Online-Journals.org

iJET International Journal of Emerging Technologies in Learning

iJET | eISSN: 1863-0383 | Vol. 18 No. 15 (2023) | OPEN ACCESS

https://doi.org/10.3991/ijet.v18i15.42251

PAPER

Evaluation of Online Teaching Effect of Vocational College Teachers Based on TOPSIS Technology and the Hierarchical Chi-Square Model

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ABSTRACT

Internet teaching space requires teachers to be skilled in new technological platforms and tools and use new teaching interaction modes and evaluation means. Moreover, most front-line teachers have no online teaching experience before and bear the great pressure of online teaching. Hence, the evaluation of online teaching is challenge that has to be solved. A total of 169 teachers from six vocational colleges in Zhejiang Province were chosen as the research subjects in this study to improve the poor accuracy of the simple linear evaluation results of traditional classroom teaching. The relative efficacy of the online teaching quality of 169 teachers was estimated through the technique for order of preference by similarity to ideal solution (TOPSIS) technology. Next, the causal relationship between excellent achievement in online teaching training and the teaching effect of teachers with different titles was analyzed using the hierarchical chi-square model. Research results demonstrated that 12 level-2 indexes used in this study could depict the online teaching effect of university teachers comprehensively. The TOPSIS method calculated the scientific and reasonable ranking and evaluation values of 169 teachers. The Cochran–Mantel–Haenszel conditional independence test of the chi-square test presented significance. Our study of the instruments used to evaluate teacher success in online teaching shows that significant differences exist between evaluation grades for online teaching training and excellent achievement in online teaching training. This study can provide important references to comprehensively guide teachers to understand the value orientation of the new online teaching mode.

KEYWORDS

TOPSIS, hierarchical chi-square model, vocational college teachers, online teaching, effect evaluation

1 INTRODUCTION

With the continuous development of the Internet, artificial intelligence (AI), big data, blockchains, and 5G, including their extensive applications to higher education,

Zheng, Y. (2023). Evaluation of Online Teaching Effect of Vocational College Teachers Based on TOPSIS Technology and the Hierarchical Chi-Square Model. *International Journal of Emerging Technologies in Learning (iJET)*, 18(15), pp. 161–173. https://doi.org/10.3991/ijet.v18i15.42251

Article submitted 2023-06-14. Resubmitted 2023-06-15. Final acceptance 2023-06-15. Final version published as submitted by the authors.

the forms of teaching used in colleges and universities may change accordingly. The necessity of education reform in the new situation has been widely accepted globally. Countries worldwide have issued education innovation strategies and formulated teaching reform and development plans, which strongly support the breakthroughs in educational teaching in the "Internet+" environment. In particular, advanced technologies such as multimedia and network technology have been integrated into education in recent years. Technologies are used increasingly in education and have become increasingly mature. Educational informatization in China progresses at a steady rate, and the software and hardware environments in schools have been improved significantly. Online learning has the advantage of meeting the learning needs of different learner groups in higher education. Comprehensive integration of online learning into higher education is an effective choice to reflect on teaching modes in higher education. With the increasing teaching reform needs of higher education, online learning is becoming important in teaching for China's higher education. Teaching based on the philosophy of "learner centered" is a consensus reached in higher education. Online teaching has developed quickly and is used extensively, although it has been challenging to implement. In particular, online teaching can fully meet the personalized learning needs of learners in the current vigorous development of higher vocational education modernization in China. Online teaching achieves teaching quality equivalent to classroom teaching. Moreover, online teaching offers learning autonomy and satisfaction of learners that it is hoped will exceed that of traditional classroom teaching. Many studies have demonstrated that compared with traditional classroom teaching, online teaching has expanded the teaching space and time, and introduced various high-quality resources. Online teaching not only is beneficial for helping learners make flexible adjustments to the learning process and stimulate their enthusiasm and autonomy fully but also can meet the personalized learning needs of learners completely.

Teaching is essentially the process of dialogue communication. Without the opportunity for dialogue, teaching becomes simply a dogmatic process of knowledge teaching. Hence, any learning system views interaction as the necessity and fundamental mechanism of knowledge acquisition, cognition, and thinking development. Nevertheless, the separation of teaching time and space in the online environment determines the fundamental properties of teaching interaction in the process of online teaching and learning. Such separation is also the key to the secondary integration of online teaching and learning. Compared with traditional teaching, online teaching lacks face-to-face communication and interaction. Moreover, online teaching proposes new requirements for the evaluation of its effect on university teachers. Recently, one of the keys of online teaching reform has been to improve the validity of online classroom evaluation and the ability to evaluate teachers' ability in online teaching. Vocational colleges are an important component of Chinese universities, and they provide abundant technical talent for national economic and social development. Hence, studying the online teaching effect evaluation of vocational college teachers can encourage additional young teachers to adapt to online teaching and is important in improving the level of online evaluation. Based on the big data of online learning and objective scientific classroom performance data, teachers can pat greater attention to personalized learning needs and the differentiation development of students in vocational colleges. In addition, students and teachers in vocational colleges can easily establish learning communities for evaluation, learning, and communication under the online teaching mode. This mode

is also beneficial to improve the learning efficiency of learners and enhance their learning motivations.

2 LITERATURE REVIEW

The online teaching mode not only offered requirements for coronavirus (COVID-19) pandemic control but has also improved the information-based teaching skills of teachers. Hence, the online teaching effect evaluation of university teachers becomes a key problem in measuring online teaching quality. Concerning online teaching effect evaluation of teachers, Li et al. [1] and Estelami [2] designed an evaluation method for online teaching quality of basic education based on AI and evaluated the online teaching quality of basic education by introducing the entropy weight method and gray cluster method. The research results provide good references for improving the online teaching quality evaluation method. Tallent-Runnels et al. [3] measured students' opinions of the teaching effect using the university teaching evaluation scale. The author found that students gave higher evaluations to teachers and the course if they encountered technological problems more frequently or their problems hindered their learning progress more seriously. In a voice assembly of teachers and learner groups in India, Selvaraj et al. [4] reflected on the advantages and disadvantages of the new normal online home education for the first time, including the praise and dissatisfaction by the participants and suggested how to improve online teaching technology. Wang et al. [5] studied the effects of online teaching on the interaction and collaborative knowledge construction of students by analyzing the teaching activities of a teacher in three courses. The results showed that the design, organization, and discourse promotion facilitated the interaction of students and decreased the quantity of peripheral students. Treischl et al. [6] emphasized the importance of selection and class absence when studying the effects of the investigation mode. The authors also pointed out that investigating the reasons for students' absence during the evaluation of online teaching is necessary and beneficial.

Taylor et al. [7] believed that teacher performance evaluation has become the major theme of school reform and argued that the increase in students' academic performances can be used to measure teachers' performances objectively. Tang et al. [8] carried out a questionnaire survey of engineering undergraduates from Chengdu University of Information Technology. The authors found that students were generally unsatisfied with online learning, particularly with communication and its question-and-answer mode. However, the online learning combined mode can improve the learning and attention of students and their evaluation of courses. Bangert [9] developed and verified students' evaluation of the online teaching effect. Based on an analysis of 498 undergraduates and graduates participating in online courses, he concluded that teacher–student interaction, active learning, time to complete a task, and cooperation of students are key factors influencing the online teaching effect. Bi et al. [10] investigated the teaching effect of teachers and students who participated in learning activities. The authors found that the blended learning mode based on the Moodle platform was conducive to improving the teaching effect. Johnson et al. [11] believed that students' evaluation of teaching (SET) was an extensively used index to evaluate the effectiveness of teachers. Şendağ et al. [12] demonstrated that online problem-based learning (PBL) had no significant effects on the content and knowledge acquisition scores of learners but could improve the critical-thinking skills of students significantly. Feistauer et al. [13] investigated the

effectiveness of SET as a tool to measure teaching quality. The authors demonstrated the favorable fixed effect of teachers and the fixed effect that previous respondents were interested in before the course measurement. Lan et al. [14] measured the evaluation and comments of 202 undergraduates to teachers and the course. The authors noted that universities have to study the relationship between teaching evaluation and technological problems students encountered in the Internet environment to encourage the online teaching of teachers. Chen [15] tested whether teaching evaluation could improve teaching quality through a SET survey in a top-class university in China from 2016 to 2021. The author found that teachers with poor (or good) ranks in previous evaluations might get a better (or worse) rank in the current evaluation. According to existing studies, teachers should use various technological schemes more comprehensively and flexibly during online teaching rather than choosing complicated technological schemes blindly, which can make students unable to adapt, or adding technological platforms, which students can find too complicated. This case helps teachers consider how to adapt to the new online teaching mode and improve online teaching, thereby improving the online teaching effect. However, the influencing factors of the online teaching effect evaluation are very complicated and diversified. The simple linear evaluation method cannot measure the teaching effect of teachers in schools scientifically. Meanwhile, training teachers' online teaching ability should be increased to improve their online teaching quality.

3 METHODS

3.1 Brief introduction to models

The TOPSIS method is essentially a ranking method of an approximately ideal solution. This method only requires monotonic increasing (or decreasing) of each utility function. In a multi-objective decision analysis, additional studies are used utilizing the TOPSIS method, which achieves great scientific and reasonable ranking results and better solving effects. This method detects the distance from the evaluation objects to the optimal and worst solutions. If the evaluation object is closer to the optimal solution and further away from the worst solution, then it is optimal; otherwise, it is not optimal. Specifically, all indexes of the optimal and the worst solution meet the requirements of optimal and worst values, respectively.

General steps are introduced as follows. First, m objects were evaluated according to n different evaluation indexes. The judgment matrix X was acquired according to the evaluation results of objects (Eq. (1)).

$$X = \begin{bmatrix} x_{11} & x_{12} & \cdots & x_{1n} \\ x_{21} & x_{22} & \cdots & x_{2n} \\ \vdots & \vdots & \ddots & \vdots \\ x_{m1} & x_{m2} & \cdots & x_{mn} \end{bmatrix} \tag{1}$$

x_{ij} refers to the evaluation results of the jth factor of the ith evaluation objects. The evaluation factors that reflect the evaluated objects often have different dimensions and dimensional units. Hence, the range transformation method was applied, and dimensionless treatment of evaluation indexes was carried out to eliminate the incommensurability of indexes (Eqs. 2 and (3)). Specifically, the positive indexes (the higher the value, the better) were treated by Eq. (2).

$$r_j = \frac{x_{ij} - x_{\min(j)}}{x_{\max(j)} - x_{\min(j)}} \tag{2}$$

The negative indexes (the smaller the value, the better) were treated according to the method in Eq. (3).

$$r_j = \frac{x_{\max(j)} - x_{ij}}{x_{\max(j)} - x_{\min(j)}} \tag{3}$$

The relation judgment matrix (R) was acquired through dimensionless treatment (Eq. (4)).

$$R = \begin{bmatrix} r_{11} & r_{12} & \cdots & r_{1n} \\ r_{21} & r_{22} & \cdots & r_{2n} \\ \vdots & \vdots & \ddots & \vdots \\ r_{m1} & r_{m2} & \cdots & r_{mn} \end{bmatrix} \tag{4}$$

where r_{ij} is the dimensionless treatment result of the original data x_{ij}. Based on the standardized weighting evaluation decision matrix, the positive and negative ideal solutions (V^+ and V^-) were calculated, as shown in Eqs. (5) and (6).

$$\begin{aligned} V^+ &= (v_1^+, v_2^+, \ldots, v_j^+, \ldots, v_n^+) \\ v_j^+ &= \{(\max_{1 \le i \le m} v_{ij} | j \in J^+), (\min_{1 \le i \le m} v_{ij} | j \in J^-)\} \end{aligned} \tag{5}$$

$$\begin{aligned} V^- &= (v_1^-, v_2^-, \ldots, v_j^-, \ldots, v_n^-) \\ v_j^- &= \{(\min_{1 \le i \le m} v_{ij} | j \in J^+), (\max_{1 \le i \le m} v_{ij} | j \in J^-)\} \end{aligned} \tag{6}$$

The Euclidean distances from different schemes to the positive and negative ideal solutions were calculated as follows:

$$\begin{aligned} D_j^+ &= \sqrt{\sum_{j=1}^{n} (v_{ij} - v_j^+)^2} \\ D_j^- &= \sqrt{\sum_{i=1}^{n} (v_{ij} - v_j^-)^2} \end{aligned} \tag{7}$$

Finally, the relative degree of proximity of different schemes was calculated as follows:

$$C_i = \frac{D_i^-}{D_i^+ + D_i^-} \tag{8}$$

The hierarchical chi-square test, also called the Cochran–Mantel–Haenszel (CMH) test is mainly applied to the above hierarchical analysis. In other words, the blending effects among hierarchical factors were considered according to the correlation between exposure/treatment factors and outcome events. The CMH test analyzes the correlation between contact/treatment factors and outcome events after adjustment by controlling

for hierarchical factors. That is, the CMH test begins to include the multi-factor analysis thinking mode rather than the simple single-factor analysis of problems and is one of the simplest multi-factor analytical methods in terms of operation.

3.2 Evaluation indexes

The Education Branch of the China Information Industry Association formulated *Online Teaching Quality Evaluation and Standards* according to the spirit of relevant documents to standardize online teaching practices and make full development of the unique function of online teaching. Examples include *Educational Informatization 2.0 Action Plan of Ministry of Education*, *Notice of Ministry of Education on Issuing "Online Learning Space Construction and Application Guideline*," *Guidance of Ministry of Education on Strengthening Online Learning Space Construction and Applications*, and *Guidance of Ministry of Education on Strengthening Applications of "Three Classrooms*." The system is composed of three-level index systems. Level 1 indexes include preparation, resource use, teaching process, and course evaluation. Level 2 indexes include 10 aspects, such as technological tools and network environmental preparation. These evaluation indexes form the basis for online teaching quality evaluation in this study. Table 1 shows the details.

Table 1. Online teaching quality evaluation and standards

Primary Indicators	Secondary Indicators	Number
Prerequisites	Preparation of technical tools and networking	*A1*
	Preparation of teachers' online instruction	*A2*
	Preparation of students' online learning	*A3*
Resource utilization	Selection and application of resources	*B1*
	Course time management	*B2*
Teaching process	Target-based learning	*C1*
	Self-directed research and learning	*C2*
	Collaborative learning	*C3*
Course evaluation	Accurate evaluation of learning	*D1*
	Reflection and self-assessment of learning	*D2*

3.3 Data processing

Zhejiang is a province with strong vocational education in China. During the COVID-19 pandemic, vocational college teachers in Zhejiang Province were held responsible for teaching management of online open courses. They had to establish a perfect online open-course management system, strengthen supervision over course teaching services and management, execute course-selection management strictly, and adopt strict assessment and evaluation. The online open-course management system is divided into three levels of index systems. The management layer of higher education institutions pays close attention to improving teachers' teaching quality and strictly requires lecturers and teaching teams of online open

courses to provide high-quality teaching services according to the requirements of teaching guidelines. Meanwhile, teachers responsible for the chosen sources must strengthen management and service throughout online teaching. In this study, an empirical analysis of teaching data of 169 teachers from six vocational colleges in Zhejiang Province in the spring semester from 2021 to 2022 was carried out.

In the TOPSIS model, teaching advisors, students, and teachers were asked to give scores (1–5) according to Table 1 of *Online Teaching Quality Evaluation and Standards* at the end of the semester. The weights of teaching advisors, students, and teachers were set at 0.5, 0.4, and 0.1, respectively. In this way, the original data of 10 level-2 indexes of 169 teachers was calculated. Subsequently, the distance to the positive ideal solution (D+), the distance to the negative ideal solution (D–), relative proximity (C), and ranking result were calculated by using the TOPSIS method.

In the hierarchical chi-square model, teachers with $C > 0.5$ in TOPSIS calculation were set as teachers with excellent online teaching quality, and they were expressed as 1. Then, those with $C < 0.5$ were set as teachers without excellent online teaching quality, and they were expressed as 0. Hence, dependent and independent variables were gained. Whether teachers had excellent achievement in online teaching training was set as an independent variable. Teachers who had excellent achievements in online teaching training were set 1, whereas others were set as 0. Finally, the titles of teachers were set as the hierarchical term.

4 RESULTS

4.1 TOPSIS results

According to Eqs. (1)–(9), the first thing when using the TOPSIS method is to process the original data of indexes. The positive and negative ideal solutions of 10 level-2 indexes were calculated using Matlab2017b software (Table 2).

Table 2. Positive and negative ideal solutions of TOPSIS method

Item	Positive Ideal Solution $A+$	Negative Ideal Solution $A-$
Preparation of technical tools and networking	4.940	1.087
Preparation of teachers' online instruction	4.970	1.024
Preparation of students' online learning	4.992	1.020
Selection and application of resources	4.989	1.000
Course time management	4.950	1.015
Target-based learning	4.965	1.010
Self-directed research and learning	4.921	1.010
Collaborative learning	4.997	1.005
Accurate evaluation of learning	4.949	1.014
Reflection and self-assessment of learning	4.945	1.029

The relative closeness degree C was calculated and is shown in Table 3.

Table 3. TOPSIS evaluation calculation results

Item	Positive Ideal Solution Distance *D*+	Negative Ideal Solution Distance *D*–	Relative Closeness Degree *C*	Ranking Result
Evaluation target 1	7.304	7.263	0.499	86
Evaluation target 2	7.394	6.855	0.481	98
Evaluation target 3	7.375	7.354	0.499	85
Evaluation target 4	4.986	9.112	0.646	5
Evaluation target 5	6.813	8.129	0.544	36
Evaluation target 6	7.914	6.139	0.437	136
Evaluation target 7	7.313	7.42	0.504	80
Evaluation target 8	8.171	5.793	0.415	151
Evaluation target 9	8.319	5.985	0.418	149
Evaluation target 10	8.609	5.508	0.39	158
:	:	:	:	:
Evaluation target 160	8.09	7.034	0.465	117
Evaluation target 161	7.007	7.034	0.501	84
Evaluation target 162	6.31	7.749	0.551	33
Evaluation target 163	7.883	6.423	0.449	130
Evaluation target 164	6.12	8.076	0.569	20
Evaluation target 165	8.198	6.464	0.441	135
Evaluation target 166	7.268	6.601	0.476	103
Evaluation target 167	5.009	8.694	0.634	6
Evaluation target 168	7.717	6.973	0.475	104
Evaluation target 169	7.848	6.711	0.461	121

Note: Due to length limitations, this paper provides evaluation results for only 20 teachers.

Table 3 shows that all 169 teachers could gain *C* and ranking results comprehensively through the TOPSIS method. *C* of 169 teachers was further analyzed (Table 4).

Table 4. Descriptive statistical results of relative closeness degree *C*

Name	Mean±Standard Deviation	Variance	25th Percentile	Median	75th Percentile	Standard Error
Relative closeness degree *C*	0.496±0.068	0.005	0.452	0.499	0.54	0.005
Name	Mean 95% CI (LL)	Mean 95% CI (LL)	*IQR*	Kurtosis	Skewness	Coefficient of variation
Relative closeness degree *C*	0.485	0.506	0.088	0.045	0.085	13.685%

Table 4 shows that the median of C was 0.499, which was very close to the principle that teachers with $C > 0.5$ were set as teachers with excellent online teaching quality in the TOPSIS method. The hierarchical chi-square analysis is carried out in the Section 4.2.

4.2 Hierarchical chi-square analysis results

The hierarchical chi-square analysis was carried out using SPSS22.0 software. Table 5 presents the summary of the hierarchical chi-square analysis.

Table 5. Stratified chi-square test summary

Title	Teaching Evaluation Level	0		1		χ^2	p Value	OR Value	OR Value 95% CI
	Whether Online Teacher Training is Excellent	0	1	0	1				
Teaching Assistant		8	2	2	5	4.496	0.058	10	1.048 ~ 95.457
Lecturer		42	6	2	38	59.4	0	133	25304 ~ 699.052
Associate Professor		31	3	3	16	30.121	0	55.111	9.965 ~ 304.786
Professor		5	2	1	3	2.213	0.242	7.5	0.458 ~ 122.696
Total		86	13	8	62	94.544	0	51.269	20.041 ~ 131.158

Table 6 shows that the Breslow–Day–Tarone test did not show significance ($\chi^2 = 5.129$, $p = 0.163 > 0.05$), indicating a homogeneous relationship among different layers and no blending effect among hierarchical factors.

Table 6. Ratio equality test (Breslow-Day-Tarone)

χ^2	df	p Value
5.129	3	0.1626

In Table 7, the CMH conditional independence test presented significance ($\chi^2 = 88.791$, $p = 0.000 < 0.05$). This result reflected the significant difference between excellent achievement in online teaching training and teaching evaluation grades after interference factors were considered.

Table 7. The Cochran–Mantel–Haenszel test of conditional independence

OR Value (Mantel–Haenszel Common)	95% CI	χ^2	df	p Value
43.1522	16.5807 ~ 112.3062	88.7911	1	0.000

This conclusion fully demonstrates that good online teaching training for vocational college teachers can influence their teaching evaluation grades significantly. The main reason is that during the COVID-19 pandemic control period, vocational college teachers had to suspend the traditional classroom teaching mode and provide online classes. Faced with online teaching, some vocational college teachers not only found the experience psychologically stressful but also lacked practice ability. They often encountered many difficulties and problems in online teaching practices [16]. On the one hand, studying online teaching and training needs of vocational college

teachers is one of the important links between universities and colleges to support and help teachers and students to adapt to and complete online teaching tasks successfully. On the other hand, it is the key to improving the online teaching effect and quality of vocational college teachers, promoting vocational college students to improve their online teaching ability positively and pursue excellent online teaching. During the COVID-19 pandemic control, most university teachers participated in online teaching training, aiming to help complete the teaching tasks successfully.

Some teachers want to improve their online teaching ability and lay the foundation for further teaching development. Teachers with relatively strong teaching innovation ability and good online teaching basis hope that online teaching training can help them build high-quality online courses. Teachers participate in online teaching training for different goals and have different training needs. With respect to training needs, most teachers emphasize a brief introduction to online teaching platforms, using skills and modes of these platforms. Teachers who want to improve classroom teaching focus on the leading online teaching platforms and tools, using skills at present. Hence, many good teachers participating in online teaching training can easily accept the advanced online teaching philosophy, experiences, high-efficiency of online teaching, etc. They may pursue online teaching and training needs from teachers of high-quality online courses, including current advanced platforms, tools, and technologies, as well as advanced ideas, concepts, views, and methods of online teaching. This case can facilitate the improvement of online teaching quality.

5 DISCUSSION

The traditional teaching mode is impossible in the new online space. The new Internet space requires teachers to master new technological platforms and means, and use new teaching interaction modes and evaluation means. Nevertheless, most schools are prepared to copy the original class, discipline, and time units directly to online teaching mode. Moreover, most front-line teachers have no experience in live broadcasts. They can only undertake online broadcasting in haste and face great pressure. The teaching quality and teaching effect are difficult to guarantee. The new online teaching mode is not a simple copy of the online classroom but requires redesigning the teaching plan and reconstructing the classroom culture. In the digital era, students have to learn independently. During the COVID-19 pandemic control, teachers could not make face-to-face communication with students, and they had to try teaching in online and offline spaces thoroughly. In the Internet environment, students have a relatively large free space for independent learning, and they should be equipped with good digital learning innovation ability. Additionally, students often lack effective external supervision during home study. Therefore, they must learn self-management, independent learning, and online learning in a new situation. Online teaching during the COVID-19 pandemic control offered a unique teaching mode in a special period. As a special teacher group, vocational college teachers require special assistance and support from schools and society. Hence, understanding the demands of vocational college teachers for online teaching training during the COVID-19 pandemic control is beneficial for schools and society to provide targeted support and aid. Schools and society can adopt the combination of concentrated and hierarchical training, classified guidance and individual counseling, teaching guiding and video diagnosis, and online observation to give targeted services and support to vocational college teachers for online teaching to meet vocational college teachers' diversified and personalized

needs for online teaching and training. People are very nervous about facing sudden changes in teaching mode. Such pressure not only makes university teachers unable to adapt to online teaching well but also may influence online effect and quality. University teachers all have strong training needs to provide online teaching services. The reason is that online teaching requires teachers to master more new knowledge and skills than traditional classroom teaching. However, many teachers only need training when preparing to provide online teaching services. Teachers pay additional attention to teaching itself but pay less attention to the creation of learning environments and giving learning guidance. Hence, attention shall be paid to designing student-oriented online teaching to improve the online teaching effect of teachers in the future.

6 CONCLUSIONS

Online teaching in the full sense is not a copy of the old teaching mode and cannot be integrated and changed from traditional classroom teaching in schools. Hence, teachers must consider how to adapt to the new online teaching mode positively and provide high-quality online teaching. The scientific and objective evaluation of online teaching quality in vocational colleges to reflect vocational education quality truly and improve the teaching level of vocational college teachers effectively has been a key problem in the academic circle for a long time. In this study, 169 teachers from six vocational colleges in Zhejiang Province were investigated. The relative proximity of their online teaching quality was estimated through the TOPSIS method, and the causal relationship between excellent achievement in online teaching training and the teaching effect of teachers with different titles was analyzed through the hierarchical chi-square model. Three major conclusions could be drawn: (1) the 12 level-2 indexes in this study can depict the online teaching effect of university teachers comprehensively; (2) additional scientific and reasonable ranking and evaluation values of 169 teachers were calculated based on the TOPSIS method; (3) the CMH conditional independence test showed significance (chi = 88.791, $p = 0.000 < 0.05$). Future studies can further examine the causal relationship between the personalized teaching needs of learners and dynamic teaching plan adjustment, including the causal relationship between students' online learning engagement and teachers' teaching effect.

7 ACKNOWLEDGMENT

This study was funded by Educational Science Planning Project of Ningbo City (2023YGH068) and Vocational Education Project of China (B61).

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