Optimization of Teachers' Teaching Behaviors in the Virtual Digital Graphic Design Teaching Environment

https://doi.org/10.3991/ijet.v17i18.34181

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Abstract—Different teaching and interaction methods applied by teachers in the virtual teaching environment will lead to certain differences in the characteristics of their teaching behaviors. An in-depth understanding of the teaching behavior characteristics of teachers in virtual digital graphic design teaching and the influencing factors to the teacher-student interaction effect can help different types of teachers cater to students' extensive needs in learning digital graphic design skills. This paper studies the optimization of teachers' teaching behaviors in the virtual teaching environment of digital graphic design. Firstly, the problems existing in the application of virtual reality technology in digital graphic design teaching were summarized, a structural model for the virtual teaching environment of digital graphic design was constructed, and the optimization of teachers' teaching behaviors under the virtual teaching environment of digital graphic design was quantified based on the LDA model. An effect model for teachers' teaching behaviors was constructed, and through analysis of the evaluation results of students on the virtual digital graphic design teaching effect of teachers, the effectiveness indicator of teachers' teaching behavior decisions was obtained. The experimental results verified the effectiveness of the proposed model.

Keywords—virtual reality technology, digital graphic design teaching, optimization of teaching behaviors

1 Introduction

With the promotion of digital media applications, virtual reality technology is becoming the main method for digital graphic design teaching. The virtual reality technology brings perceptions to students and allow students to interact with teachers in digital graphic design teaching in virtual scenes, which is a brand new three-dimensional teaching mode different from the traditional one [1–9]. The current goal and challenge of virtual teaching of digital graphic design is how to make students obtain better learning experience and effect. However, the behavioral characteristics of teachers and in what way their behaviors can be optimized in the virtual teaching process of digital graphic design have not been fully explored [10–16]. Due to the different teaching and interaction methods adopted by teachers in the virtual teaching environment, there are certain differences in the characteristics of teaching behaviors presented by teachers [17–25]. An in-depth understanding of the teaching behavior characteristics of teachers in virtual digital graphic design teaching and the influencing factors to the teacher-student interaction effect can help different types of teachers cater to students' extensive needs in learning digital graphic design skills.

The application of virtual reality technology has gradually expanded from the computer field to all aspects of life, and has also become a new way of digital media art. Qian [26] analyzed the characteristics of virtual reality technology and three commonly used methods, and conducted in-depth exploration and practice of these methods. The experimental results have provided specific reference and comparison for the teaching and research fields, and it is found that students are more sensitive and open to vision and images than language. Through the combination of virtual reality technology and school education, the disadvantages of traditional art teaching such as simple repetition and mechanical reproduction are well avoided. It is a multi-structured teaching model, which integrates the theoretical model of art teaching with the digital multimedia technology into a new method based on computer-aided art teaching. Feng et al. [27] first analyzed the advantages of auxiliary teaching from the application value of computer-aided technology, then studied the design of an auxiliary platform system, analyzed the database construction and web search service of the system, and provided the system framework and teaching process, and finally, applied the system to the art teaching practice and achieved certain results. The teaching of art design requires students to analyze three-dimensional space, and the application of virtual reality technology can be of great help to teachers in cultivating this ability of students in art design teaching. Du [28] emphasized that the multi-sensing, interaction and simulation of the virtual reality technology enabled people to have the "super ability" to participate in and control events, and proposed the application of the virtual reality technology in the cultivation of practical abilities of art design students at colleges and universities. Lu [29] analyzed how to promote the development of digital media art teaching based on the virtual reality technology. Compared with the traditional online teaching with text or pictures, learning in the campus environment built on the virtual reality technology allows students to have a greater sense of participation and identity. Liu [30] proposed a design method for art teaching platforms based on the virtual reality technology, which presents and visualizes the abstract and profound concepts, theories and working processes in art teaching; it also introduced in detail the implementation of the modeling software and the interactive functions.

In terms of research content, the existing studies on the teaching behaviors of teachers in virtual teaching has not yet formed a relatively mature theoretical system. Experts and scholars at home and abroad have paid more attention to the fields where virtual reality technology can be applied and how they can be applied, but few analyzed their application in the education field and the characteristics of teachers' teaching behaviors in this context. The existing quantitative methods for teachers' teaching behaviors have certain limitations, and there has been a lack of effective integration of various quantitative analysis methods for behaviors. Therefore, this paper studies the optimization of teachers' teaching behaviors in the virtual teaching environment of digital graphic design. Section 2 summarizes the problems existing in the application of virtual reality technology in digital graphic design teaching, constructs a structural model for the virtual teaching environment of digital graphic design, and quantifies the optimization of teachers' teaching behaviors under the virtual teaching environment of digital graphic design based on the LDA model; Section 3 establishes an effect model for teachers' teaching behaviors and gives the effectiveness indicator of teachers' teaching behavior decisions by analyzing the evaluation results of students on the virtual digital graphic design teaching effect of teachers. The experimental results prove the effectiveness of the proposed model.

2 Quantification of the optimization of teaching behaviors

There are still many practical problems in the application of the virtual reality technology in digital graphic design teaching, mainly as follows: 1) when students perform digital graphic design tasks, it is difficult for them to find scientific and feasible design ideas within a limited time; 2) students are not familiar with the functions of virtual reality equipment and thus unskilled in operating them, and they are not able to execute digital graphic design tasks in an organized manner; 3) a considerable number of students find the teaching activities launched by teachers difficult and need to solve the difficult problems through teacher-student and student-student interactions; 4) the results of digital graphic design need to be evaluated by teachers and other students, and group reporting also needs to be set up. Figure 1 presents the design framework for optimization of teachers' teaching behaviors.

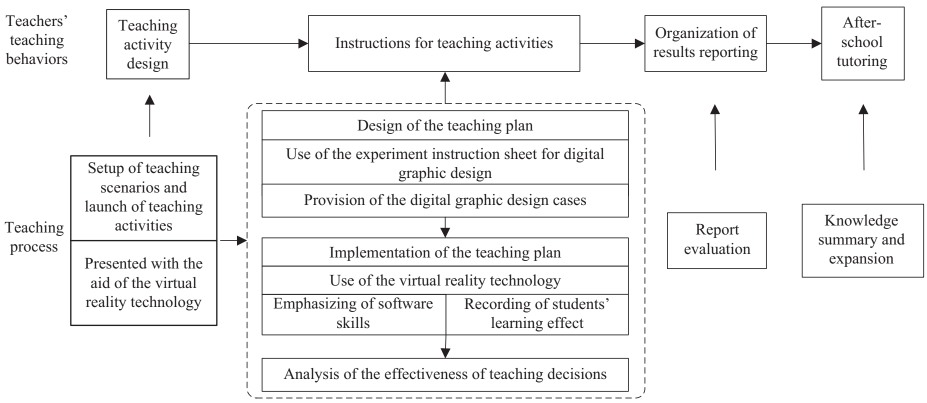

Fig. 1. Design framework for optimization of teachers' teaching behaviors

The virtual and real teaching environments form a whole in the optimization process of teachers' teaching behaviors. The two environments cover all the interaction elements between teachers and students and those between students and the virtual reality equipment. Figure 2 shows the structural model for the virtual teaching environment of digital graphic design, where teachers optimize their teaching behaviors by taking into full account the elements of digital graphic design teaching such as the content of digital graphic design teaching, the operation interfaces of virtual reality equipment and the teaching activities.

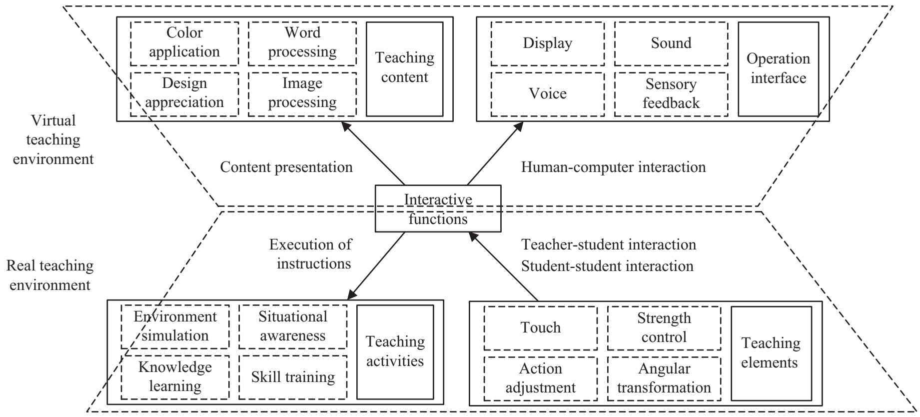

Fig. 2. Structural model for the virtual teaching environment of digital graphic design

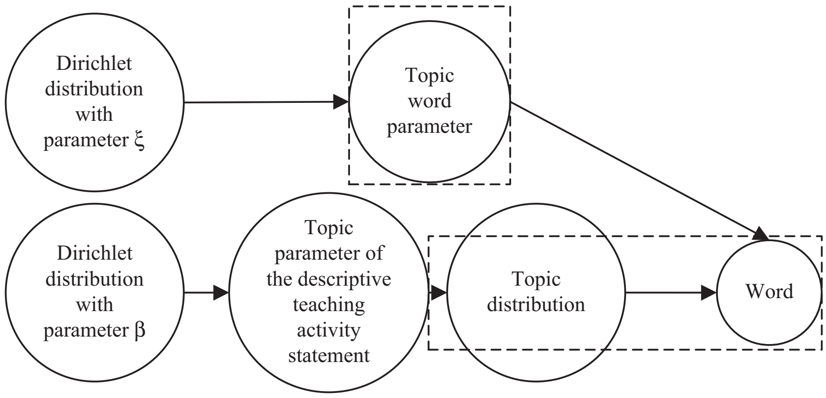

Fig. 3. Principle of the LDA model

Based on the *LDA* model, the optimization of teachers' teaching behaviors in the virtual teaching environment of digital graphic design were quantified in this paper. A teaching activity launched by teachers may contain multiple topics, and the *LDA* model characterizes the distribution of the vocabulary in each activity topic. The principle of the model is shown in Figure 3. The *LDA* model provides two initial outputs: the probability $GV(q|c)$ of each word falling within a topic and the estimated probability $GV(c)$ of the topic-generated descriptive statement of the teaching activity. Eq. (1) shows the equation that the probability distribution of each word needs to satisfy:

$$GV(q_i) = \sum_{j=1}^{P} GV(q_i \mid c_i = j) GV(c_i = j) \quad (1)$$

In this paper, based on the *Gibbs* sampling method, each word in the descriptive statement of a teaching activity was assigned to a topic, and then, based on the assignment results, the topic distributions of all words were calculated until convergence. Suppose that the probability that the *n*-th descriptive teaching activity statement falls within topic *l* is denoted by ω_{nl}, that the number of times for which the topic *l* is allocated to the words in the descriptive teaching activity statement *n* is denoted by ${n^l}_n$, that the total number of words is denoted by m_n, and that the number of topics is denoted by *L*. Based on the topic distribution results, the topic distribution of the descriptive teaching activity statement can be calculated:

$$\omega_{nl} = \frac{m_n^l + \beta}{m_n + L \cdot \beta} \tag{2}$$

First, input the optimization standard for a teacher' teaching behavior in virtual teaching of digital graphic design into the *LDA* model, to obtain the topic of the descriptive teaching activity statements in line with the optimization standard and the probability of each word under the topic. If there is a difference of a certain degree between the teacher's teaching behavior in the teaching activities and this standard, then calculate the topic similarity between the two based on the cosine similarity to measure the optimization degree of the teacher's teaching behavior. Assuming that the optimization standard for teaching behaviors and the teacher's actual teaching behavior are represented by *v*, *u*, the topic distribution of the descriptive teaching activity statements in line with the optimization standard *v* is represented by $p_{vi} = (p_{v1}, p_{v2}, ..., p_{vl})$, that the topic distribution of the descriptive teaching activity statements corresponding to the teacher's actual teaching behavior *u* is $p_{ui} = (p_{u1}, p_{u2}, ..., p_{ul})$, and that there exists a link from *v* to *u* is represented by $(v,u) \in O_F$, then there is:

$$cos(v,u) = \frac{\sum_{i=1}^{l}(p_{vi} \times p_{ui})}{\sqrt{\sum_{i=1}^{l}(p_{vi})^2}\sqrt{\sum_{i=1}^{l}(p_{ui})^2}}, (v,u) \in O_F \tag{3}$$

If (v,u) does not belong to O_F, it can be considered that there exists no link from *v* to *u*, and then the similarity between the teacher's actual teaching behavior and the optimization standard for teaching behaviors is 0, and thus the teacher's teaching activity design needs to be reset. Since cosine similarity is symmetric, if $(v,u) \in O_F$, and $(v,u) \in O_F$, then there is the equation $cos(v,u) = cos(u,v)$. Eq. (4) shows the normalized expression of the link weight function:

$$q_p(v,u) = \frac{cos(v,u)}{d(v)} \tag{4}$$

Suppose $d(v) = \sum_{(v,u) \in OF} cos(v,u)$, and thus $q_p(v,u) \neq q_p(u,v)$. After normalization, $0 \leq q_p(v,u) \leq 1$ and for *v*, $\sum_{(v,u) \in OF} q_p(v,u) = 1$.

3 Construction of teachers' teaching behavior effect model

The teacher-student relationship in the virtual digital graphic design teaching environment can be illustrated by a directed, unweighted graph, where nodes represent the teacher and students, and edges teacher-student relationships in the virtual teaching environment. When the teacher implements an effective teaching decision, the effects on students can be divided into direct effects and potential ones. The latter are the effects that the teacher has the other students transmit through the teacher-student interaction and student-student interaction in the designed teaching activities.

Suppose in the virtual teaching environment, the teachers and students are represented by V_i and V_j, that the effect indicator of teacher V_i by $VS(V_i)$, that the direct effect of the teacher on students by $VS\_Direct\ (V_i)$, that the effectiveness of the teacher's teaching decision by $DK(v)$, and that the indirect effect of the teacher on students by $VS\_Indirect(V_i)$, and there is:

$$VS(V_i) = VS\_Direct(V_i) \times DK(v) + VS\_Indirect(V_i) \tag{5}$$

Students like to learn from teachers who carry out teaching activities that are in line with their learning preferences. The greater the weight of the edge characterizing the teacher-student relationship, the higher correlation between the teacher's teaching behaviors and the behavior optimization standard, and the greater the degree of coincidence between students' interests and the teaching activities. Suppose $q_v(v,u)$ is obtained by normalization of the topic similarity between the descriptive teaching activity statements of the optimization standard and those of the teacher's actual teaching behaviors, and that the decay factor is represented by α. The measurement formula of teachers' teaching behavior effects constructed based on the topics of the descriptive teaching activity statements and the characteristics of teachers' teaching behaviors is given as follows:

$$\Gamma(t_v) = \alpha \sum_{v:(v,u)\in O_F} \frac{\Gamma(t_u)}{k(u)} \times q_{pk}(v,u) + (1-\alpha)c(v) \tag{6}$$

The measurement formula of teachers' teaching behavior effects is not intended to equalize the effectiveness of the teaching decisions, but to adjust the distribution based on $q_v(v,u)$. Combining the above two equations, we have:

$$\Gamma(V_i) = \alpha \sum_{V_j\in N(V_j)} \frac{VS\_Direct(V_i) \times VS\_Indirect(V_i)}{K(V_i)} \times q_{pk}(i,j) + (1-\alpha)c(V_i) \tag{7}$$

$$\begin{aligned}\Gamma(V_i) = {} & \alpha \sum_{V_j\in N(V_j)} \frac{VS\_Direct(V_i) \times DK(V_i)}{K(V_i)} \times q_{pk}(i,j) \\ & + \alpha \sum_{V_j\in N(V_j)} \frac{VS\_Indirect(V_i)}{K(V_i)} \times q_{pk}(i,j) + (1-\alpha)c(V_i)\end{aligned} \tag{8}$$

It can be known from the above formula that $\sum_{Vi\in N(Vi)} VS\_Direct(V_i)/K(V_j)$ and $DK(V_i)$ are fixed values. Since Eq. (4) is convergent, Eq. (8) also has iterative convergence.

In the teacher-student relationship network under the virtual teaching environment of digital graphic design, teachers whose teaching behaviors have more effects on students tend to be more active in class, have stronger teacher-student relationships, and share knowledge more frequently. The activity level and knowledge dissemination ability of a teacher in class in the virtual teaching environment are mainly reflected in the number and frequency of teaching activities launched and the number of teaching interactions produced. The degree of effect of a teacher's teaching behaviors on students can be defined as the initial influence of the teacher. The direct influence of the teacher on students $VS\_Direct(V_i)$ can be obtained by adding together the number of teacher-student interactions, the rating of classroom activity and the rating of knowledge dissemination ability, as shown in Eq. (9):

$$VS\_Direct(V_i) = (VE(V_i) + FO(U_i) + AC(V_i) + PR(V_i)) \tag{9}$$

The certification of teacher V_i for teaching under the virtual teaching environment is represented by $VE(V_i)$, and the weight of a certified teacher is represented by parameter o. Assuming that V_i has the certification, $VE(V_i)$ is 0.5, and if he fails to obtain the certification, $VE(V_i)$ is 0, that is:

$$VE(V_i) = (o, e) \tag{10}$$

$FO(V_i)$ is a basic indicator to measure the influence of a teacher on students. The higher the number of teacher-student interactions $FO(V_i)$ of teacher V_i is, the more links the teacher node has in the topology of the teacher-student relationship network. When the number of teacher-student interactions is chosen as the initial influence indicator, it needs to be transformed as follows:

$$FO(V_i) = \begin{cases} 0, sts(V_i) \le 30 \\ 0.5, 30^4 \le sts(V_i) \le 50 \\ 1, sts(V_i) \ge 50 \end{cases} \tag{11}$$

The classroom activity of a teacher in the virtual teaching environment is represented by $AC(V_i)$, the total number of teaching activities launched by teacher V_i in period P by $\Psi(TA)$, and the average number of teaching activities launched by the teacher every day by $Avg(TA)$. In this paper, the time parameter P is introduced to reflect the temporal changes in the classroom activity of a teacher in the virtual teaching environment, as shown in Eq. (12):

$$AC(V_i) = \frac{\Psi(TA)}{Avg(TA)} / P \tag{12}$$

A teacher's knowledge dissemination ability indicator is represented by $PR(V_i)$. The numbers of teacher-student interactions and student-student interactions in the virtual teaching environment are closely related to the scope of the teacher's knowledge dissemination in this environment. The more teaching activities launched, the more effective teaching behaviors implemented, and the wider the scope of the teacher's knowledge dissemination, the greater the influence on students. The total number of students participating in teaching activities in period P is represented by $\Psi(ST)$, the total number of students participating in the evaluation of teaching effect by $\Psi(STP)$, and the total number of students by $\Psi(STN)$, and then there is:

$$PR(V_i) = \left(\frac{\Psi(ST)/\Psi(TA)}{\Psi(STN)} + \frac{\Psi(STP)/\Psi(TA)}{\Psi(STN)} \right) / P \tag{13}$$

The potential influence of the teacher on students is calculated based on the teacher-student relationship:

$$VS\_Indirect(V_i) = (1-c) + c \sum_{V_j \in N(V_j)} \frac{VS(V_j)}{K(V_j)} \tag{14}$$

Suppose the teacher-student relationship set of teacher V_i is represented by $N(V_i)$, and the network node V_j is one of the students influenced by teacher V_i. For any node V_j in the teacher-student relationship set, the influence of V_i on V_j can be obtained by dividing his own influence $VS(V_j)$ by the number of student-student relationships $K(V_j)$ of V_j.

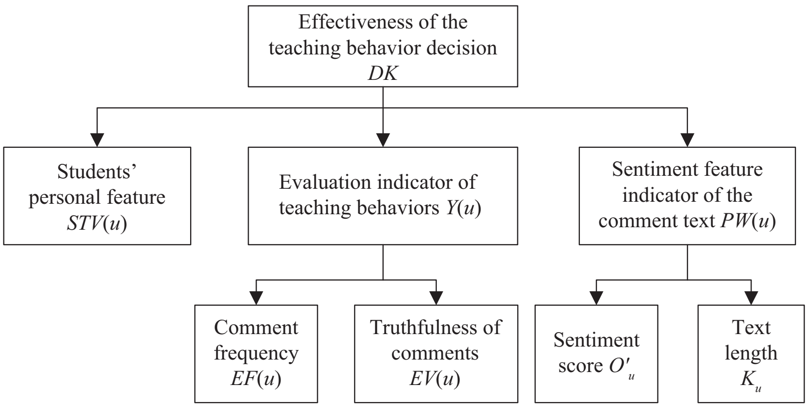

Fig. 4. Effectiveness indicator of teachers' teaching behavior decisions

Through analysis of the evaluation results of students regarding the teacher's virtual teaching effect of digital graphic design, the effectiveness indicator of the teacher's teaching behavior decision is obtained, as shown in Figure 4. It can be seen that, the effectiveness *DK* of the teacher's teaching behavior decision is measured from three aspects—the sentiment features of the comment text, the characteristics of teaching behaviors and the personal feature of students. Suppose that the effectiveness of teacher V_i's decision on teaching behavior u is represented by $DK(u)$, that the corresponding comment text indicator of the teaching effect by $PW(u)$, that the teaching behavior evaluation indicator by $Y(u)$, and that the personal feature indicator of students with respect to the teacher's teaching behavior u by $STV(u)$, then there is:

$$DK(u) = \sqrt{PW(u) \times Y(u) \times STV(u)} \tag{15}$$

The sentiment score O'_u of the teaching effect evaluation and the text length K_u determine the size of the text indicator $PW(u)$:

$$P(u) = O'_u \times K_u \tag{16}$$

O'_u is the sentiment polarity variance of the teacher's teaching behavior u, and O_u is the average sentiment value of m comments on the teacher's teaching behavior u, and then there is:

$$O_u = \frac{1}{m}\sum_{i=1}^{m} O_i \tag{17}$$

$$O'_u = \sum_{i=1}^{m} (O_i - O_u)^2 \tag{18}$$

It can be seen from the above formula that the smaller O'_u is, the more stable the students' sentiment is towards the teacher's teaching behavior u, which means the teacher's teaching decision is more effective. Assuming that the average length of the m comments on the teacher's teaching behavior u is represented by K_u, and that the length of the i-th true comment on u by TK_i, then there is:

$$K_u = \frac{1}{m}\sum_{i=1}^{m} TK_i \tag{19}$$

The teaching behavior evaluation indicator $Y(u)$ is determined by the students' comment frequency and truthfulness of comments on the teacher's teaching behavior in period P. The more frequent and truthful the comments are, the more effective the teacher's teaching decision is. Suppose that the comment frequency is represented by $EF(u)$, that the truthfulness of comments by $EV(u)$, that the number of truthful comments on the teaching behavior posted in period P by $TR(u)$, and that the number of truthful comments on the teaching behavior by $FA(u)$, then there are:

$$Y(u) = EF(u) \times EV(u) \tag{20}$$

$$EF(u) = \frac{TR(u)}{P} \tag{21}$$

$$EV(u) = \frac{TR(u)}{FA(u)} \tag{22}$$

The personal feature of students $STV(u)$ is determined by the proportion of their truthful comments on the teacher's teaching behavior in the total comments. If the majority of the comments posted by students are truthful, the teacher's teaching decision is more effective. Assuming that the total number of comments posted in period P is represented by $TP(v)$, there is:

$$STV(u) = \frac{TR(u)}{TP(u)} \tag{23}$$

4 Experimental results and analysis

Table 1. Comparison of the quantitative results of the teacher's influence on students

Proposed Model	Reference Model 1	Reference Model 2	Reference Model 3
1253562247	3625948557	2015486238	2514836295
5142847591	2514263281	1326594855	1412518523
3625915845	1524875412	2615247858	2351248510
2512974852	1326594579	1958851222	1625395854
1374851222	1021417451	3962594785	1320524857
1845962327	1958612527	2032518411	3625142845
1142518512	1325152841	3521418521	1362591272

Based on the existing research results, the performance of the GN model (reference model 1), Louvain model (reference model 2), SLPA model (reference model 3) was compared with that of the proposed one, and the teachers' effective teaching behaviors in the virtual teaching of digital graphic design were sorted and manually labeled. In order to avoid the subjective interferences caused by manual operation to the model execution results, while data of virtual teaching behaviors were collected, the direct and indirect influences of teachers on students were also summarized. The teaching behaviors of different teachers in the database were matched with the optimization standard of virtual teaching behaviors. Table 1 shows the comparison results of the optimized teaching behaviors of the top 10 teachers mined by the four models. For the manually labeled teachers of virtual digital graphic design teaching with a class size, the precision and recall rates of the GN, Louvain, SLPA models and the proposed one for mining the teachers with good optimization effects of teaching behaviors were calculated, and the execution results of the four models were verified under different numbers of topics for the descriptive teaching activity statements. The visualized results of the precision and recall rates in the ranking of teaching behavior optimization effects are shown in Figures 5 and 6.

Figures 5 and 6 show the precision and recall rates of different models in ranking the optimization effects of teaching behaviors. It can be seen that the precision of the proposed model was slightly better than that of the other three reference ones, i.e. GN, Louvain and SLPA models. It can be found that, with the increase in the number of topics in the descriptive statements of teaching activities, the precision of all models in ranking the optimization effects of teaching behaviors decreased, because with the increase in the number of topics, the value density of the effective comment words in a unit interval gradually decreased, and accordingly, it became more difficult to identify the correct comment words. Regarding the top 10 and top 20 rankings, both the precision and recall rates of the proposed model were significantly better than those of reference model 1.

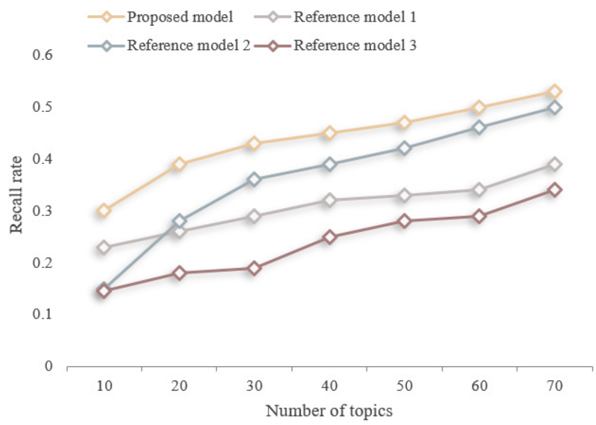

Fig. 5. Precision of different models in ranking of teaching behavior optimization effects

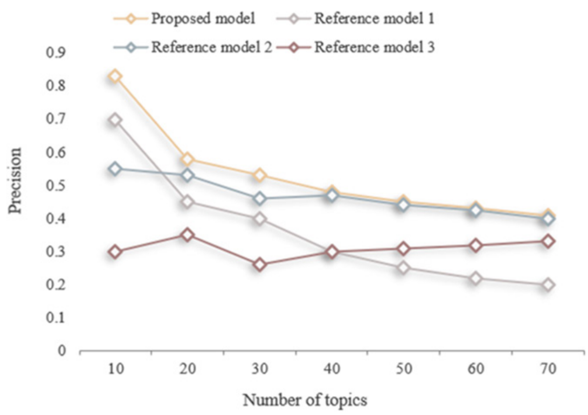

Fig. 6. Recall rates of different models in ranking of teaching behavior optimization effects

Figures 7 and 8 show the experimental results of the precision and recall rates after less truthful comments were removed. Judging from the evaluation indicators of the proposed model and reference model 1 in the two figures, it can be confirmed that removing the less truthful comments is helpful for the ranking of optimization effects of teaching behaviors.

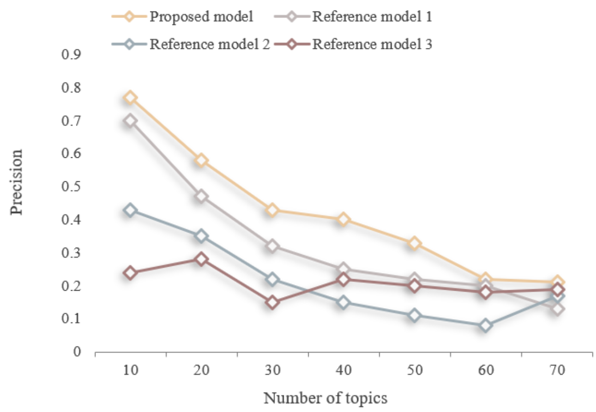

Fig. 7. Experimental results of precision after removal of less truthful comments

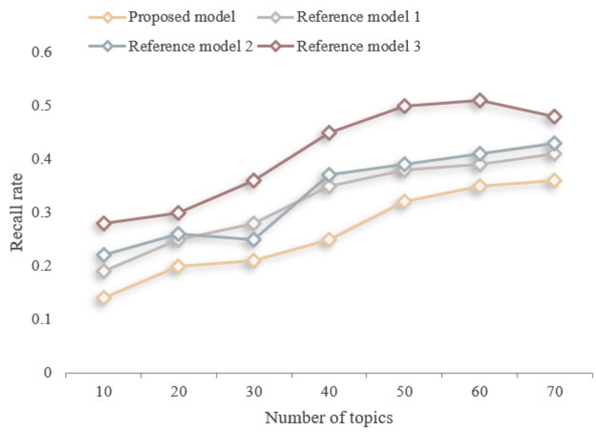

Fig. 8. Experimental results of recall rates after removal of less truthful comments

5 Conclusions

This paper studied the optimization of teachers' teaching behaviors in the virtual teaching environment of digital graphic design. Firstly, the problems existing in the application of virtual reality technology in digital graphic design teaching were summarized, a structural model for the virtual teaching environment of digital graphic design was constructed, and the optimization of teachers' teaching behaviors under the virtual teaching environment of digital graphic design was quantified based on the LDA model. Then, an effect model for teachers' teaching behaviors was constructed, and through analysis of the evaluation results of students on the virtual digital graphic design teaching effect of teachers, the effectiveness indicator of teachers' teaching behavior decisions was obtained. The performance of the GN, Louvain and SLPA models and that of the proposed model were compared and analyzed. The virtual teaching behaviors of digital graphic design teachers with good teaching effects were ranked and manually labeled, and based on this, the precision and recall rates of different models in ranking the optimization effects of teaching behaviors were given, which proves that the precision of the proposed model is slightly better than that of the other three reference ones. The experimental results of the precision and recall rates after removal of the less truthful comments were also given, which shows that removing the less truthful comments is helpful for improving the ranking of teaching behavior optimization effects.

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Article submitted 2022-07-12. Resubmitted 2022-08-07. Final acceptance 2022-08-09. Final version published as submitted by the authors.