching, and classroom effect,” which are reduced to 7 core indexes and evaluated comprehensively by using the rough set theory (RS), and the evaluation results are used as input data for simulation training of the BP neural network. The RS-BP neural evaluation model of multimedia classroom teaching effect (MCTE) is successfully trained, and finally five nonuniversities are selected for empirical research. The empirical study shows that this model has certain applicability when MCTE is such a nonlinear problem and can provide reference for the quality evaluation and improvement of multimedia teaching. The model in this study has certain practical value, but the index system is not comprehensive enough, the training data is insufficient, and the model maturity still needs further improvement.

1. Introduction

With the advent of the information age, the rapid development of science and technology has accelerated the updating of knowledge in the field of education, and the traditional teaching mode and teaching methods have failed to meet the needs of modern teaching and the requirements of current social, economic, and cultural development [1]. Multimedia classroom teaching (MCT), as a product of the combination of computer technology and current education technology, can be rich in teaching content and vivid teaching forms applied in teaching. The application of modern education technology can fully reveal the subjectivity of students, through contextual design and writing learning, and promote students’ active thinking and exploration, so that students become the main body of information processing in the learning process. Practice has proved that multimedia teaching has the characteristics of image, diversity, and intuition, which can stimulate students' interest in learning and play a fairly important role in deepening classroom teaching reform, improving teaching quality and comprehensively improving students' comprehensive quality.

Most of the current studies on MCT stay on partial improvement, lacking holistic research, and are not distinguished from traditional classroom teaching evaluation in terms of evaluation [2]. Compared with traditional classroom teaching, MCT pays more attention to and emphasizes the process of students’ independent participation and self-learning, while teachers provide students with a self-learning environment through multimedia teaching means, so that students can rise from perceptual to rational understanding and realize the unity of educational regularity and purpose [3]. The teaching evaluation system is a comprehensive examination of teaching quality, and the evaluation of teaching activities is a correct evaluation derived from the teaching objectives and through technical analysis methods [4]. Therefore, it is necessary to establish a scientific and reasonable evaluation system of MCT.

The evaluation of teaching quality is one of the most important aspects of teaching and learning, and Caballero (2017) states that online resources as a new vehicle for knowledge fragmentation and contextualization reform can be very useful for optimizing teaching and learning [5]. The multimedia classroom allows for “self-directed learning
strategies,” motivating students with a variety of learning strategies that allow them to discover the teaching context [6]. In this environment, online teaching is a key information resource for students’ independent learning. In recent years, the development of information processing technologies has accelerated the expansion of online instructional databases, bringing a wealth of information to students and teachers [7]. To address the main problems of application in multimedia teaching, Yong (2020) proposed an online classroom visual data tracking system combined with an advanced data mining-based tracking quality evaluation method [8]. Representing, analyzing, interpreting, and teaching evaluation results can make evaluation play a more important role in teaching level evaluation activities [9]. Ke (2021) pointed out that building a multimedia classroom evaluation index system for universities should be combined with the era of 5G multimedia network, and the evaluation process should include steps such as data collection, analysis, result output, and result feedback [10].

In terms of evaluation index system construction, Hiary used hierarchical analysis to construct an importance matrix and then determined the teaching quality evaluation index system [11]. Liu pointed out that teaching quality evaluation indexes should include teaching goal evaluation, teaching program evaluation, teaching process evaluation, and teaching effect evaluation [12]. Khaled et al. used a fuzzy mathematical mining algorithm to analyze the satisfaction of teaching quality and derived key indicators affecting teaching evaluation [13]. Liu proposed a hybrid intelligent algorithm based on the genetic algorithm and back-propagation neural network to evaluate teaching quality and proved that this evaluation method is effective and reasonable [14]. Kuriakose introduced feature selection based on certain evaluation criteria to preprocess the initial data and optimize from the original feature set to the low-Witt levy set to reduce data redundancy [15]. Ji et al. pointed out the role of functional selection of rough set neural networks that can be effectively applied to the solution of evaluation models [16]. Considering the advantages of rough sets and neural networks in evaluation [17], this study uses RS-BP neural networks to analyze MCTE evaluation indexes in order to establish a better MCTE evaluation index system and provide more accurate evaluation.

2. Evaluation Index System of MCTE

Multimedia classroom teaching evaluation should be guided by modern education theory and modern education evaluation theory, and on the basis of determining evaluation subjects and evaluation methods, the evaluation index system should be finally formed after repeated discussion and modifications using the Delphi method.

In the evaluation index system designed in this paper, the evaluation subjects should have a close relationship with teaching quality, including students, peer teachers, experts, and teachers themselves. Students’ evaluation refers to students’ effective value evaluation through their participation in classroom teaching practice. The effectiveness of teaching in terms of meeting classroom teaching objectives, the demand for teaching contents, students’ classroom participation, students’ adaptation to learning, and students’ adaptation to learning can be reflected in students’ evaluation results. Peer teachers, on the other hand, are able to consider the effectiveness of teachers’ teaching in terms of the subject characteristics of their teaching, mastery of new knowledge, teaching style, and teaching ideology. Expert evaluation means that the school hires connoisseurs to assess the level and quality of teachers’ teaching, to evaluate the quality of teachers’ teaching by listening to classes with them, and to make a rational evaluation of teachers’ teaching from the perspective of subject development and overall training of students’ quality. Teacher self-evaluation is to ask the evaluated teachers to evaluate their own performance according to the evaluation principles and against the evaluation standards, so as to fully mobilize teachers’ enthusiasm and initiative and then to play the functions of teacher evaluation such as motivation, development, and management.

The multimedia teaching evaluation index system is to make various kinds of indicators specific and behavioral, so that teaching evaluation is measurable. Teaching evaluation is not a single-factor judgment work; it is multidimensional and is a process of multiple factors interacting and influencing each other. After the initial determination of the evaluation indexes, through several times using the Delphi method for revision and improvement, it is clear that the first-level indicators of multimedia classroom teaching evaluation include multimedia courseware, classroom teaching process, and classroom teaching effect, and the specific evaluation indexes are shown in Table 1. Multimedia courseware in the classroom teaching process is an inseparable whole, which embodies the teaching ideas, classroom teaching design, and teaching content and belongs to the static multimedia classroom presentation. Multimedia classroom teaching is a dynamic organizational process, using courseware to achieve multimedia teaching.

The evaluation criteria of multimedia courseware should reflect teaching meaning, logic, and operability and make use of the interactivity, control, and nonlinearity of multimedia computers to diversify and three-dimension Alize the teaching process. The quality of multimedia courseware is an important aspect to measure the actual teaching value and teaching effect, which is not only designed to the teaching design idea, teaching content, teaching plan design intention, and other pedagogical issues but also involves the technicality and artistry of courseware design and use. In addition, the economy of the courseware production is also a factor that must be verified in teaching evaluation. The pedagogical nature of the courseware should be reflected in the delivery of the teaching content specified in the syllabus and the unique teaching function of the multimedia courseware on the basis of achieving the expected teaching objectives. Technicality is mainly reflected in the maintainability and stability of the courseware and its ease of use in operation. Artistic is to the beauty and coordination of pictures, text, sound, and images of the courseware, that is, the relevant elements of multimedia courseware need to conform to the laws of aesthetics, to make the presentation

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of content with artistic expression and infectious power without violating the premise of science and education. Economy means that the production of courseware should follow the principle of minimum cost or the law of maximum value. Specific indicators include pedagogical $A_{11}$, technical $A_{12}$, artistic $A_{13}$, and economic $A_{14}$.

Multimedia classroom teaching is a dynamic process of implementing classroom programs using multimedia courseware. Although it differs from the traditional classroom, there are still commonalities in the basic objectives, basic rules, and basic requirements of classroom teaching. Therefore, in the evaluation of multimedia classroom teaching process, it is necessary to emphasize the coordination of classroom teaching and the use of various media and the openness of information sources and the evaluation of creative ability and comprehensive application ability, so that teachers can grasp the systematic and holistic nature of teaching. The specific indicators include five aspects: teaching attitude $A_{21}$, teaching content $A_{22}$, teaching ability $A_{23}$, teaching organization $A_{24}$, and multimedia operation $A_{25}$.

The evaluation of multimedia teaching effectiveness needs to consider the determination of comprehensive qualitative indicators and requires direct feedback from learners on relevant information. The overall effectiveness of instruction includes student classroom interactions, student work completion, and value judgments on quantified results based on instructional goals. Learning evaluation is an important part of teaching design, which can measure the behavioral changes of students at different stages of teaching, and teachers understand the learning status of students by evaluating them. Multimedia teaching effectiveness evaluation indexes mainly include student attendance $A_{31}$, classroom teacher-student interaction $A_{32}$, and teaching effectiveness $A_{33}$ (Figure 1).

The above evaluation index system can summarize the actual situation of multimedia classroom teaching in a more comprehensive way. Using the data of multimedia teaching
effect evaluation indexes as the input samples of the evaluation model, the evaluation of multimedia classroom teaching effect can be realized.

3. Evaluation Model of MCTE

3.1. Rough Set Theory (RS). RS theory is able to analyze and reason about some incomplete information, discover the implied knowledge, and reveal the potential patterns among the data. Since the rough set method does not require any a priori information when dealing with uncertain information, the theory is able to analyze and infer some incomplete information based only on the observed data, discover the implied knowledge, and reveal the potential patterns among the data. Therefore, it is more objective than conventional methods in the description and treatment of uncertainty problems.

Due to the advantages of RS such as attribute simplification, objectivity, and reduction of computational pressure, the research on optimization and evaluation of index system based on RS has gradually become one of the hot spots in academia and is widely used in many fields such as management, sociology, and economics. The working principle of rough set theory for multi-indicator evaluation is based on data mining: first, removing the redundant indicators by combining the attribute simplification principle to obtain the core indicators, then calculating the objective weight of each indicator according to the importance of each core indicator, and then obtaining the comprehensive score of each evaluation object.

Generally, the core of RS is the approximation of unclear, or undefined, knowledge based on existing knowledge [18]. In RS theory, an information system can be represented by a quadruple \( S = (U, A, V, f) \), where \( U \) is the universe of discourse, that is, the nonempty finite set of evaluation objects; \( A \) is the attribute set, containing the condition attribute \( C \) and the decision attribute \( D \); \( V \) is the value range of the attribute set; \( f \) is the mapping relationship. The calculation process of the importance of \( C \) to \( D \) is

\[
\text{sig}(c, C, D) = r_c(D) - r_{c-(C)}(D)
\]

\[
\text{sig}(c, C, D) = \frac{|\text{Pos}_C(D)| - |\text{Pos}_{C-(C)}(D)|}{|U|}
\]

where \( C = (c_1, c_2, \ldots, c_n) \) stands for conditional attribute set; \( \text{sig}(c, C, D) \) stands for importance; and \( \text{Pos} \) stands for the positive region of the variable. The weight of the conditional attribute is

\[
\omega_c^c = \frac{\text{sig}(c, C, D)}{\sum_{c=1}^{n} \text{sig}(c_1, C, D)}
\]

The dependence of \( D \) on \( C \) is calculated:

\[
r_c(D) = \frac{\sum_{c=1}^{n} |\text{Pos}_c(y)_{y_0}|}{|U|}
\]

Similarly, the dependence of \( D \) on the remaining \( c \) is achieved by decreasing:

\[
r_c(D) = \frac{\sum_{c=1}^{n} |\text{Pos}_c(y)_{y_0}|}{|U|}
\]

From this, the final importance of each conditional attribute can be obtained:

\[
I_D(c_k) = r_D(D) - r_{c-k}(D).
\]

The weight of the conditional attribute can be obtained by normalization: \( \omega_i = (I_{D_i}/\sum I_{D_i}) \). In the process of determining the index weight, the introduction of RS to improve the content with greater interference and noise and weaken the influence of subjective experience factors can objectively solve the problems caused by some uncertain factors.

3.2. BP Neural Network. A typical BP neural network consists of three layers: input, hidden, and output. During forward propagation, the learning samples enter from the input layer and are calculated layer by layer through the hidden layer to reach the output layer. If the output layer does not get the expected output, it will be back-propagated; back-propagation is from the output layer back through the hidden layer. In the process of the input layer, during the training process, the output error is reduced by continuously modifying the neuron weights of each layer until the desired output target value is reached.

Given a training set \( D = \{(x_1, y_1), (x_2, y_2), \ldots, (x_n, y_n)\} \), \( x_i \in R^d \), \( y_i \in R^l \). In order to facilitate the derivation of equations, Figure 2 is given for illustration. The weight between input layer \( i \) and hidden layer \( h \) is \( \omega_{ih} \), and the weight between hidden layer \( h \) and output layer \( j \) is \( \omega_{vh} \). The input received by the \( h \)-th hidden layer neuron is \( a_h \). The input received by the \( j \)-th output layer neuron is \( \beta_j \). All activation functions \( \theta \) are sigmoid. The underlying index information in the evaluation index system is used as the input vector of the BP neural network, and the corresponding desired output value is used as the output vector. The network is trained with the sample data, different input vectors get different output values, and the output values are compared with the expected values, when the error is less...
than a set value, the neural network model training is completed.

3.3. MCTE Evaluation Model Based on the RS-BP Method. Combined with the RS theory and the principle of BP neural network, the steps of the MCTE evaluation model constructed in this paper are shown in Figure 3:

1. Obtain the source data by means of a questionnaire and conduct reliability and validity tests on the data to ensure the rationality of the questionnaire design and the data
2. Discrete preprocessing of the source data by the equal width method
3. Apply the principle of attribute importance to determine the weights of each core evaluation index
4. Conduct comprehensive evaluation of MCTE quality based on RS
5. According to the comprehensive evaluation results, constitute learning samples to input into the BP neural network for learning training and generate the RS-BP neural network evaluation model of MCTE after the training is completed and then use the evaluation model to evaluate other multimedia classes.

4. Experimental Results

4.1. Data Preprocessing. In order to obtain qualified qualitative data, this study selects students and teachers from five different universities (HU, HE, HN, HP, and ST) in Hebei Province as the research object. In order to improve the professionalism and participation of the questionnaire, we conducted a visit survey. A total of 350 questionnaires were distributed, and 314 questionnaires were recovered. After dealing with outliers through SPSS, 309 valid questionnaires were obtained, with an effective rate of 88.29%.

The reliability and validity test results of the questionnaire are shown in Tables 2 and 3. The Cronbach’s $\alpha$ of each questionnaire is above 0.9, the KMO coefficient is 0.935, and the $P$ value is 0.000. This shows that the internal consistency of each questionnaire is good, the structural design is reasonable and can better reflect the content of the required survey, and the questionnaire has high reliability in the above universities. In this paper, the equal width method is used to discretize all data. Let the interval number $n = 3$, the maximum value of data is Max, the minimum value of data is Min, and then the width of each interval is $(\text{Max} - \text{Min})/n$. Therefore, the value of the first interval is 0, the second is 1, and the third is 2.

4.2. Comprehensive Evaluation Based on RS. Attribute reduction based on the importance of attributes is the core concept in rough set theory. Redundant information that has no value in the original data and can be deleted through...
4.3. Training and Evaluation of the BP Neural Network.

In the five schools, 15 evaluation data (60 in total) are selected to form the BP neural network test and evaluation sample database, and the remaining evaluation data (249 in total) form the learning and training sample database. The proportion of training set and verification set is 8:2.

Firstly, MATLAB is used to program and construct a $7 \times 3 \times 1$ neural network. For the three-layer BP neural network model, the tansig function is selected as the neuron transfer function in the middle hidden layer, the logsig function is selected as the neuron in the output layer, the trainlm function with the largest memory demand and the fastest convergence speed is selected as the network training function, the maximum number of iterations is set to 10000 times, the display step size is 50, the learning efficiency is 0.05, and the target error is set to be less than 0.0001. The initial weights and thresholds are random numbers. Then, 249 training samples are input into the BP neural network model for training and learning, and the error target is achieved after 56 iterations. The BP neural network model after training is called MCTE evaluation model based on the RS-BP neural network in this paper.

In order to verify the rationality and advantages of this model, we choose two other common machine learning methods: support vector machine (SVM) and random forest (RF) to compare and analyze the accuracy of the model. The accuracy comparison between the model training set and the verification set is shown in Figure 4 and 5. In general, the statistical data in this paper have strong discrimination, which also shows that MCTE is suitable for machine learning evaluation. The accuracy of the BP neural network, SVM and RF methods in the training set is very high, reaching 98.12%, 96.77%, and 96.56%, respectively. However, the average accuracy on the validation set is 95.23% and 88.74% And, 83.19%, which shows that SVM and RF have different degrees of over fitting and also reflects the advantages of BP neural network when the sample data increase. The accuracy of the model shows that, under the BP neural network method, the MCTE score of each school is almost the same as the comprehensive evaluation score, which has certain accuracy and feasibility. It is proved that the RS-BP neural network model can be used in the evaluation of MCTE in other universities.

The MCTE core evaluation index and comprehensive evaluation model constructed in this paper provide a reference for university managers and teachers to improve the efficiency of multimedia teaching. In the multimedia classroom, the communication between teachers and students, teaching ability, and the artistry of courseware have the highest weight, which should also be the focus of universities. With the development of automatic speech
knowledge. Teachers can analyze the current shortcomings through the evaluation results, adjust their knowledge structure and ability structure, and constantly improve their teaching methods and teaching quality. The ideal feedback time should be before the end of the final exam of the semester and the holiday, so that teachers can adjust and improve their teaching with reference to the feedback results when preparing the course of the next semester, so as to achieve an immediate effect. The school will adjust the training mode with the change of social needs for talents. Similarly, MCTE evaluation indicators should also comply with the development of the times and monitor and guide teachers’ teaching quality.

5. Conclusion

The evaluation of multimedia teaching is a systematic and complex project. We should pay attention to the accuracy of content and the effectiveness and guidance of teaching, so as to scientifically and reasonably control the teaching content and the effectiveness and guidance of teaching, complex project. We should pay attention to the accuracy of the evaluation of multimedia teaching as a systematic and learning methodology.

Due to the limitations of time, energy, and conditions, the research done in this paper still needs to be improved. In the future research, it is also necessary to conduct large-scale empirical research, modify, and improve the index system to make it more scientific, reasonable, and more suitable for teaching practice. Based on this research, we can also improve the multimedia technology combined with the intelligent voice system, so as to improve the overall level of MCTE in universities.

Data Availability

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

Conflicts of Interest

The author declares no conflicts of interest.

Acknowledgments

This work was supported by the Liaoning Urban Construction Technical College.

References


