J. COMBIN. MATH. COMBIN. COMPUT. 127a (2025) 3467--3481

Journal of Combinatorial Mathematics and Combinatorial Computing
www.combinatorialpress.com/jcmcc

Combinatorial Press

A Path Modeling Study on the Integration of Science and Technology and Education for Quality Improvement of Vocational Education

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ABSTRACT

The integration of science and education is conducive to promoting the integrated development of education, science and technology, and talents, and is a key path for the high-quality development of vocational education and serving the strategy of a strong education nation. This paper explains the necessity of integrating science and technology with education, and realizes the path design of vocational education quality improvement based on the new concept of science and education integration. Then, the quality of science and education integration in vocational education is evaluated using hierarchical analysis and fuzzy comprehensive evaluation. Then, a comparison test is designed and independent sample t-test is applied to verify the practicality of the path in this paper. In the criterion layer of the established evaluation index system, the weight of industry-university-research integration is the largest, which is 23.91%, indicating that industry-university-research integration is particularly important in the path of vocational education quality improvement. In the indicator layer, the research team building has the largest weight, 10.17%, which needs to be emphasized in the implementation of the integration of science and education in vocational education. The overall rating of the quality of science and education integration in H higher vocational colleges implementing the path of this paper is 84.638, which is between good and very good, and is at a high level. And the two-sided Sig value of the T-test of the evaluation score of the quality of science and education integration in the higher vocational colleges and universities using this paper's pathway and those using the traditional education model is 0.000<0.05, which is a significant difference. It indicates the practicality of this paper's path for improving the quality of vocational education based on science and education integration. This paper provides a path paradigm for improving the quality of vocational education using science and education integration.

Keywords: hierarchical analysis, fuzzy comprehensive evaluation method, independent sample t-test, vocational education science and education integration

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Received 10 January 2024; Revised 15 March 2024; Accepted 25 December 2024; Published Online 15 April 2025.
DOI: 10.61091/jcmcc127a-198

1. Introduction

High-quality development of vocational education is the inherent requirement of the development and reform of vocational education in China in the new period, and it is also the core driving force for the development of vocational education at a higher level, and it has the role of promoting the construction of a perfect education and training environment for vocational talents in China [1-2]. Nowadays, the reform of vocational education is steadily advancing, which provides new ideas for the high-quality development of vocational education [3]. Vocational colleges and universities should be based on the changes in the educational environment and industry development environment in the new era, do a good job of reforming the development of vocational education dynamically [4-5].

Vocational education needs to keep up with these changes and adjust the curriculum and training content in time to meet the needs of the job market. Industry technology is rapidly updating, and vocational education needs to keep pace with it to ensure that students are equipped with the latest technological capabilities, which requires constant updating of teachers' professional knowledge and technical skills [6-8]. At the same time, vocational education needs to establish close school-enterprise partnerships with industry to provide more opportunities for students to participate in practice, internships and job training. However, the lack of effective cooperation mechanisms and resource support between some regions and industries limits students' opportunities for practice [9].

The necessity of change in vocational education lies in meeting the demands of the employment market, improving the quality of workers, promoting social and economic development and enhancing the status and recognition of vocational education [10-11]. Specifically, the first is to meet the employment market demand. Vocational education changes to better meet the needs of the job market. By adjusting curricula and updating technology and knowledge content, vocational education can provide students with employment-related skills and knowledge, thus increasing their competitiveness in employment. The second is to promote social and economic development [12]. Vocational education is closely related to social and economic development. By training talents for various industries, vocational education can promote the development of the industry, promote technological innovation, and enhance the competitiveness of the country, and finally, it is to enhance the status of vocational education [13].

Literature [14] combined the analysis of the systematic impact diagram and the effect of vocational teaching experiments to point out that the experimental teaching mode is very necessary in vocational education, and exposed the lack of facilities and equipment corresponding to the experimental teaching mode in vocational schools, as well as the importance of teachers with experimental teaching skills. Literature [15] through the questionnaire survey tool learned that in vocational teaching, there are significant differences in the standards of students' academic performance and learning logic, and it is believed that vocational education can be selectively optimized and improved according to these differences. Literature [16] describes the significance of the role of the teacher for the quality of vocational education and argues that the teacher must have an in-depth understanding of the quality of vocational education and must assume responsibility for the quality of vocational education and the implementation of standards of professional management. Literature [17] analyzed the SVE Service Quality Perception Scale for Students with Disabilities in Vocational Schools and found that the factors related to the quality of SVE services include the responsiveness of vocational education, the living and teaching environment, and training facilities, etc., and pointed out that this instrument has a positive significance for the improvement of the quality of vocational education. Literature [18] systematically summarizes the paths and strategies of vocational education system reform, puts forward the idea of linkage and synergy between vocational education learning environment and students' learning motivation, and gives specific implementation measures and evaluation standards. Literature [19] analyzes the factors that significantly influence the development of ownership and the role played by ownership in the sustainable development activities of vocational education based on quality measurement methods and examples, and the study points out that a high degree of receivability, the participation of stakeholders in vocational education, as well as internal and external regulation of the process of sustainable development activities are related to the establishment of ownership.

Literature [20] followed the association between education and labor market and found that early educational differences can have a great impact on the future life and employment of students, so it is proposed to extend the time frame of education and reduce the impact of the curriculum on the differentiation of the students and try to reform and restructure the vocational education curricula and the pathways of vocational training in order to adapt to the dynamics of the changing labor market. Literature [21] used descriptive methods, questionnaires, and inferential statistical strategies to explore the status of vocational training in TVET institutions in Khartoum state and found that the quality of vocational education in the state is poor, while students' expectations of vocational education are very high, and emphasized the urgency of optimizing the local vocational education policy and financial support. Literature [22] used statistical methods to compare the differences in employment between general and vocational education students at different ages, verifying the phenomenon of trade-offs in social employment, i.e., the growth of employment in youth is offset by a decrease in the adaptability of social agents to employment due to technological development, and a decrease in the rate of employment in later life. Literature [23] describes the integration of distance education technologies and vocational education in the context of the epidemic to ensure the functioning of vocational education, but this also leads to reflections on the quality of vocational distance education, and evaluates electronic educational resources such as information technology, virtual reality technology, and other technologies. Literature [24] conducted a Higher Technical and Vocational Education and Training (HTVET) teaching and learning practice to explore how the Problem Based Learning (PBL) model impacts on students' academic performance, and the results of the study showed that PBL was effective in moderating HTVET and facilitating the improvement of students' academic performance. Literature [25] discusses the significance of vocational education for national construction and competitiveness, and analyzes the concept of vocational education, the importance of vocational education practitioners, etc., and puts forward some opinions on the construction of vocational education, including the guidance of vocational education policies, auxiliary funds for vocational education, and the design of reforms in vocational education curricula. Based on the results of qualitative analysis of the phenomenon of linkage and matching between vocational and technical education and industry in Indonesia, the literature [26] clarifies that strengthening the relevance of vocational and technical education to the job market, cognitive and adaptive abilities can help to improve the quality of employment for vocational education graduates.

In this paper, we design a path to improve the quality of vocational education based on the integration of science and education, and use hierarchical analysis, fuzzy comprehensive evaluation method and independent samples t-test to empirically analyze the implementation effect of the path. Firstly, the necessity of integrating science and technology with education is elaborated to introduce the new concept of “science and education integration”, and then the implementation path of science and education integration in vocational education is designed. Then, based on the implementation path, the quality evaluation index system of science and education integration in vocational education is constructed, and the weights of the indexes at each level are determined by using the hierarchical analysis method. Finally, based on the fuzzy comprehensive evaluation method, we evaluate the quality of science and education integration in H higher vocational colleges and universities that implement the path of this paper, and design a comparative test using the independent sample t-test to verify the effectiveness of the path of this paper.

2. Path of improving the quality of vocational education based on the integration of science and education

2.1. The need to integrate science and technology with education

The traditional model of vocational education is facing many challenges in today's world of accelerated knowledge updating and frequent technology iterations. The integration of science and technology with education can effectively solve the practical problems in vocational education and improve the quality and effect of education through the introduction of new technologies, new methods and new ideas.

2.2. New Paths for High-Quality Development of Vocational Education

The deep integration of science and technology and education, science and technology-enabled educational change is the general trend. The new concepts and ideas of science and education integration will certainly promote and facilitate the convergence and deep integration of the education chain, talent chain and industrial chain, innovation chain, and bring together the resources of industry, education and research to open up new fields and new paths for the high-quality development of vocational education.

Therefore, this paper designs a vocational education quality improvement path based on the integration of science and education, through the integration of scientific and technological and educational resources, breaking down the barriers between the scientific and technological community and the vocational education community, promoting the cross-fertilization of the two systems, bringing together the power of scientific and technological innovation and the power of educating people, and empowering the economic and social high-quality development by improving the quality of vocational education and innovative personnel training.

2.3. Implementation Path of Science and Education Integration in Vocational Education

2.3.1. Establishment of the concept of running schools by integrating science and education. In the process of promoting the integration of science and education, it is necessary to change the traditional concept of “teaching as the mainstay” and set up the philosophy of “promoting teaching with science, bringing education with science, and integrating science and education”. Scientific research should be used as a leader to promote education and teaching reform and innovation. Supported by scientific research, improve the quality of talent training. Driven by scientific research to enhance the ability to serve economic and social development.

2.3.2. Building a platform for scientific and educational integration and utilizing synergistic functions. The practical nature of scientific research is extremely strong, and the complexity of scientific and educational integration is also increased by the nature of multiple subjects. For this reason, it is necessary to build a comprehensive platform for science and education integration that integrates scientific research cooperation, resource sharing and results transformation, provides a practical base for vocational schools, research institutes and industrial enterprises to jointly develop scientific and technological innovation projects, and promotes the synergy of “schools, government, industry and enterprises” in scientific research, so as to realize the integration of scientific research resources of all kinds of subjects.

Through the platform, vocational schools can establish close cooperative relationships with enterprises and research institutes to jointly carry out scientific research projects and share technologies and resources. Research institutes, on the other hand, can transform the latest scientific research results into practical applications through the platform, promoting the integration of industry, academia, research and utilization. Meanwhile, enterprises can also obtain technical support and talent reserves through the platform to enhance their competitiveness.

2.3.3. Strengthening institutional innovation and building educational models:

1) Establishment of a mechanism for multi-participation among government, schools, industry, enterprises and research institutes. In order to deepen the integration of science and education, vocational colleges and universities should carry out comprehensive cooperation with the government, enterprises, industry associations and scientific research institutions. This includes the formation of interdisciplinary and cross-field scientific research teams to jointly overcome key technical problems and ensure that scientific research activities are closely integrated with teaching activities, thus improving the educational effect of scientific research. In addition, it is also necessary to improve the scientific research evaluation system, and regard the results of collaborative innovation as an important evaluation index, so as to further incentivize teachers and students to actively participate in scientific and technological innovation and technological research and development.

2) Strengthen the status of popularization of science and promote science education. Popularization of science should be included in the long-term development plan of the school. To this end, schools can set up additional popular science courses to popularize scientific knowledge and spread the spirit of science. At the same time, the potential value of popularization of science should be explored in order to cultivate students' sense of innovation and scientific literacy. In addition, the integration and sharing of popular science resources should be strengthened, so that popular science education can be closely integrated with specialized courses and daily teaching.

3) Utilizing the advantage of accumulation of technical skills to promote the integration of science and education. Vocational education has significant advantages in the accumulation of technical skills, which should be fully utilized to promote the transformation of scientific and technological achievements into teaching programs and teaching materials. For example, teachers can integrate the latest scientific research achievements into classroom teaching, so that students can have timely access to cutting-edge technologies and practical applications in related fields. At the same time, schools can also strengthen the synergistic cooperation between scientific and technological research and development projects, popularization of science activities and teaching innovation projects, so as to realize the mutual promotion and coordinated development of all parties.

4) Enhancing teachers' scientific research and practical teaching ability. In order to deepen the education model of integrating science and education, teachers should continuously strengthen their scientific research and practical teaching abilities. Schools can encourage teachers to actively participate in scientific research projects and practical activities, accumulate experience through practical operation, and improve their comprehensive quality and teaching level.

5) Development of teaching materials in accordance with practical needs and the frontier of the discipline. The development of teaching materials should be combined with practical needs and the frontier of the discipline to ensure that they are both practical and relevant. At the same time, the teaching materials should also introduce modern teaching methods and means to improve the teaching effect and quality.

6) Emphasize the cultivation of students' practical and innovative abilities. In terms of educational methods, it is necessary to emphasize the training of students' hands-on and creativity. For example, case study, group discussion, role play and other ways to enhance students' enthusiasm for learning.

2.3.4. Building a diversified approach to quality assessment. It is necessary to reform the evaluation system, incorporate the performance of science and education integration into the evaluation system of schooling and teaching, and construct a diversified quality evaluation method to comprehensively reflect the quality of teaching and the level of scientific research in vocational schools, so as to effectively guide and incentivize vocational schools to actively participate in the work of science and education integration, and to promote the improvement of the quality of vocational education.

This kind of diversified evaluation needs to be considered from various aspects, such as discipline construction, integration of industry-university-research, employment of graduates, social service level and international exchange.

1) Discipline construction. It should focus on evaluating the fit between teaching and research and the comprehensive competitiveness of disciplines, paying attention to the quality and level of discipline leaders, research teams and research achievements.

2) Industry-university-research integration. Attention needs to be paid to the management efficiency of the cooperative projects, the effect of cooperation, the utilization rate of resources, the academic contribution of research results and the impact on social development, etc. Vocational schools are encouraged to carry out in-depth cooperation with enterprises to jointly promote scientific and technological innovation and talent cultivation.

3) Employment of graduates. Attention should be paid to the employment rate of professional counterparts, the fitness of occupational positions and employment satisfaction, etc., and the tracking survey of graduates and analysis of employment data should be strengthened to provide reference for the optimization of talent training programs.

4) Social services. It is necessary to evaluate the level of professional skill service and social influence, and encourage vocational schools to utilize their own advantages to provide technical support, vocational training and other services for the society.

5) International Exchange. Attention should be paid to teachers' and students' overseas study, internships and exchanges, as well as the school's international reputation and influence, etc., so as to strengthen exchanges and cooperation with international advanced vocational schools and enhance the international competitiveness of vocational education.

3. Evaluation model of the quality improvement path of vocational education

3.1. Hierarchical Analysis

Hierarchical analysis method (AHP) is a reasonable indicator system established by analyzing and organizing all the influencing factors of the object under study, and then determining the importance of each category as well as the importance of each indicator within the category through expert scoring, on the basis of which the corresponding judgment matrix is established, and calculating the weight of each indicator on the basis of the judgment matrix obtained, and based on the results of the calculated weights, determining the influence factors of the implementation effect of the integration path in vocational factors influencing the implementation effect of the science and education integration path of education [27].

The steps of the hierarchical analysis method are as follows:

1) Establish a hierarchical model, determine the overall goal of vocational education science and education integration according to the problem under study, and list, analyze and stratify the relevant factors affecting the overall goal to form a hierarchical model.

2) Determine the judgment matrix based on the results of expert scoring:

$$A=\begin{bmatrix} a_{11} & a_{12} & \cdots & \cdots & a_{1n} \\ a_{21} & a_{22} & \cdots & \cdots & a_{2n} \\ \cdots & \cdots & a_{ij} & \cdots & \cdots \\ \cdots & \cdots & \cdots & \cdots & \cdots \\ a_{n1} & a_{n2} & \cdots & \cdots & a_{nn} \end{bmatrix} \tag{1}$$

3) Matrix element importance judgment. When the scale of a_{ij} is 1, 3, 5, 7, and 9, it indicates that A_i is equally important, slightly important, significantly important, strongly important, and extremely important relative to A_j, respectively. When the scale is 2, 4, 6, and 8, it indicates the middle value of the importance judgment of two neighboring factors.

4) Calculate the weight vector of indicators:

Step 1: Formalize the matrix by using the following formula:

$$\overline{a_{ij}} = \frac{a_{ij}}{\sum_{i=1}^{n} a_{ij}} (i, j = 1, 2, \cdots n) \tag{2}$$

Step 2: Add the elements of the matrix:

$$\overline{w_i} = \sum_{j=1}^{n} \overline{a_{ij}} (i, j = 1, 2, \cdots n) \tag{3}$$

Step 3: For $\overline{w_i}$ in the above equation, implement regularization:

$$w_i = \frac{\overline{w_i}}{\sum_{i=1}^{n} \overline{w_i}} (i = 1, 2, \cdots n) \tag{4}$$

Step 4: Calculate the maximum eigenvalue of judgment matrix A:

$$\lambda_{\max} = \frac{1}{n} \sum_{i=1}^{n} \frac{(Aw)_i}{w_i} \tag{5}$$

5) Consistency test, assuming that CI stands for consistency index, the following is the arithmetic method [28]:

$$CI = \frac{\lambda_{\max} - n}{n - 1} \tag{6}$$

The RI values are 0, 0, 0.52, 0.89, 1.12, 1.26, 1.36, 1.41, 1.46, 1.49, and 1.52 when the matrix order n is from 1 to 11, respectively. The test is achieved when CR < 0.1.

3.2. Fuzzy integrated evaluation method

The specific operational steps are as follows [29]:

1) Establish the evaluation factor set of fuzzy comprehensive evaluation U. U is the set consisting of factors affecting the object of evaluation. $U = \{u_1, u_2, \ldots, u_m\}$.

2) Create a rubric set for comprehensive evaluation V. A rubric set is a collection of the various possible evaluation results that an evaluator can make on an evaluation object. $V = \{v_1, v_2, \ldots, v_n\}$.

3) Establishment of a fuzzy comprehensive evaluation matrix R. The evaluation result according to U_i can be expressed as a fuzzy set:

$$R_i = (r_{i1}, r_{i2}, \ldots, r_{im}) \tag{7}$$

After the single-factor fuzzy evaluation, a total evaluation matrix is constructed by utilizing the same principle to evaluate all factors separately:

$$R = \begin{bmatrix} r_{11} & r_{12} & \cdots & r_{1n} \\ r_{21} & r_{22} & \cdots & r_{2n} \\ \vdots & \vdots & \ddots & \vdots \\ r_{m1} & r_{m2} & \cdots & r_{mn} \end{bmatrix} \tag{8}$$

Where $r_{ij} (i = 1, 2, \ldots, m; j = 1, 2, \ldots, n)$ indicates the degree of possibility of making the j rd comment on the subject of evaluation from the perspective of the i nd factor.

4) Determine the weight vector of the evaluation factors. In order to reflect the importance of each

factor, each factor U should be assigned a corresponding weight $w_i(i=1,2,\ldots,m)$ to indicate the weight of the i rd factor, which is usually required w_i to satisfy $w_i \geq 0, \Sigma w_i = 1$, and then the weights are composed of the weight set W. In this paper, the hierarchical analysis method is used to determine the weight coefficients.

5) Establish fuzzy comprehensive evaluation model. The model of fuzzy comprehensive evaluation is [30]:

$$C = W \times R = (w_1, w_2, \ldots, w_m)\begin{bmatrix} r_{11} & r_{12} & \cdots & r_{1n} \\ r_{21} & r_{22} & \cdots & r_{2n} \\ \vdots & \vdots & \ddots & \vdots \\ r_{m1} & r_{m2} & \cdots & r_{mn} \end{bmatrix} = (c_1, c_2, \ldots, c_n) \tag{9}$$

6) Derive fuzzy comprehensive evaluation results

$$A = \frac{\sum_{j=1}^{n} b_j^2 \cdot j}{\sum_{j=1}^{n} b_j^2} \tag{10}$$

4. Analysis of model applications

4.1. Evaluation of the effectiveness of pathway implementation

4.1.1. Construction of the evaluation indicator system. Based on the diversified vocational education quality evaluation approach in the previous section, this paper obtains the initial index system for the quality evaluation of vocational education science and education integration, and then utilizes the Delphi method to conduct 2 rounds of expert consultation. In the first round, 40 questionnaires were sent out and 35 valid questionnaires were recovered, with an effective recovery rate of 87.5%. In the second round, 35 questionnaires were sent out and 32 valid questionnaires were recovered, with an effective recovery rate of 91.4%.

The positive coefficient of experts in the first round was 0.85, with 21 suggestions from 14 experts. The positive coefficient of experts in the second round was 0.93, and a total of 5 experts put forward 8 suggestions. Both rounds of expert positivity coefficients were >0.7, indicating that the experts in this study were highly motivated.

The Cs of this study ranged from 0.85 to 1.00, with a mean of 0.93. The Cr ranged from 0.92 to 1.00, with a mean of 0.94, which means that the overall authority coefficient of the expert advice is 0.94, which is greater than 0.7 and acceptable.

The degree of harmonization of expert advice in the first and second rounds is shown in Table 1. Where w denotes the Kendall harmony coefficient. As can be seen from Table 1, the Kendall harmony coefficients of the indicators at all levels in the 1st and 2nd rounds are 0.273 and 0.324 respectively, with significance P-values of 0.001 and 0.000 respectively, which are less than 0.05, and the differences are statistically significant. It indicates that the harmonization of the opinions of the consulting experts in both rounds is acceptable.

Table 1. The degree of coordination of expert advice

Project		w	x2	df	P
First round	Primary indicator	0.125	8.941	5	0.000
	Secondary indicator	0.391	193.245	24	0.002
	Overall	0.273	209.674	29	0.001
Second round	Primary indicator	0.163	12.163	5	0.000
	Secondary indicator	0.437	189.752	23	0.001
	Overall	0.324	228.346	28	0.000

The initial indicators were revised according to 2 rounds of experts' opinions, and the final evaluation index system of the quality of science and education integration in vocational education was obtained, which was divided into the target layer, the criterion layer and the indicator layer. The target layer is the quality of science and education integration in vocational education (A). The criterion layer includes discipline construction (A1), industry-university-research integration (A2), graduate employment (A3), social service level (A4) and international exchange (A5). The indicator layer includes faculty construction (A11), specialty and curriculum construction (A12), research team construction (A13), science and education integration platform construction (A21), training base construction (A22), practical guidance from industry and enterprises (A23), collaborative cooperation in scientific research projects (A24), transformation rate of project research results (A25), employment rate of professional counterparts (A31), fitness of occupational positions (A32), Employment Satisfaction (A33), Invention Patent Authorization (A41), Vocational Training (A42), Technical Service Satisfaction (A43), International Visibility (A51), International Research Project Cooperation (A52), and International Co-operation in Running Schools (A53), totaling 17 indicators.

4.1.2. Determination of indicator weights. In this paper, using the hierarchical analysis method, based on the results of the experts' assignment of the relative importance of the relationship between the indicators, the judgment matrix of each level is obtained as shown below:

$$A=\begin{bmatrix}1 & 3/2 & 5/4 & 1/2 & 4/3\\ 2/3 & 1 & 5/3 & 1 & 9/5\\ 4/5 & 3/5 & 1 & 8/7 & 8/5\\ 2 & 1 & 7/8 & 1 & 8/9\\ 3/4 & 5/9 & 5/8 & 9/8 & 1\end{bmatrix},\quad A_1=\begin{bmatrix}1 & 5/4 & 5/7\\ 4/5 & 1 & 2/5\\ 7/5 & 5/2 & 1\end{bmatrix},\quad A_2=\begin{bmatrix}1 & 1/2 & 4/5 & 1/2 & 9/5\\ 2 & 1 & 3/5 & 5/8 & 4/5\\ 5/4 & 5/3 & 1 & 3/5 & 5/7\\ 2 & 8/5 & 5/3 & 1 & 4/7\\ 5/9 & 5/4 & 7/5 & 7/4 & 1\end{bmatrix},$$

$$A_3=\begin{bmatrix}1 & 2/3 & 4/3\\ 3/2 & 1 & 5/6\\ 3/4 & 6/5 & 1\end{bmatrix},\quad A_4=\begin{bmatrix}1 & 5/8 & 1/2\\ 8/5 & 1 & 6/5\\ 2 & 5/6 & 1\end{bmatrix},\quad A_5=\begin{bmatrix}1 & 1/3 & 1/2\\ 3 & 1 & 1\\ 2 & 1 & 1\end{bmatrix}.$$

The maximum eigenvalue λmax and the consistency ratio CR of the judgment matrix are calculated using MATLAB software.The results are shown in Table 2.

As shown in Table 2, the λmax values of A, A1, A2, A3, A4, and A5 are 5.2504, 3.0142, 5.4266, 3.0857, 3.0183, and 3.0183, respectively. The CR values calculated from the λmax values are 0.0559, 0.0137, 0.0953, 0.0824, 0.0177, respectively, 0.0177, all of which are less than 0.1, in accordance with the consistency test.

Table 2. Calculation result

	W	λmax	CI	RI	CR
A	[0.2124,0.2391,0.1880,0.2091,0.1514]T	5.2504	0.0626	1.12	0.0559
A1	[0.3045,0.2166,0.4789]T	3.0142	0.0071	0.52	0.0137
A2	[0.1713,0.1747,0.1848,0.2410,0.2282]T	5.4266	0.1067	1.12	0.0953
A3	[0.3204,0.3579,0.3217]T	3.0857	0.0428	0.52	0.0824
A4	[0.2189,0.3997,0.3814]T	3.0183	0.0092	0.52	0.0177
A5	[0.1698,0.4429,0.3873]T	3.0183	0.0092	0.52	0.0177

Calculating the weights of each index from the judgment matrix, the weights of vocational education science and education integration quality evaluation index system are shown in Table 3.

As shown in Table 3, the ratio of the five guideline layers of discipline construction, combination of industry-university-research, employment of graduates, social service level and international exchange are 21.24%, 23.91%, 18.80%, 20.91% and 15.14% respectively. Among them, the ratio of the combination of industry-university-research is higher, indicating that the combination of industry-university-research is particularly important in the quality improvement path of vocational education. In the indicator layer, the one with the largest weight is the construction of scientific research teams in vocational colleges, which needs to be focused on when implementing the integration of science and education in vocational education.

Table 3. The weight of the evaluation index system

Target layer	Criterion layer	Weight	Index layer	Weight	Composite weight
A	A1	0.2124	A11	0.3045	0.0647
			A12	0.2166	0.0460
			A13	0.4789	0.1017
	A2	0.2391	A21	0.1713	0.0409
			A22	0.1747	0.0418
			A23	0.1848	0.0442
			A24	0.2410	0.0576
			A25	0.2282	0.0546
	A3	0.1880	A31	0.3204	0.0602
			A32	0.3579	0.0673
			A33	0.3217	0.0605
	A4	0.2091	A41	0.2189	0.0458
			A41	0.3997	0.0836
			A43	0.3814	0.0797
	A5	0.1514	A51	0.1698	0.0257
			A52	0.4429	0.0671
			A53	0.3873	0.0586

4.1.3. Analysis of evaluation results. First of all, five level rubrics are set for each indicator, i.e., V=[V1, V2, V3, V4, V5]=[very good, good, average, poor, very poor] and assigned the value of V=[100, 80, 60, 40, 20], and the value system of the indicator is evaluated by experienced personnel, and 40 experts are invited to individually conduct a comprehensive evaluation of the importance of each indicator. Due to the fuzzy nature of the indicator, the number of times the experts scored the indicator was synthesized, and the weight of the rating level of the rubric in favor of the indicator was taken as the degree of affiliation to establish a single-factor comprehensive judgment matrix. The fuzzy evaluation of the quality of science and education integration in vocational education is shown in Table 4.

Table 4. Fuzzy evaluation of the quality of the vocational education

Target layer	Criterion layer	Index layer	V1	V2	V3	V4	V5
A	A1(0.2124)	A11(0.3045)	0.75	0.25	0	0	0
		A12(0.2166)	0.65	0.20	0.15	0	0
		A13(0.4789)	0.55	0.35	0.10	0	0
	A2(0.2391)	A21(0.1713)	0.50	0.25	0.15	0.10	0
		A22(0.1747)	0.45	0.25	0.15	0.15	0
		A23(0.1848)	0.55	0.20	0.20	0.05	0
		A24(0.2410)	0.45	0.35	0.10	0.05	0.05
		A25(0.2282)	0.40	0.40	0.10	0.05	0.05
	A3(0.1880)	A31(0.3204)	0.65	0.25	0.05	0.05	0
		A32(0.3579)	0.45	0.35	0.15	0.05	0
		A33(0.3217)	0.60	0.25	0.10	0.05	0
	A4(0.2091)	A41(0.2189)	0.55	0.45	0	0	0
		A41(0.3997)	0.35	0.35	0.20	0.05	0.05
		A43(0.3814)	0.40	0.30	0.20	0.10	0
	A5(0.1514)	A51(0.1698)	0.55	0.35	0.10	0	0
		A52(0.4429)	0.35	0.30	0.25	0.05	0.05
		A53(0.3873)	0.45	0.25	0.20	0.10	0

According to Table 4, the weights of the three evaluation indexes included in "discipline construction" are W1=[0.3045,0.2166,0.4789], and R1 is its quality evaluation matrix, which leads to the evaluation vector C1 of "discipline construction":

$$C_1 = W_1 \cdot R_1$$

$$= [0.3045, 0.2166, 0.4789] \circ \begin{bmatrix} 0.75 & 0.25 & 0 & 0 & 0 \\ 0.65 & 0.20 & 0.15 & 0 & 0 \\ 0.55 & 0.35 & 0.10 & 0 & 0 \end{bmatrix} = (0.6325, 0.2871, 0.0804, 0, 0)$$

Similarly, the evaluation vector C2 of "industry-university-research integration" can be obtained as:

$$C_2 = W_2 \cdot R_2 = (0.4656, 0.2991, 0.1358, 0.0760, 0.0235)$$

The evaluation vector C3 for "Employment of graduates" is:

$$C_3 = W_3 \cdot R_3 = (0.5623, 0.2858, 0.1019, 0.05, 0)$$

The evaluation vector C4 for "level of social services" is:

$$C_4 = W_4 \cdot R_4 = (0.4129, 0.3528, 0.1562, 0.0581, 0.02)$$

The evaluation vector C5 for the "international exchange situation" is:

$$C_5 = W_5 \cdot R_5 = (0.4227, 0.2891, 0.2052, 0.0609, 0.0221)$$

The overall evaluation vector is:

$$C = W \cdot C_i = (0.2124, 0.2391, 0.1880, 0.2091, 0.1514) \circ \begin{pmatrix} C_1 \\ C_2 \\ C_3 \\ C_4 \\ C_5 \end{pmatrix}$$

$$= (0.5017, 0.3038, 0.1324, 0.0489, 0.0132)$$

Quantifying the above results makes the evaluation results more intuitive. On a percentage basis, assigning the grades in the rubric set V={very good, good, fair, poor, very poor} as V={100, 80, 60, 40, 20}, the overall rating value is:

$$F = V \cdot C^T = [100 \quad 80 \quad 60 \quad 40 \quad 20] \circ \begin{pmatrix} 0.5017 \\ 0.3038 \\ 0.1324 \\ 0.0489 \\ 0.0132 \end{pmatrix} = 84.638$$

Then the overall rating value of the quality of science and education integration in H higher vocational colleges and universities is 84.638, which is between good and very good, i.e. the quality of science and education integration is at a high level.

4.2. Comparative Experiments on the Effectiveness of Pathway Implementation

This paper selects two higher vocational colleges and universities of the same level to conduct a comparative test. The experimental group uses the educational model of the path of this paper, and the control group uses the traditional educational model. Before the experiment, using the constructed index system, the two higher vocational colleges and universities were respectively evaluated on the quality of science and education integration, and the evaluation results were subjected to the independent sample T-test, the P-value of each level of indicators and comprehensive evaluation scores are less than 0.05, there is no significant difference, i.e., the two higher vocational colleges and universities are at the same level of quality, and the sample selection is reasonable.

The data statistics software SPSS was used to process the sample data, and the software was used to test the hypothesis of whether there is a difference in the comprehensive evaluation scores of the quality of science, education and integration of independent samples, and to make comprehensive judgments and interpretations based on the results of the Levene test of the chi-square test and the results of the t-test of the independent samples. The results of the t-test are shown in Table 5.

From Table 5, the value of F-statistic is 0.421 and the p-value (Sig.) at the level of significance is 0.489>0.1. Therefore, the assumption of equal variance cannot be denied and the results of the t-test in the first row should be referred to. The two-sided Sig value of the T-test in the first row is 0.000<0.05, which indicates that there is a significant difference between the quality evaluation scores of higher vocational colleges and universities using the path of this paper on science and education fusion and those using the traditional education model on science and education fusion. This shows the practicality of this paper's path to improve the quality of vocational education based on the integration of science and education

Table 5. Test results before the experiment

Levene test						The average T test is equal to				
		F	Sig.	T	df	Sig.(two-tailed)	Mean difference	Standard error	95% confidence interval	
									Lower limit	Upper limit
Evaluation score	Equal variance			-7.842	17	0.000	-7.824	0.984	-9.154	-4.753
	Unequal variance	0.421	0.489	-7.735	14.626	0.000	-7.824	0.999	-9.235	-4.714

5. Conclusion

This paper realizes the design of vocational education quality improvement path based on the integration of science and education, and analyzes the implementation effect of the path using hierarchical analysis method, fuzzy comprehensive evaluation method, and independent sample t-test.

In the quality evaluation index system of science and education integration constructed, the weights of the five guideline layers of discipline construction, industry-university-research integration, graduates' employment, social service level and international exchanges are 21.24%, 23.91%, 18.80%, 20.91% and 15.14%, respectively. Among them, the ratio of the combination of industry-university-research is higher, indicating that the combination of industry-university-research is particularly important in the quality improvement path of vocational education. In the indicator layer, the most weighted is the construction of scientific research team in vocational colleges, thus it needs to be focused on in the implementation of the integration of science and education in vocational education.

Based on the fuzzy comprehensive evaluation method, the overall rating of the quality of science and education integration of H higher vocational colleges implementing the path of this paper is 84.638, and the overall level of the quality of science and education integration is high, between good and very good. It shows that the implementation path of science and education integration designed in this paper has a better effect on improving the quality of vocational education.

The two higher vocational colleges and universities that respectively use the path of this paper and the traditional education model are selected to conduct a comparative test, and using the independent samples t-test, the p-value of their science and education integration quality evaluation scores is obtained to be 0.000, which is less than 0.05, so there is a significant difference. This shows the effectiveness of the vocational education quality improvement path based on science and education integration in this paper.

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