The Reflective Teaching Practice of Teachers Based on Optimal Teaching Quality

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Abstract—Reflective teaching, also known as self-examination teaching, has received much attention from field scholars and education experts around the globe. However, most of their focus has laid on teachers' teaching competence and professional development, and few of them have concerned about the empirical study on reflective teaching. To fill in this research blank, this paper studied the reflective teaching practice of teachers based on optimal teaching quality. At first, a reflective teaching-based teaching quality gap model was constructed, and an evaluation index system (EIS) was built for assessing the reflective teaching quality of teachers. Then, based on the proposed EIS, this paper built a neural network prediction model to give quantitative assessment on teachers' reflective teaching quality, and examined the applicability and accuracy of the constructed model in the quality assessment of reflective teaching. At last, the quality assessment results of reflective teaching were given in the experiment based on the proposed neural network, which had verified the effectiveness of the constructed model.

Keywords—teaching quality, reflective teaching, prediction, gap, assessment, neural network

1 Introduction

According to American scholar Posner, the growth of teachers is the accumulation process of their teaching experience and teaching reflection [1, 2]. Enhancing teachers' teaching reflection competence and urging them to carry out reflective teaching are important factors to cultivate them into expert educators [3-5]. In recent decades, world field scholars have devoted a lot of time and energy into the research on reflective teaching, which is considered a teaching method with important theoretical and practical value both in the academic circle and the pedagogy industry [6-12]. Some scholars believe that the key to teachers' professional development is to solve the contradiction between the high demands for teachers' teaching quality and the inadequate teaching competence hold by teachers at current stage [13-15]. Therefore, to apply reflective teaching and formulate solutions and countermeasures for problems raised during the process of reflective teaching, it's necessary to build an EIS that is scientific, reasonable, and suitable for the assessment of the quality of reflective teaching, thereby providing useful information for teachers' reference, so that they could improve their weak links in a targeted manner.

Scholars Variacion et al. [16] assessed educators' developed differentiated activities carried out in the learning module for the grade-seven science class. The results of self-reflection indicated that educators regard the developed DI learning module as an opportunity or a way for students to cultivate their patience, train their teamwork, and develop their values of safety. In a broad sense, learning analytics is a methodology of collecting and analyzing teaching data for the purpose of education outcome improvement, these data can describe the contents and techniques given and adopted by lecturers, and the reflections made by teachers on these two might be helpful in education outcome improvement. Eickholt [17] introduced iTracer, a lightweight system for multimodal instructor data collection that can provide instructors with feedback on instructor speech and student interaction, the information can help instructors reflect on the teaching techniques they employed and the teaching content they interacted with students. Such reflection ensures the consistency between applied techniques and their intentions. The development of information technology has greatly changed the quality of education, especially triggering positive changes in the quality of language teaching. Thanks to the support of various equipment and devices, the reflective practice in teaching becomes much easier in a smart teaching environment. Thu [18] investigated students' opinions with the effects and challenges of using information technology to improve communication ability, and recommended a few technology-assisted teaching strategies for reflective practice in oral English teaching, the findings of this study suggest that the use of technology-driven teaching methods in reflective practice could bring more benefits for learners in improving their communication skills. In the education of engineering designers, it's quite meaningful to train their ability to extend and reflect on their thoughts and apply the agile method in the learning and teaching process. Inkermann et al. [19] introduced a project-based agile learning and teaching process that integrates lecture, feedback, reflection, and presentation modules with a virtual learning room that supports self-study. About the reflection form, they emphasized the usefulness of reflecting on core questions for the structured reflection (namely the self-reflection) in the team as well as teachers' insights for adaption and expansion. Sorensen-Unruh [20] gave a narrative of actual teaching practice that emphasizes the use of social media as a tool for reflection and student engagement in class.

After reviewing relevant literatures, it's found that most of the existing studies focus on teachers' teaching competence and professional development, they discussed more on the importance of reflective teaching, while few have concerned about the empirical study on reflective teaching; moreover, subjective evaluation took a large proportion in existing studies, and their assessment methods are generally questionnaire survey or expert interview; so, in order to reduce human factor intervention, it's necessary to search for more advanced models for the effectiveness assessment and prediction of reflective teaching, so as to enhance teachers' teaching competence and realize the optimal teaching quality. Therefore, to fill in this research blank, this paper aims to study the reflective teaching practice of teachers based on optimal teaching quality. In the second chapter, this paper constructed a teaching quality gap model of reflective teaching, and built an EIS for assessing the reflective teaching of teachers. In the third chapter, based on the proposed EIS, this paper built a neural network prediction model to give quantitative assessment to the quality of reflective teaching, and examined the applicability and accuracy of the constructed model in the quality assessment of reflective teaching. At last, the experiment part gave the quality assessment results of reflective teaching based on the proposed BP neural network, and verified the effectiveness of the constructed model.

2 EIS for quality assessment of reflective teaching

Service quality model is a type of service quality assessment system newly proposed in the service sector based on the theory of comprehensive quality management, it is usually used to measure the gap between the actual satisfaction and the expected satisfaction of customers who have received the service. If this model is to be applied in medical, financial, telecommunications, and other industries, then the model must be adjusted and modified to fit the different features of each industry, thereby attaining useful conclusions based on the actual conditions of each industry.

This paper introduced the service quality model into the assessment of teachers' reflective teaching, in the hopes of figuring out the gap between the actual teaching quality and the expected teaching quality of reflective teaching, then, based on the size of the gap, teachers could judge the effectiveness of the improvement measures of reflective teaching in a targeted manner, and further optimize the strategies of reflective teaching. According to the features of reflective teaching, this paper made the following modifications to the original service quality model, please see Figure 1 for details.

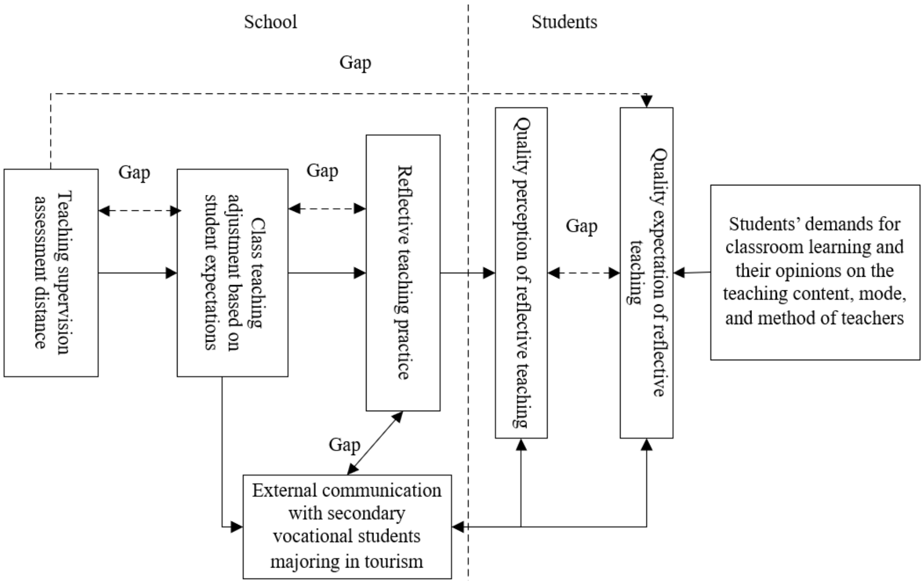

Fig. 1. The modified teaching quality gap model of reflective teaching

The teaching quality gap model of reflective teaching contains five gaps: the gap of self-assessment, the gap of teaching supervision assessment, the gap of student assessment, the standard gap, and the concept gap; wherein the gap of self-assessment refers to the gap between a teacher's expected teaching quality of reflective teaching and the actual teaching quality of his/her reflective teaching; the gap of teaching supervision assessment refers to the gap between the expected teaching quality of staffs who work in the school teaching quality management department, the school leaders, and other professional teachers, and the actual teaching quality of reflective teaching; the gap of student assessment refers to the gap between students' expected teaching quality of reflective teaching and the actual teaching quality of reflective teaching; the standard gap refers to the gap between the teaching quality of reflective teaching of teachers and the standard teaching norms; the concept gap refers to the gap between the teaching quality of reflective teaching of teachers and the training concept of the implemented talent training program.

Modern higher education emphasizes the teaching philosophy of "letting students take the dominant role in class", so the training concept and the rank of teachers' teaching quality could be measured by students' feedback on teaching effect and teaching activity engagement attitude. The reflective teaching based on student demands has gradually received the attention of the academic circle, however, for students of different ages and cognition levels, there're great differences in their demands for classroom learning, and the teaching content, mode, and method of teachers. Thus, teachers need to fully reflect on the talent training concept issued by the majors or disciplines and students' feedback and opinions with classroom teaching, and constantly adjust the teaching content, mode, and method of next teaching links, thereby achieving the goal of optimal teaching quality.

Since the service quality model adopted in this paper mainly assesses the classroom teaching effect from students' point of view, the model has certain reference value for the reflective teaching assessment of teachers, however, before applying it in reflective teaching practice, the model needs to be modified based on the features of reflective teaching. During the modification process, extra attention should be paid to the real-time update of talent training concept and the learning preference of students at different learning stages. Besides, the EIS for assessing the quality of reflective teaching is not mature enough, so we had consulted expert opinions twice and referred to existing research results, viewpoints, and academic papers, and then attempted to establish the said EIS and the model for assessing the quality of reflective teaching.

In the reflective teaching practice of teachers, the idea of "letting students take the dominant role in class" emphasizes on the process of student practice and enhancing their personal literacy and social adaptability during classroom learning. During such practice, teachers constantly reflect on their instruction method and effect again and again in the teaching process, thereby changing students' cognitions, skills, and behaviors and making them develop in an all-round way, and the after-class reflection of teachers should consider these three aspects as well. The EIS for assessing the quality of reflective teaching proposed in this paper is given in Figure 2.

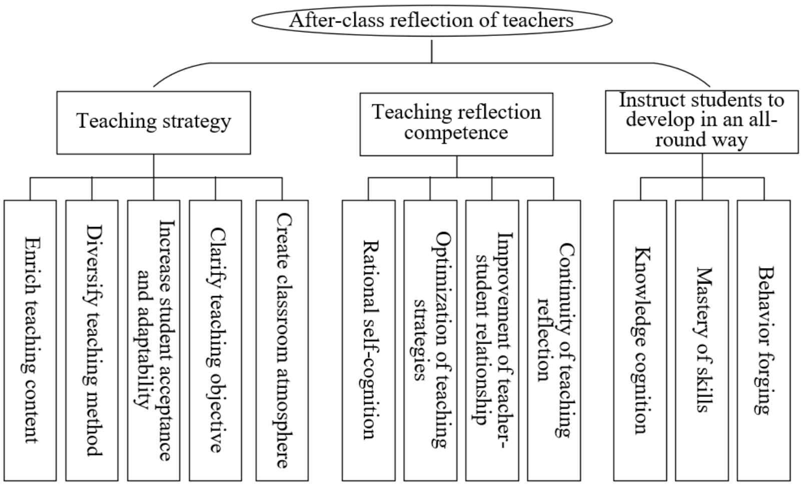

Fig. 2. Structure of the proposed EIS for assessing the quality of reflective teaching

3 The reflective teaching quality prediction model

Based on the EIS proposed in the previous chapter, this paper adopted a quantitative method to assess the quality of reflective teaching, namely the BP neural network, to further examine the applicability and accuracy of the constructed model in the quality assessment of reflective teaching.

BP neural network is a kind of machine learning algorithm with the advantages of objective, easy, and fast. Neurons are the basic units of the network. A complete neural network system consists of several layers, and the neuron nodes in each layer transmit the input information through links among them. The input information is processed by the input layer, several hidden layers, and the output layer, and a result will be output by the network in the end.

Assuming: $a_1,a_2,a_3,...,a_m$ represents the number of input neurons; $q_{11},q_{12},q_{13},...,q_{1m}$ represents the weight between layers; φ represents the neuron threshold; the neural network predicts data samples through iterations and updates based on the threshold and weight and achieve the optimal prediction performance at the same time.

Assuming: n represents the sum of neurons; $g(a)$ represents the activation function or the transfer function; when the input sample data, network structure and threshold, and weight parameters of the network are all determined, the summation of neurons can be performed using Formula 1:

$$n = \sum_{i=1}^{m} a_i q_{1i} + \phi \tag{1}$$

The threshold function is a binary function, when a is less 0, its value is 0; when a is greater than or equal to 0, its value is 1; Formula 2 gives its expression:

$$g(a)=\begin{cases}1.a\geq 0\\0,a<0\end{cases} \tag{2}$$

If there is a proportional relationship between *a* and g(*a*), then there is:

$$g(a)=la \tag{3}$$

The expression of the *Sigmoid* function is:

$$g(a)=\frac{1}{1+o^{-a}} \tag{4}$$

The input sample data of the network needs to be weighted and summed first, and then processed by the activation function of each layer, at last, the prediction result will be output by the output layer, Formula 5 gives the expression of the output function:

$$b=g(qa+\phi) \tag{5}$$

Assuming: *m*, *w*, and *n* respectively represent the number of neurons in the input layer, hidden layer, and output layer; the *Sigmoid* function is taken as the activation function of neurons in each layer; u_q represents the weight between the input layer and the hidden layer; q_{jl} represents the weight between the hidden layer and the output layer; *g*(*a*) represents the activation function between the input layer and the hidden layer; *h*(*a*) represents the activation function between the hidden layer and the output layer; if the data sample of evaluation indexes of teacher's reflective teaching *a*(*i*=1,2,3,...,*m*) are input into the network and propagated forwardly in the constructed neuron network, then, the output results of the hidden layer and output layer of the network could be attained, Formula 6 calculates the output of the hidden layer:

$$d_l=g\left(\sum_{i=0}^{m}u_{li}\times a_i\right)(l=1,2,3,...,w) \tag{6}$$

Formula 7 calculates the output of the output layer:

$$b_j=h\left(\sum_{l=0}^{w}q_{jl}\times d_l\right)(j=1,2,3,...,n) \tag{7}$$

If the prediction error of output result attained by the forward propagation of the BP neural network is small, then the network stops iterating; otherwise, if the prediction error is large, then the output error is propagated backwardly from the output layer to the input layer, and the network weights are continuously adjusted during the propagation process until reaching the target error.

The condition for this backward propagation of output error is to have a reasonable value of the targe error. Assuming: $a^1,a^2,a^3,...,a^T$ represents T data samples of evaluation indexes of reflective teaching; $b^b{}_j$(*j*=1,2,3...,*n*) represents the output samples, then

Formula 8 gives the calculation formula of the target error of this evaluation index data sample:

$$O_t = \frac{\sum_{j=1}^{n}\left(p_j^t - b_j^t\right)^2}{2} \tag{8}$$

Formula 9 gives the calculation formula of the total target error of this evaluation index data sample:

$$O = \frac{\sum_{t=1}^{t}\sum_{j=1}^{n}\left(p_j^t - b_j^t\right)^2}{2} = \sum_{t=1}^{t} O_t \tag{9}$$

In order to realize the continuous update of weight q_{jl}, this paper adopted a cumulative error method to calculate the network error, so as to gradually reduce the total target error of the sample during iterations. Formula 10 gives the weight correction formula:

$$\Delta q_{jl} = -\delta \frac{\partial O}{\partial q_{jl}} = -\delta \frac{\partial}{\partial q_{jl}}\left(\sum_{t=1}^{t} O_t\right) = \sum_{t=1}^{t}\left(-\delta \frac{\partial O_t}{\partial q_{jl}}\right) \tag{10}$$

The formula for calculating the error is:

$$\eta_{bj} = -\frac{\partial O_t}{\partial R_j} = -\frac{\partial O_t}{\partial b_j} \times \frac{\partial b_j}{\partial R_j} \tag{12}$$

By decomposing Formula 12, we can get:

$$\frac{\partial O_t}{\partial R_j} = \frac{\partial O_t}{\partial b_j}\left[\frac{\sum_{j=1}^{n}\left(p_j^t - b_j^t\right)^2}{2}\right] = -\sum_{j=1}^{n}\left(p_j^t - b_j^t\right) \tag{13}$$

$$\frac{\partial b_j}{\partial R_j} = h\left(R_j\right) \tag{14}$$

The formula for calculating the adjustment error is:

$$\sum_{j=1}^{n}\left(p_j^t - b_j^t\right) \times h\left(R_j\right) \tag{15}$$

Based on chain quantification, there is:

$$\frac{\partial O_t}{\partial q_{jl}} = \frac{\partial O_t}{\partial R_j} \times \frac{\partial R_j}{\partial q_{jl}} = -\sum_{j=1}^{n} \left(p_j^t - b_j^t \right) \times h'\left(R_j \right) \times d_l \tag{16}$$

Combining the above formulas, Formula 17 calculates the corrected value of weight between the hidden layer and the output layer:

$$\Delta q_{jl} = \sum_{t=1}^{t} \sum_{j=1}^{n} \delta \left(p_j^t - b_j^t \right) \times h'\left(R_j \right) \times d_l \tag{17}$$

Similarly, Formula 18 calculates the corrected value of weight between the input layer and the hidden layer:

$$\Delta u_{jl} = \sum_{t=1}^{t} \sum_{j=1}^{n} \delta \left(p_j^t - b_j^t \right) \times h'\left(R_j \right) \times g'\left(R_l \right) \times q_{jl} \times a_i \tag{18}$$

Figure 3 shows the execution flow of the prediction model. Due to their respective attribute features, the evaluation indexes of reflective teaching have different units, so they need to be assigned with scores or values before calculation. According to the updated data of evaluation indexes of reflective teaching of teachers in sample schools collected within the study period, a "factor-quality score" relationship table was established for the reflective teaching quality of teachers in sample schools, and the a new-round of score and value assignment of the evaluation indexes was performed.

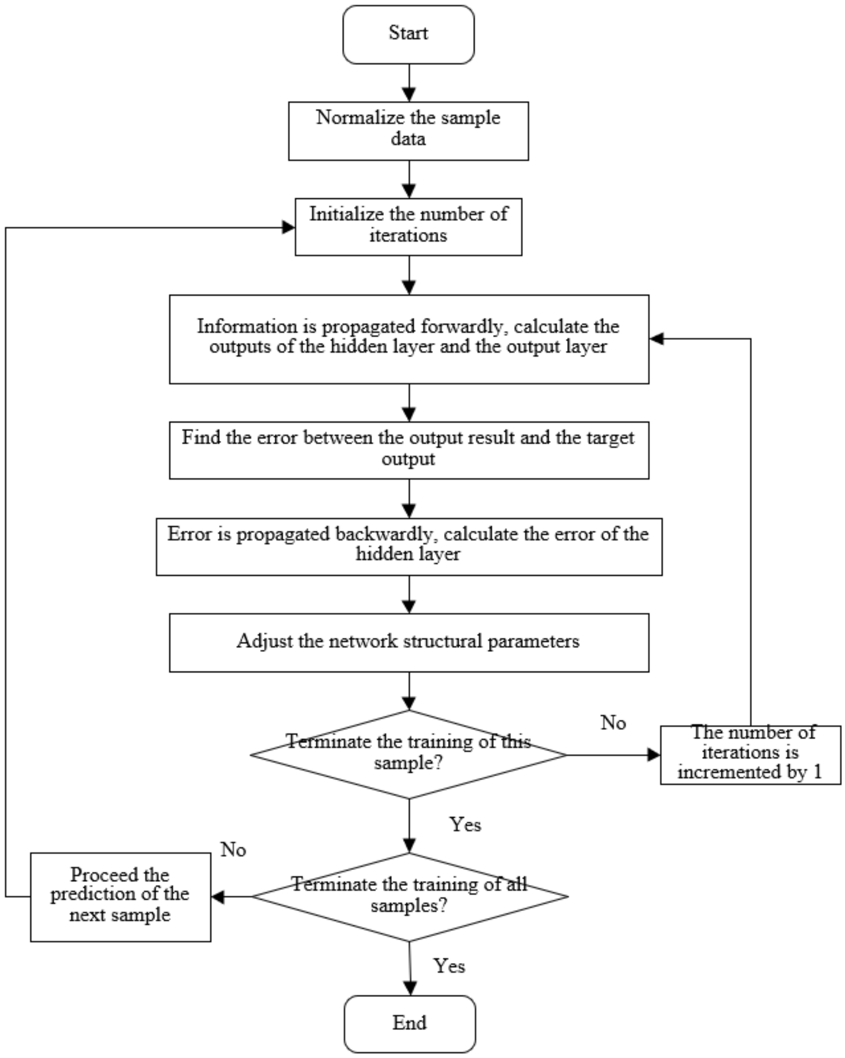

Fig. 3. Execution flow of the prediction model

4 Experimental results and analysis

Figure 4 shows the scree plot of evaluation indexes of reflective teaching. According to the figure, after 12 evaluation indexes, the trend of the curve tends to be smoother, which verified that it is feasible to extract the determined 12 evaluation indexes after eliminating indexes with too small load values or too heavy cross loads.

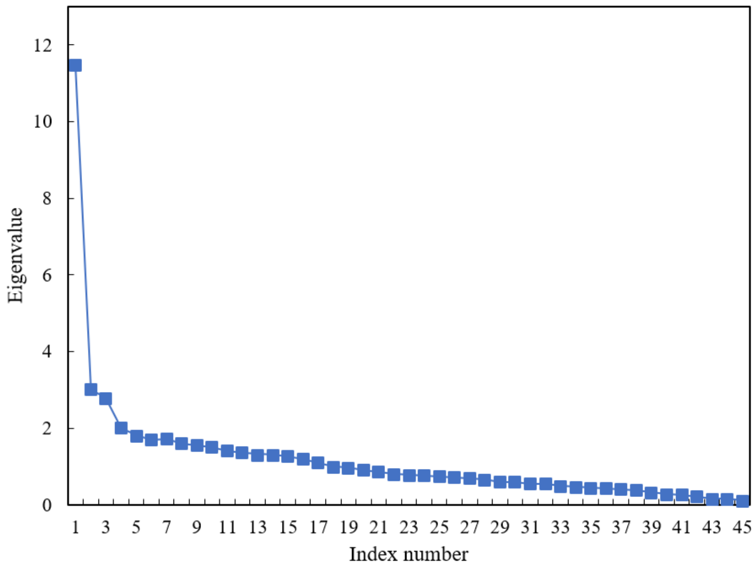

Fig. 4. The scree plot of evaluation indexes of reflective teaching

Table 1 shows the assessment results of teachers' reflective teaching quality based on BP neural network, and Figure 5 shows the proportion of each class of the evaluation results. According to Table 1 and Figure 5, within the study period of 8 semesters, the assessment results of the reflective teaching quality of 10 teachers were mainly A Class (representing the best level) and B Class, wherein A Class accounted for 13% and B Class accounted for more than 83%, which had proved the effectiveness of teachers' reflective teaching, overall speaking, the teaching quality was good.

Table 1. Evaluation results of reflective teaching quality based on BP neural network

Serial number of teachers	Semester 1	Semester 2	Semester 3	Semester 4
1	*B* Class	*E* Class	*A* Class	*C* Class
2	*E* Class	*C* Class	*B* Class	*C* Class
3	*B* Class	*E* Class	*E* Class	*B* Class
4	*F* Class	*A* Class	*C* Class	*C* Class
5	*B* Class	*E* Class	*C* Class	*B* Class
6	*C* Class	*B* Class	*A* Class	*A* Class
7	*B* Class	*A* Class	*B* Class	*E* Class
8	*E* Class	*B* Class	*A* Class	*E* Class
9	*D* Class	*D* Class	*E* Class	*B* Class
10	*C* Class	*E* Class	*E* Class	*A* Class
Serial number of teachers	**Semester 5**	**Semester 6**	**Semester 7**	**Semester 8**
1	*B* Class	*A* Class	*B* Class	*C* Class
2	*A* Class	*C* Class	*B* Class	*A* Class
3	*C* Class	*B* Class	*C* Class	*B* Class

4	*D* Class	*C* Class	*B* Class	*C* Class
5	*D* Class	*B* Class	*C* Class	*D* Class
6	*C* Class	*B* Class	*A* Class	*B* Class
7	*B* Class	*C* Class	*B* Class	*A* Class
8	*B* Class	*B* Class	*A* Class	*B* Class
9	*A* Class	*B* Class	*E* Class	*B* Class
10	*E* Class	*B* Class	*A* Class	*B* Class

Figure 6 shows the prediction results of teaching strategy optimization after applying reflective teaching. According to the figure, teachers have their respective emphasis on teaching strategy optimization after different application stages of reflective teaching. Regardless of enriching teaching content, diversifying teaching method, improving student acceptance and adaptability, clarifying teaching objective, or creating better classroom atmosphere, all these measures can improve the teaching quality. Figure 7 shows the prediction results of teachers' reflective teaching competence after applying reflective teaching. As can be known from the figure, many teachers have reflected on their teaching constantly and gained rational self-cognition, their mastery level of teaching strategy optimization had been increased, the teacher-students relationship had been effectiveness improved, and they had attained sustained reflective teaching effects.

Figure 8 shows the prediction results of students' all-round development instruction effects after applying reflective teaching. In order to emphasize on the process of student practice and enhancing their personal literacy and social adaptability during classroom learning, teachers should give effective instructions to the all-round development of students during the application process of reflective teaching. Figure 8 shows that many teachers conducted reflective teaching based on three aspects of students' all-round development, namely cognitions, skills, and behaviors. They adjusted their instruction method again and again during the teaching process, thereby guiding students to achieve all-round development.

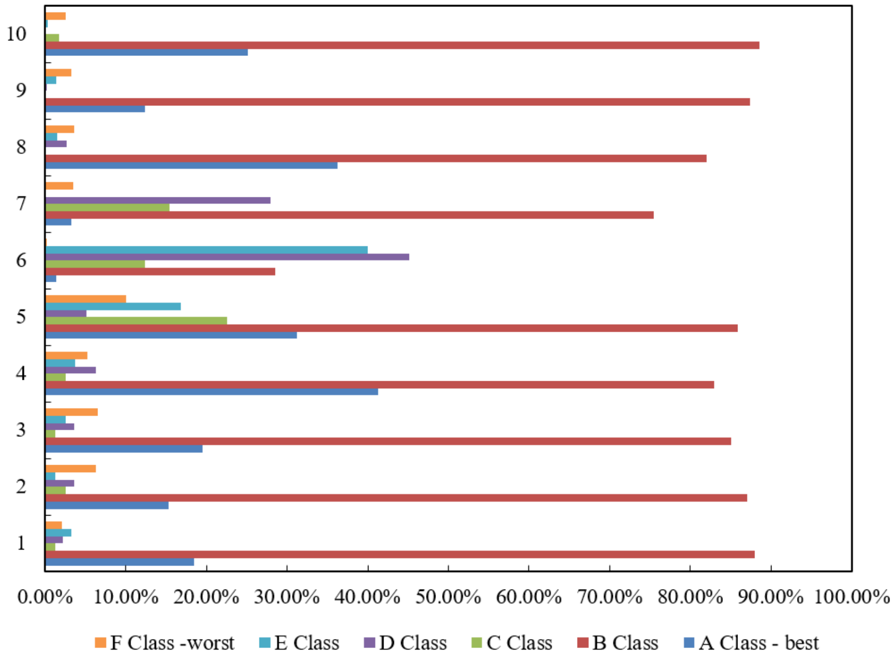

Fig. 5. Proportion of each class of assessment results of reflective teaching quality of teachers

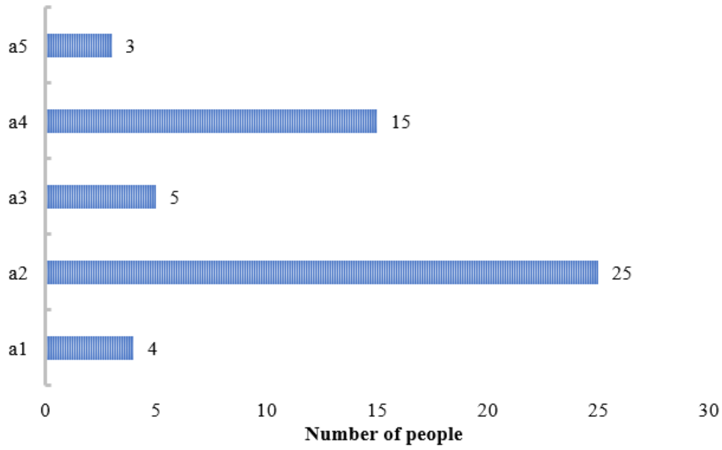

Fig. 6. Prediction results of teaching strategy optimization after applying reflective teaching

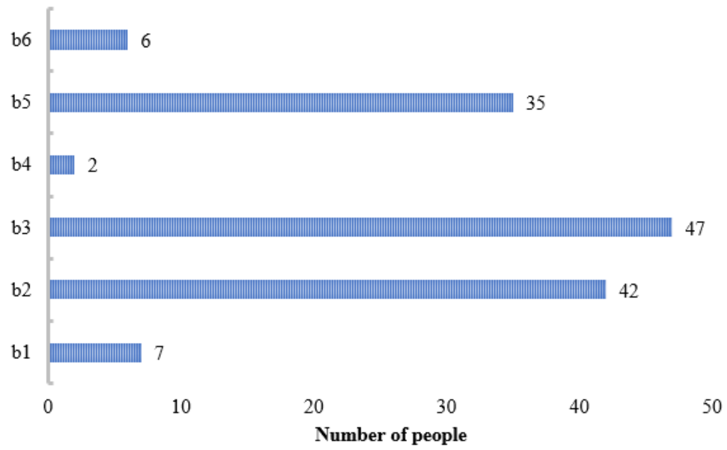

Fig. 7. Prediction results of teachers' reflective teaching competence after applying reflective teaching

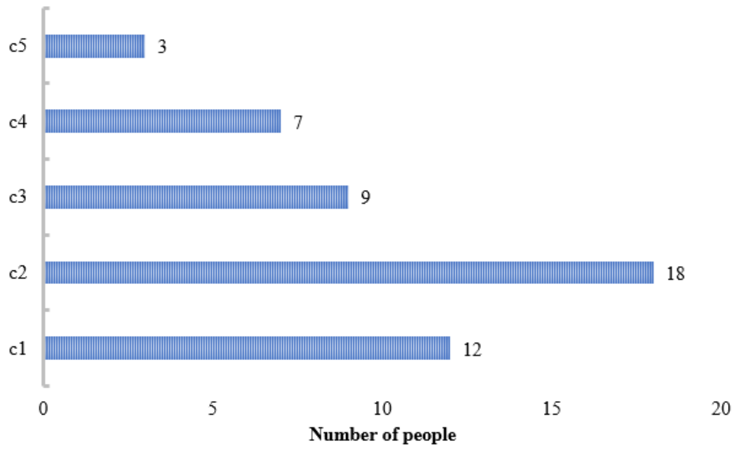

Fig. 8. Prediction results of students' all-round development instruction effects after applying reflective teaching

5 Conclusion

This paper studied the problem of reflective teaching practice of teachers based on optimal teaching quality. In the beginning, this paper constructed a teaching quality gap model for the reflective teaching of teachers and established an EIS for assessing the quality of reflective teaching. Then, based on the proposed EIS, a BP neural network was built for the purpose of quantitatively assessing the quality of reflective teaching, and the applicability and accuracy of the network were discussed. Later, experimental results gave the assessment results of teachers' reflective teaching quality based on the proposed neural network, and gave the proportion of each class of the assessment results, which had verified effectiveness of reflective teaching and its good teaching quality. In the end, this paper also gave the prediction results of teaching strategy optimization, reflective teaching competence improvement, and the instruction effects of students' all-round development, which had proved that most teachers can enhance their teaching quality via reflective teaching.

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