ingegneria sismica
International Journal of Earthquake Engineering
Anno XLIII - Num. 1 - 2026

Practice Path of Innovation and Entrepreneurship Education Mode in Colleges and Universities Based on the Concept of Integration of Industry and Education

Yan Xie[1], *Zhiping Li*[2,*] *and Chunxiang Fan*[3]

[1] School of Finance and Business, Jiangxi College of Applied Technology, Ganzhou, Jiangxi, 341000, China
[2] Vocational Skills Center, Jiangxi College of Applied Technology, Ganzhou, Jiangxi, 341000, China
[3] College of Mechanical and Electronic Engineering, Jiangxi College of Applied Technology, Ganzhou, Jiangxi, 341000, China

SUMMARY: *China has been experiencing a constant improvement in its economic structure and industrial structure with an upward trend in demand on innovative and specialized talents. This leads to greater demands on innovation and entrepreneurship education. In light of the inevitability of the integrated approach of industries and education to train talents, the present paper develops the model of talent training of innovation and entrepreneurship, which embodies the concept of the integration of industries and education. In line with the CIPP assessment model, index system is developed to assess the quality of innovation and entrepreneurship education. The weight of each index is calculated based on the entropy weight method and the cloud model is applied to assess the quality of innovation and entrepreneurship education in colleges and universities overall. The subjects of the teaching experiment were undergraduate students who majored in civil engineering. The findings indicated that the experimental group scored 62.16 + 3.59 points in terms of innovation and entrepreneurship awareness, which was 76.49 percent higher than the control (blank) group and the difference between the two groups was significant (P < 0.05). Based on the cloud model, the evaluation grade of the quality of innovation and entrepreneurship education in higher education is defined as good. It implies that we should enhance the curriculum system as well as increase teaching staff and distribute the available resources properly to achieve the best possible implementation of the concept of industry-education in higher education on the aspect of innovation and entrepreneurship education in colleges and universities.*

KEYWORDS: *entropy power method; cloud model; industry-teaching integration concept; innovation and entrepreneurship education*

1 Introduction

Education in innovation and entrepreneurship is one of the critical components of higher education and has a significant share in the development of an innovative attitude and entrepreneurial competencies of students [1]. The last several decades have seen much attention given to innovation and entrepreneurship education in China where numerous efforts are made to advance reforms and advancements in higher education institutions. However, there are a

*xy15979704617@126.com
https://doi.org/10.65102/is2026165
Published: 30 April, 2026

number of practical issues related to the implementation of innovation and entrepreneurship education, such as the mismatch between educational materials and market needs [2], the absence of sufficient practice-oriented instruction in the area of innovation and entrepreneurship education [3], and the lack of adequate depth in school-industry partnerships [4]. Each of them has become significant barriers on the way to enhancing innovation and entrepreneurship education in higher education institutions [5]. One of the promising models of solving all the current issues of innovation and entrepreneurship education is industry-education integration, which can be successfully implemented with the help of the establishment of synergy in the education chain, talent chain, industrial chain, and innovation chain [6, 7].

In recent years, scholars at home and abroad have conducted extensive research on the integration of industry and education. For example, Alshehri, A et al [8] argued that the integration of industry and education is an effective way to promote the cultivation of talents in institutions, the enhancement of the workforce in enterprises, the transformation of technological achievements, cooperative scientific research and the promotion of entrepreneurial practices. Gibson, E et al. [9] described the TAFE college industry-teaching integration model, which has a synergistic layout with the local industry clusters, modularized curriculum system, flexible restructuring in quick response to the industry changes, the students are mainly employed, the training takes into account the different skill levels, and the credits are awarded with vocational qualification certificates, which can be used to seek employment in the corresponding industries, and continuously delivering the appropriate workforce for the various industries in Australia. Fernandes, G et al [10] stated that school-industry collaboration is a powerful tool that can improve the competitiveness of the country as it is advocated and implemented by the government, which actively encourages collaboration between schools and business-industry so as to improve the competitiveness of the country and realize the innovation of the country's industry. Li, Y et al [11] showed that after entering the 21st century, with the rapid development of science and technology and the acceleration of the process of economic globalization, the evaluation of the integration of industry and education has entered into a new stage, and the research focuses more on the symbiotic system of the integration of industry and education, in which the contract, the transaction cost, the definition of the property right, the behavior of cooperation and the stability of the ecosystem internally are the key elements. Borges, P et al [12] identified the integration of industry and education as an important tool to promote the creation of human capital, knowledge and technology transfer, and thus increase the capacity of economic innovation within the region, which can help students to improve their skill levels and bridge the skill gaps during practical exercises.

As the core of vocational education, the German “dual system” teaching model is widely recognized worldwide for its scientific and advanced nature. This model emphasizes the combination of theory and practice, and students receive systematic cultural and theoretical teaching as well as sufficient practical training. Deissinger, T and Gonon, P [13] pointed out that in the "dual system" model, the school "unyuan" is responsible for teaching theoretical knowledge and cultivating students' comprehensive abilities, while the enterprise "unyuan" provides guidance for apprentices' professional skills and practical operations. The two sides of industry and education are deeply integrated to jointly cultivate high-quality skilled talents. Gessler, M [14] investigated the cooperation between enterprises and schools under the dual system in Germany through the empirical research method and found that although the macro level German dual system showed a high degree of institutionalized cooperation, at the meso level, the cooperation between enterprises and vocational colleges and universities was not deep enough, and the willingness of enterprises to cooperate was low. Meissner, D and Shmatko, N [15] proposed in their research that in Europe and North America, policies such as knowledge transfer and knowledge innovation have a great relationship with government support to promote UICs (University-industry collaborations), and the government, as the main body of system supply for industry-industry fusion, establishes a special development fund through the establishment of a special development fund, Improvement of financial subsidy policy and tax incentive mechanism to build a public service system to support collaborative education.

The interest of stakeholders in the coordination of the relationship between vocational colleges, universities, and industries and enterprises is a new research paradigm of innovative coordination mechanisms for industry-university cooperation [16]. For example, Wright, M et al [17] used a case study method to develop a staged industry-education integration model, in which they argued that universities need to adopt a joint research and development model in the technological invention phase; the commissioned development model when technologies enter the marketization stage; and the technology consultation model in the diffusion phase of technologies. Ahmed, F et al [18] identified some problems caused by inconsistent goals, a lack of talent supply-demand balance, weak trust, and poor communication in the process of industrial-university collaboration. Based on their findings, they designed a cooperation program model between academics and industry that covered the processes, methods or approaches, and instruments for identifying activities that different participants can do in each phase of the integration process. In so doing, they would help to minimize the complexity of organizational collaboration in university-industry cooperation. The findings of Mohmood, H and Tamyez, P [19], based on a case study analysis, revealed that universities and industries used conventional, bidirectional, business, services, and diversified communication and interaction channels. Also, diverse interaction channels were more reflective of university capabilities and enabled the participation of firms in industry-education integration.

The integration of industry and education includes cross-border collaborations amongst different institutions, where the methods used by scholars to study the factors that influence integration differ. Berghe, L and Guild, P [20] devised an innovative performance assessment approach to university-industry collaboration based on the opinions of 32 stakeholders. This assessment tool uses the concepts of inputs and outputs associated with the transformation process in order to measure the general performance of university-industry collaboration. Çabiri, K. M and Qosja, E [21] analyzed the integration of industry and education in Albania and found out that the formal and legal barriers defined in the Law on Higher Education limit university-enterprise cooperation to some extent. Moreover, lack of industry funding to promote academic research along with outdated university management models act as deterrents in integrating industry and academia. In their case study analysis, Schmidt, T et al [22] found that regulatory and policy pressures force vocational education and training (VET) practitioners to combine their role as a full-time teacher with continuous updating of industrial-related knowledge and competencies; nevertheless, it is extremely difficult to translate the theoretical idea into action. Hence, the gap between policy and practice becomes a bottleneck that prevents teachers from engaging with enterprises in vocational colleges/universities. Partial Least Squares Structural Equation Modeling (PLS-SEM) was employed by Ćudić, B et al [23] to empirically research the elements that influence the integration of education and industry in European countries discovering that institutional, human, linkage, and framing factors were the four most significant factors that impact the effectiveness of the integration between education and industry.

The current research develops an innovative talent cultivation model, which is a combination of industry-education collaboration and innovation-entrepreneurship synergy. The present paper will subsequently assess the effectiveness of such an innovative model of talent cultivation through the use of comparative experiment in teaching practice and educational quality of innovations and entrepreneurship offered in higher education institutions through the application of entropy weighted cloud model. Therefore, it can be seen that this paper suggests more tight cooperation between industries and education with education about innovation and entrepreneurship in institutions of higher learning, aligning the cultivation of talents to the needs of industrial development, so as to enhance the overall process of talent cultivation in innovation and entrepreneurship.

2 Design of innovation and entrepreneurship education models in higher education

The study proposes a talent development system based on the industrial-education integration and innovative conceptualized coordinated growth. The study later performs a teaching comparative experiment to evaluate the effectiveness of the talent cultivation framework and also uses the entropy weighted cloud model to evaluate the quality of innovation and entrepreneurship education in colleges and universities. As it is shown by the results, through the encouragement of the tie between industry-education integration and the education of innovation and entrepreneurship, colleges and universities will be capable of making talent cultivation more appropriate to the needs of the industrial development, develop an integrated approach to cultivating innovation and entrepreneurship talents, and offer strong backing to mass entrepreneurship and innovation.

2.1 The basic connotation of the concept of integration of industry and education

The theory of the industry-education integration holds that the nature of man cannot be abstracted from him because he actually represents all the social relations together. In its theoretical framework, the focus should be on the interpenetration and complementary development of education and industry, integration and rational allocation of resources. In the methodological aspect, the research mainly uses the theory-practice integrated, qualitative-quantitative combined, and comparative method.

(1) Education and industry are intertwined and reinforce each other in their development, representing a two-way link between education and industry. On the one hand, education can provide high-level human resources for industrial development; on the other hand, education can provide technological capabilities and skills necessary for furthering the development of industries. On the contrary, industry offers rich material resources for promoting the development of education; hence, the integration of education and industry becomes possible.

(2) Resource optimization and allocation, as well as resource integration, are the integrations of education and industry. In this case, the key to such integration is optimizing the resources common to both education and industry. In the process of developing talent, the job requirements of industries are included in education; subsequently, through continuous improvement of teaching and learning content, an optimal allocation of resources between education and industry is realized.

(3) Constructing a collaborative education mode is another way to integrate education and industry. In this regard, the key factor is creating a cooperative education system. To achieve this goal, relevant resources of industries are integrated into the education system, and innovative talents are nurtured through cooperation between education and industry.

2.2 The Importance of Talent Cultivation through Industry-Education Integration

Industry-education integration represents the partnership between the two sectors of higher learning institutions and industries that aim at developing professionals together. Industry-education integration reflects a modern pathway in the process of modern education development and has significant implications for the progress of society, economy, university learning, and company development. To be more specific:

In terms of social and economic development, the development and dissemination of the innovation and entrepreneurship talent cultivation model based on industry and education are tightly bound up with the existing social and economic environment. Currently, the social situation stands at a crucial point where economic development transforms and upgrades and at which a strong need for "dual venture" personnel arises, who can demonstrate courage, boldness, and innovativeness. With economic development at this new stage, industry and education integration can greatly contribute to the growth of regional economy, increase industrial competitiveness, and promote industrial transformation and upgrading.

In terms of corporate development, corporate development is contingent upon the existence of competent technical personnel, and it falls within the realm of higher education institutions to nurture professional practitioners to foster societal development. Collaboration between industry and academia will serve as an effective mechanism to link corporations and educational institutions, thus fostering growth within both fields.

According to the developmental aspect of the higher education, the integration of industries and education is one of the key mechanisms that can guarantee the effective communication between the students of university and companies. The given type of combination is a guiding principle of developing talents that contributes to the enhancement of the quality of talent development. On top of providing the students with the theory of professions, local colleges and universities should also take their students through necessary training, which will enable them to have enough experience of working in an enterprise.

2.3 Talent Training Model for Innovation and Entrepreneurship

The nurturing of innovative and entrepreneurial skills is a multiple dimension and multiple level process. Not only does it involve fostering of creative thoughts and innovation approaches but also nurturing of operational skills. Taking the idea of industry-education integration as a basis, this paper has suggested a model to nurture innovation and entrepreneurship skills. The diagram in figure 1 below shows such a model. In the figure, the yellow color represents the core level of the model, the purple color represents the operational level while the blue color represents the participating level. By following the model in which training is led by university professors within the modern apprenticeship system, it facilitates nurturing of a mentor and working relationship with the training camp. Through good coordination, it is possible to implement the program on a replicable scale.

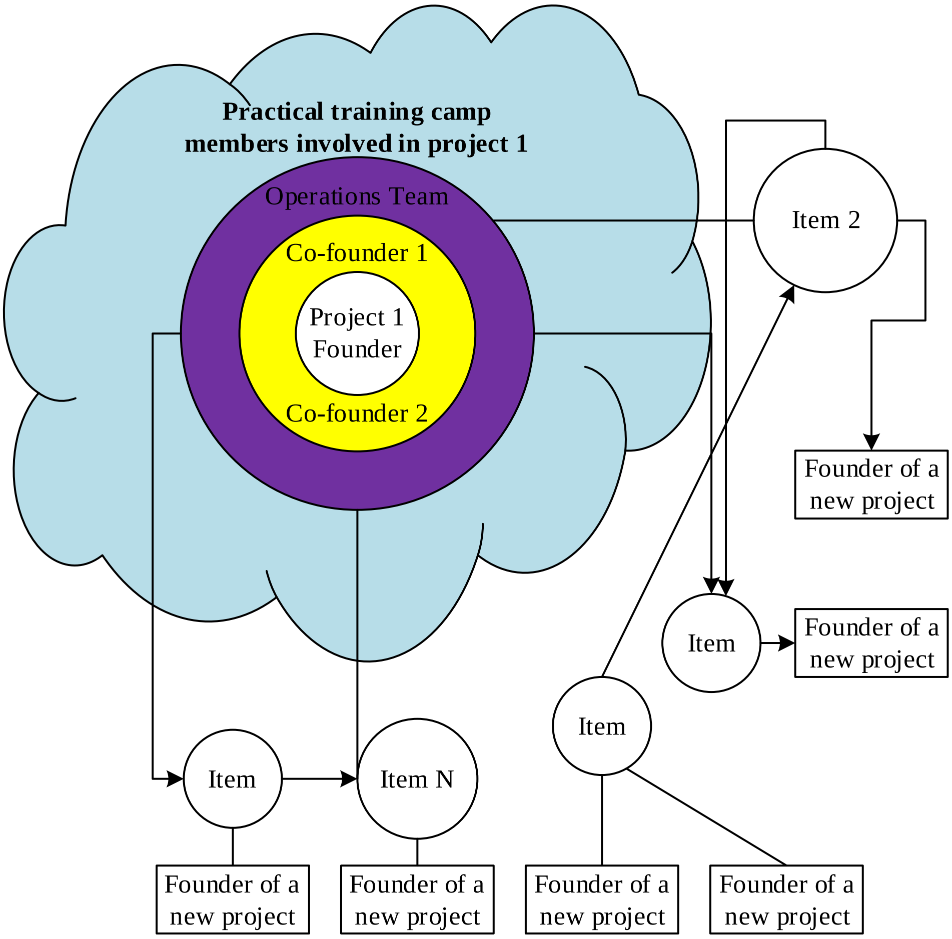

Figure 1: A talent cultivation model for innovation and entrepreneurship

Under the coordination of the teachers, the innovative project teams of the practical training camp will continuously dock with the resources of enterprises to form a serial entrepreneurial incubation environment, cultivate entrepreneurs and entrepreneurial experiencers while operating the projects, and gradually incubate the entrepreneurial enterprises. In this context, the entrepreneurial projects can usually realize certain commercial gains, and the enterprises behind them can likewise obtain certain social and economic benefits.

Members of the camp are at different levels of work in the various programs of the camp. The organization's entrepreneurial projects are centered on the project founders, with ex-apprentices or senior apprentices forming the core layer of the project, which is effectively the project management. The core layer attracts senior apprentices and intermediate apprentices to form the operation layer, and the core layer and the operation layer have to recruit apprentices at different levels to participate in the operation of the program, forming the participation layer. In other words, while nurturing entrepreneurs (founders) to set up their projects, university teachers have to recommend core management members for them to form a project management team to form the core tier. Teachers also assist the project management team to recruit project operation members to form the project operation team, forming the operation layer. On this basis, teachers should also organize a certain scale of peripheral team to participate in the operation of the project, forming the participation layer.

3 Model for evaluating the quality of innovation and entrepreneurship education

As China has developed into a period of increased quality development rather than rapid growth, the Chinese government has also emphasized an innovation-driven approach to development, and the concept of mass entrepreneurship and innovation has become one of the most important ones that can help drive economic development. Under these conditions, the implementation of the industry-education ideas into the framework of teaching in higher vocational colleges and universities on the basis of innovation-and-entrepreneurship is inseparable with the transformation of the supply-side of the educational system.

3.1 Evaluation system of innovation and entrepreneurship education

With regard to how industry and education interact, the evaluation of the innovation and entrepreneurship education in higher education institution will focus on the environmental base, inputs of resources, implementation process, and effectiveness in order to offer practical feedbacks and improve evaluation and implementation policies. In comparison with other models, the CIPP model is more suitable to assess the education of innovation and entrepreneurship in colleges and universities today. This paper has therefore chosen CIPP model as the theoretical framework, taken into account the characteristics of the industry and education combination and created an assessment index system of innovation and entrepreneurship education in higher education institutions as shown in Table 1. The four main indicators that have been included in the evaluation index system include entrepreneurial environment, entrepreneurial resources, education process, and entrepreneurial effectiveness.

Table 1: Innovation entrepreneurship education quality evaluation system

Primary index	Secondary index	Symbol
Background evaluation: Entrepreneurial environment	Regional environment	BE1
	Technical foundation	BE2
	Top-level design	BE3
Input evaluation: Entrepreneurial resources	Faculty investment	IE1
	Institutional construction	IE2
	Capital investment	IE3
Process evaluation: Educational process	Entrepreneurship course	PE1
	Entrepreneurial project	PE2
	Management process	PE3
Achievement evaluation: Business success	Quality improvement	AE1
	Entrepreneurial effect	AE2
	Social benefits	AE3

The evaluation tool comprises the assessment of processes performed and outcomes attained through a combination of subjective and objective procedures in conformity with the sequence set out in the CIPP framework in respect of evaluating context, input, process, and products. Context evaluation operates as a precursor to any future innovations in the field of entrepreneurship education, taking into account the business environment in higher educational institutions. Input evaluation acts as a conditional factor depending on the allocation of resources used in implementing the innovation and entrepreneurship education program. The distinguishing element of the CIPP model lies in process evaluation in respect of the process of curriculum development, project implementation, and instructional management.

3.2 Entropy weight method to solve the evaluation index weights

Entropy weight method is based on the information entropy theory to determine the weight of the indicator, through the information entropy to measure the variability or dispersion of the indicator data, based on the "average degree of dispersion" of a certain indicator under different objects of the observed value, depends entirely on the volatility of the data itself, and is not subject to the influence of the evaluator's subjective desire. The practical application of the entropy weight method proceeds as follows:

(1) Determination of the initial matrix X

An initial matrix on m items, n evaluation indicators is established based on the initial indicator data. Where $1 \le i \le m$, $1 \le j \le n$. The initial matrix $X = \left(x_{ij}\right)_{n\times m}$ can be expressed as:

$$X = \begin{bmatrix} x_{11} & \cdots & x_{1m} \\ \vdots & \cdots & \vdots \\ x_{1n} & \cdots & x_{nm} \end{bmatrix} \tag{1}$$

where x_{ij} denotes the data of the ith item corresponding to the jth indicator.

(2) Establishment of normalization matrix X'

Since the problem of inconsistent scale may exist among the evaluation indicators, if the scale of the indicators is different, they are not comparable. The method of eliminating the influence of the quantitative outline is to standardize the matrix data to get the standardized data matrix $X' = \left(x'_{ij}\right)_{n\times m}$. In this case, when the indicator values are positively correlated with the utility of comprehensive evaluation, the standardization formula for positive indicators is used, i.e.:

$$x_{ij}' = \frac{x_{ij} - \min\left\{x_{ij}\right\}}{\max\left\{x_{ij}\right\} - \min\left\{x_{ij}\right\}} \tag{2}$$

When the indicator values show a negative correlation with the utility of the comprehensive evaluation, the negative indicator normalization formula is used, i.e:

$$x_{ij}' = \frac{\max\left\{x_{ij}\right\} - x_{ij}}{\max\left\{x_{ij}\right\} - \min\left\{x_{ij}\right\}} \tag{3}$$

(3) Calculate the entropy value e_j

Firstly, the indicator weights are calculated, i.e:

$$p_{ij} = \frac{x_{ij}}{\sum_{i=1}^{m} x_{ij}} \tag{4}$$

The entropy value is then calculated based on the indicator weights, i.e:

$$e_j = -\frac{\sum_{i=1}^{m} p_{ij} \ln\left(p_{ij}\right)}{\ln(m)} \tag{5}$$

(4) Calculate the coefficient of variation g_j

For a given indicator, the smaller the difference in rating values x_{ij} on different objects, the smaller the degree of fluctuation, the larger the entropy value, when x_{ij} are all equal, $e_j = e_{\max} = 1$. At this time, the data of the indicators do not play a role in the comparison between the evaluation objects. When the difference of x_{ij} is larger, the entropy value is smaller, and the degree of influence of the indicator on the comparison between evaluation objects is larger. For the convenience of representation, the difference coefficient g_j is utilized to positively measure the indicator's effect on the comparison of evaluation objects, i.e., the larger the g_j, the larger the weight of the indicator, and the formula for g_j is as follows:

$$g_j = 1 - e_j \tag{6}$$

(5) Calculation of entropy weight w''_j

After normalizing the coefficients of variability, the indicator weights w''_j are obtained as:

$$w''_j = \frac{g_j}{\sum_{j=1}^{n} g_j} \tag{7}$$

3.3 Quality evaluation based on cloud modeling approach

Let $X = \{x\}, X$ be a quantitative thesis domain expressed numerically, and T be a qualitative concept on X. If the quantitative value $x \in X$ is a one-time stochastic realization of the qualitative concept T, the certainty of x on T $\mu_T(x) \in [0,1]$ is a random number with a stabilizing tendency of random numbers, i.e:

$$\mu_T(x) : X \to [0,1] \quad \forall x \in X \quad x \to \mu_T(x) \tag{8}$$

Then the distribution of x over the domain X is called a cloud. The cloud model characterizes a concept $T(Ex, En, He)$ by three numerical features: expectation Ex, entropy En, and superentropy He. The expected value Ex is the central value of the concept represented by X in the domain of the argument, i.e., the value that best represents a given qualitative concept. Entropy En is a measure of the uncertainty of a qualitative concept, determined by a combination of the concept's ambiguity and randomness, reflecting the range of values of the cloud of drops in the domain that can be accepted by that concept. Hyperentropy He is a measure of the uncertainty of entropy, the entropy of entropy. For concepts that can be generally accepted within a certain range, the superentropy is smaller; for concepts that are difficult to reach consensus, the superentropy is larger.

In this paper, the cloud model is used to represent the expert comments, defining five evaluation levels as {very poor, poor, average, good, very good}, then the standard cloud model of quality level evaluation can be expressed as (1,1/3,0.5), (3,1/3,0.5), (5,1/3,0.5), (7,1/3,0.5), (10,1/3,0.5).

Assuming that the expert i 's comment has a bilateral constraint $\left[D_{\inf}, D_{\sup}\right]$ and corresponds to one of the interval values in $[0,1]$, the numerical features of the comment cloud can be computed, namely:

$$Ex_i = \frac{D_{\inf} + D_{\sup}}{2} \tag{9}$$

$$En_i = \frac{D_{\sup} - D_{\inf}}{6} \tag{10}$$

$$He_i = k \tag{11}$$

where Ex_i and En_i are the expected value and entropy of the expert's i comment cloud model.

The floating cloud is suitable for synthesizing multiple independent linguistic values into a broader linguistic value. When evaluating the same index, different experts have different evaluation values, and the evaluation values of each expert are independent of each other. In this paper, we adopt the method of generating floating clouds in cloud theory to aggregate expert opinions and generate the comprehensive evaluation value of each decision maker for a certain indicator.

Assuming that there are n indicators, each of which has P expert evaluations, the expert evaluation values are transformed into a cloud model according to the cloud generator, and each of the indicators has p cloud models, and taking into account the weights of the experts, w, the cloud model for the comprehensive evaluation of the indicators' expert evaluation can be computed by the following formula, namely:

$$Ex = w_1 Ex_1 + w_2 Ex_2 + \cdots + w_p Ex_p \tag{12}$$

$$En = \frac{Ex_1 En_1 w_1 + Ex_2 En_2 w_2 + \cdots + Ex_p En_p w_p}{w_1 Ex_1 + w_2 Ex_2 + \cdots + w_p Ex_p} \tag{13}$$

$$He = \sqrt{\frac{Ex_1 He_1^2 w_1 + Ex_2 He_2^2 w_2 + \cdots + Ex_p He_p^2 w_p}{w_1 Ex_1 + w_2 Ex_2 + \cdots + w_p Ex_p}} \tag{14}$$

Synthesis cloud is suitable for synthesizing multiple interrelated linguistic values into a more generalized linguistic value, which is used to realize the leap of linguistic items from low-level concepts to high-level concepts. Therefore, this paper applies the synthesis cloud to synthesize multiple indicators.

According to Eq. (12) to Eq. (14), the cloud model of each sub-indicator can be obtained, and considering the weight v of the indicator, where m is the number of indicators, the synthesized cloud model for quality performance evaluation is calculated as:

$$Ex = \frac{\sum_{i=1}^{m} v_i Ex_i En_i}{\sum_{i=1}^{m} En_i v_i} \tag{15}$$

$$En = \sum_{i=1}^{m} En_i v_i n \tag{16}$$

$$En = \frac{\sum_{i=1}^{m} v_i He_i En_i}{\sum_{i=1}^{m} En_i v_i} \tag{17}$$

The final step in the process of assessing the grade of innovation and entrepreneurship education quality is to compute the similarity between the cloud model of comprehensive evaluation of innovation and entrepreneurship education quality and the cloud model of rubric set, which will determine the quality level of innovation and entrepreneurship education at colleges and universities whose concept is industry-teaching integration. Here the similarity degree δ is calculated as:

$$\delta = \frac{1}{2} + \frac{1}{2\Phi\left(\frac{\sqrt{2}\left|Ex_2 - Ex_1\right|}{\sqrt{En_1^2 + He_1^2} + \sqrt{En_2^2 + He_2^2}}\right)} - \Phi \left(\frac{\sqrt{2}\left|Ex_2 - Ex_1\right|}{\sqrt{En_1^2 + He_1^2} + \sqrt{En_2^2 + He_2^2}}\right) \tag{18}$$

$$\text{where,} \Phi(x) = \int_{-\infty}^{x} \frac{1}{\sqrt{2\pi}} e^{-x^2/2} dx$$

4 Practical analysis of innovative entrepreneurship education models

Considering the strategic implementation of economic growth through innovation, it is one of the key goals of the contemporary vocational education to form a group of people talented with the innovative spirit and entrepreneurial capabilities. The integration of industry and education plays a significant role in connecting the education chain with the industrial chain and offers an alternative view on how to develop innovative and entrepreneurial talents. When industrial development factors are introduced as part of the talent development process, the level of talent development and the capacity to be innovative and entrepreneurial can be improved considerably. Hence, it is necessary and practical to examine the innovative and entrepreneurial talent development model, which is based on industry-education integration.

4.1 Practical application of innovation and entrepreneurship education

4.1.1 Selection of research subjects

This research examines two batches of civil engineering students of the 2023 batch from a university located in City B. These batches consist of 60 students each, where one batch will serve as the experimental batch (SC1), while the other batch will be used as the control batch (SC2). The experimental batch is taught under a new talent development framework involving industrial-academic partnership, as described above. Meanwhile, the control batch will receive education through conventional classroom instruction. Both batches study the same academic subjects; nevertheless, the experimental batch goes a step further from theory to application by means of enterprise-oriented training and apprenticeship system setup.

The examination of the impact of innovation and entrepreneurship education is made through the use of tests and questionnaires. As for the evaluation of innovative and entrepreneurial thinking of students, it involves four aspects: concept, cognition, ability, and identity. With respect to the students’ satisfaction with the talent development model concerning innovation and entrepreneurship education, information was collected using a questionnaire consisting of four aspects: learning environment, content of courses, effectiveness of teaching, and satisfaction of students. The answers to questions were provided using a seven-point Likert scale. The answers ranged from very dissatisfied to very satisfied (MY1-MY7). These options were rated from 1 to 7. The questionnaire used by researchers showed good reliability.

4.1.2 Results of pedagogical tests

After collecting data on students' innovation and entrepreneurship cognition before and after teaching, this paper was statistically analyzed using SPSS software. The general information was analyzed descriptively; the comparison of count data was tested by $\chi 2$ test, and the measurement data was tested by independent samples t-test. Independent samples t-test was conducted on the scale scores of the two groups before and after teaching, and the test level was $P<0.05$ with a significant difference, and vice versa, there was no significant difference.

The baseline information of the two groups is illustrated in Table 2 below. As can be seen from Table 2, there were no significant differences between the experimental group and the control group in terms of gender, age, and professional curriculum ($P > 0.05$).

Table 2: Comparison of baseline data of the research subjects

Group	Number	Sex		Age	Fundamentals of Professional courses
		Male	Female		
SC1	60	22	38	20.72±0.98	81.52±6.38
SC2	60	24	36	20.53±0.94	82.01±5.76
χ^2/t	-	-0.987		-0.408	-0.796
P	-	0.315		0.723	0.438

To evaluate the degree of innovative and entrepreneurial awareness in the two groups prior to and following the execution of the instructional experiment, the innovative entrepreneurial awareness of the two groups was measured. Both subjects were evaluated at pre and post intervention and analyzed using a t-test as independent samples, which are presented in Table 3. As it is seen in the table, the mean scores on innovation-entrepreneurship awareness of the experimental group and control group prior to the instruction were 34.62 +3.78 and 34.69 +3.51 respectively, however there was no statistically significant difference between them (t=0.179, p=0.704>0.05). Additionally, the sub-scores on innovation and entrepreneurship awareness did not differ significantly as well (p>0.05). Consequently, the two groups have equal degrees of awareness to start the research and the possibility of introducing the idea of industry-education partnership in the innovation/entrepreneurship education program may be tested.

Table 3: Comparison of pre-teaching test results

Dimension	SC1	SC2	*t*	*P*
Concept	6.35±1.38	6.41±1.27	-1.304	0.243
Cognition	8.59±2.14	8.38±2.49	-1.029	0.198
Ability	8.41±1.57	8.72±1.36	-0.943	0.319
Agree	11.27±2.06	11.18±2.14	0.317	0.465
Total score	34.62±3.78	34.69±3.51	0.179	0.704

At the end of the teaching experiment, the innovative and entrepreneurial awareness of the two cohorts was re-assessed. The data collected through this process were analyzed using an independent-samples t-test and are shown in Table 4. It can be seen from Table 4 that the overall score obtained by the innovation and entrepreneurship awareness of the experimental group at the end of the teaching experiment is 62.16 ± 3.59 and that of the control (blank) group is 35.22 ± 2.39. Relative to the level before the teaching experiment, the improvement score for the experimental group is 27.54 (79.55%), whereas that of the control group is 0.53 (1.53%). All the dimensions in the experimental group have significantly increased in the $P < 0.05$ range, whereas the control group did not have any significant changes ($P > 0.05$). Moreover, the difference in the improvement score between the two groups is significantly different ($P < 0.05$).

Table 4: Comparison of post-teaching test results

Dimension	SC1	SC2	*t*	*P*
Concept	10.12±2.18	6.48±1.78	7.168	0.000
Cognition	14.03±1.27	8.57±1.27	8.332	0.001
Ability	13.64±3.15	7.99±2.06	4.106	0.003
Agree	24.37±2.06	12.18±2.13	5.279	0.000
Total score	62.16±3.59	35.22±2.39	7.325	0.004

From the experimental findings, it can be inferred that a talent development approach grounded in the integration of industry and teaching can effectively strengthen students' innovative and entrepreneurial competence. Specifically, students in the experimental group achieved significantly better performance than those in the control group in terms of concepts, cognition, capabilities, and professional identity. In addition, the findings indicate that building a collaborative training system between industry and education plays a vital role in enhancing such competence. This may be explained by the fact that the above training approach encourages students to acquire knowledge actively, examine issues from multiple perspectives, expand their intellectual horizons, and enhance their creative capacity through both theoretical instruction and hands-on practice. Overall, the concept of integrating industry with teaching is highly aligned with innovation and entrepreneurship education in fostering students' related competencies.

4.1.3 Student satisfaction

This paper further analyzes the students' satisfaction with the teaching mode by summarizing the satisfaction scores of each question item of the questionnaire, and the satisfaction scores of the questionnaire and their percentages are shown in Figure 2. Of all the answers to each question item of the recovered questionnaire, the largest number of choices was satisfied, and its overall share was 40%, followed by very satisfied and very satisfied, which accounted for 26.7% and 11.7% of all the answers, respectively. The answers of dissatisfied, very dissatisfied, and very dissatisfied were less frequent, with the number of choices accounting for only 6.7%, 3.3%, and 1.7%. It shows that students show a more satisfactory attitude towards the teaching mode of combining the concept of industry-teaching integration with innovation and entrepreneurship education as a whole. The average scores of the four dimensions of learning environment, course content, teaching effect and student satisfaction were calculated to be 6.24, 6.47, 6.31 and 6.52 respectively, and there was only a difference of 0.28 points between the dimension of student satisfaction with the highest average score and the learning environment with the lowest average score. It shows that the construction progress of all dimensions of the innovative and entrepreneurial talent cultivation model that combines the concept of industry-teaching integration is basically comparable, and there is no obvious shortcoming in a certain aspect. However, at the same time, there is no dimension with an average score of 7, and students' satisfaction with each dimension only reaches an observed value close to the higher intensity. In the learning environment dimension, “Practical teaching can continuously consolidate theoretical knowledge”, “The application of modern apprenticeship system can help to improve students' entrepreneurial thinking”, and “You are satisfied with the integration of the concept of industry-teaching and innovation-entrepreneurship education” and “You are satisfied with the integration of the concept of industry-teaching and innovation-entrepreneurship education” are included in the student satisfaction dimension. In the dimension of student satisfaction, the scores of the three questions “Overall satisfaction with the integration of the concept of industry-teaching and innovation-entrepreneurship education” reached 7, i.e., very satisfied, and the average scores of the remaining questions ranged from 6.2 to 7, which indicated that the students' satisfaction with the integration of the concept of industry-teaching and innovation-entrepreneurship education program was high, but there was still a need to improve the construction of all aspects.

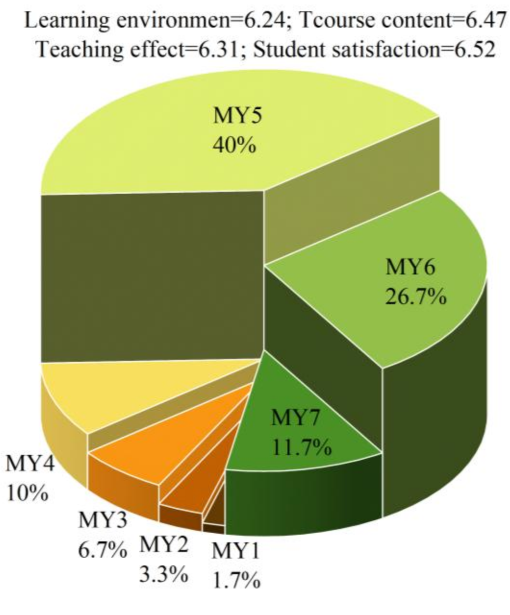

Figure 2: The satisfaction score of the questionnaire and its proportion

4.2 Evaluation of the quality of innovation and entrepreneurship education

4.2.1 Indicator weighting analysis

Based on the quality evaluation index system for innovation and entrepreneurship education in higher education institutions that had been established using the industry-education integration principle in the previous study, surveys were sent out to experts engaged in the assessment of innovation and entrepreneurship education in chosen institutions of higher learning. The number of surveys issued totaled 50, and 48 were returned validly. The gathered information was then tabulated and subjected to analysis. Using the entropy weighting approach, which had been previously discussed in the article for calculating weights of the indicators, the weight values of all the indicators were obtained, as shown in Table 5.

As can be seen from the table, for the quality of innovation and entrepreneurship education in colleges and universities that combine the concept of industry-teaching fusion, the main emphasis is on entrepreneurial resources and entrepreneurial effectiveness, with the weights of the indicators reaching 28.54% and 27.35%, respectively, while the weight of the educational process is relatively low (19.72%). This shows that in innovation and entrepreneurship education, the concept of industry-teaching integration is deeply penetrated into the classroom by relying on school-enterprise cooperation, and entrepreneurial practice resources are actively integrated to help students cultivate innovative and entrepreneurial thinking, so as to promote the improvement of entrepreneurial effectiveness. Relatively speaking, the education process puts more emphasis on the optimization of courses and programs, and invests in more refined management, which subsequently enhances the innovation and entrepreneurship of students. Among the secondary indicators, the weighted values of faculty investment (IE1), quality improvement (AE1), financial investment (IE3), institutional construction (IE2) and social benefits (AE3) are among the top five, with their values exceeding 0.9. It shows that in innovation and entrepreneurship education, faculty investment is the basic disk to ensure the quality of education, while quality improvement is the whetstone to test entrepreneurship education, while taking into account the financial investment and institutional construction to ensure the maximum social benefits.

Table 5: The weight values of each indicator

Primary index	Symbol	Absolute weight	Relative weight
Background evaluation: Entrepreneurial environment 0.2439	BE1	0.3017	0.0736
	BE2	0.3328	0.0812
	BE3	0.3655	0.0891
Input evaluation: Entrepreneurial resources 0.2854	IE1	0.3452	**0.0985**
	IE2	0.3273	**0.0934**
	IE3	0.3275	**0.0935**
Process evaluation: Educational process 0.1972	PE1	0.3359	0.0662
	PE2	0.3176	0.0626
	PE3	0.3465	0.0683
Achievement evaluation: Business success 0.2735	AE1	0.3503	**0.0958**
	AE2	0.3194	0.0874
	AE3	0.3303	**0.0903**

4.2.2 Evaluation of the quality of education

Based on the corresponding evaluation phases of the comprehensive model for measuring innovation and entrepreneurship education quality as mentioned before, along with the weights of the selected indicators calculated using the entropy weighting approach, the cloud parameters for the second-level indicators were calculated using the inverse generator of MATLAB. This is shown specifically in Table 6 below.

Table 6: Digital characteristics of the education quality cloud model

Symbol	*Ex*	*En*	*He*
BE1	7.41	0.58	0.50
BE2	7.62	0.94	0.50
BE3	6.83	0.79	0.50
IE1	7.26	1.23	0.50
IE2	6.43	0.98	0.50
IE3	7.21	0.96	0.50
PE1	5.87	0.94	0.50
PE2	6.81	0.73	0.50
PE3	7.62	0.57	0.50
AE1	6.43	1.25	0.50
AE2	7.15	1.03	0.50
AE3	7.27	0.94	0.50

Thereafter, the cloud parameters of the first-level indicators are calculated based on aggregating the low-level indicators according to Equations (15)–(17). The values are given in Table 7. For the indicator of the quality of innovation and entrepreneurship education at higher education institutions, its cloud parameter is (6.98, 1.12, 0.5), which is determined by the associated algorithm applied to the first-level indicators. Based on the first-level cloud parameters, the cloud chart of the quality of innovation and entrepreneurship education at colleges and universities is plotted, and the details are demonstrated in Figure 3. From the figure, one can see that the value of quality falls between 4.5 and 9.5 points, while the entire average value of quality is around 6.98, suggesting that there is a possibility that the quality is at the “good” level. In this regard, incorporating industry-education cooperation into innovation and entrepreneurship education at higher education institutions will significantly contribute to enhancing the quality of such education, upgrading the innovative and entrepreneurial abilities of students, and cultivating a variety of innovative and entrepreneurial talents at colleges and universities.

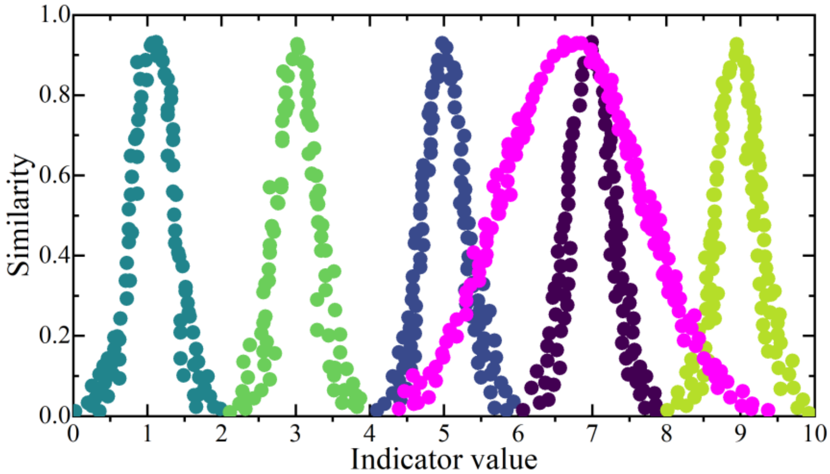

Figure 3: Education quality evaluation cloud map

Table 7: First-level indicator cloud parameters

Primary index	*Ex*	*En*	*He*
Background evaluation: Entrepreneurial environment	5.41	1.04	0.50
Input evaluation: Entrepreneurial resources	3.76	0.93	0.50
Process evaluation: Educational process	4.31	1.06	0.50
Achievement evaluation: Business success	5.81	1.27	0.50

4.3 Talent cultivation path for innovation and entrepreneurship

4.3.1 Improvement of the curriculum

To foster innovative and entrepreneurial talents under the context of industry-education integration, there is an even greater need to enhance the strategic position of entrepreneurial practice. It requires encouraging college students to make use of the knowledge and skills that they have learned to create a situation where they can keep on enhancing their integrative skills, thus laying the foundations for future entrepreneurship success. In this case, universities should change their existing educational systems in order to develop high-level innovative and entrepreneurial talents.

On the one hand, innovative and entrepreneurial thinking should be cultivated in the teaching of theoretical courses. Teachers need to incorporate problems in industrial development and actual cases of enterprise development in the form of scientific research projects in the classroom, and select teaching strategies such as problematic, inspirational and exploratory to guide students to establish a scientific entrepreneurial consciousness and strengthen innovative thinking. At the same time, the latest national and local entrepreneurship support policies should be explained to the students so that they can make full use of these preferential treatment to reduce the resistance on the road of entrepreneurship. On the other hand, it is also necessary to exercise innovative entrepreneurial ability through practical training. Increase the proportion of entrepreneurship practice in the entrepreneurship guidance course, and make use of the on-campus innovation and entrepreneurship incubator, or off-campus innovation and entrepreneurship competitions, etc., so that students can get the opportunity to practice.

4.3.2 Strengthening of the faculty

The quality of the teaching force is associated with the quality of learning of students and with developing innovation and entrepreneurial skills. As a result, higher education establishments should consider developing and improving the teaching force in the context of industrial-academic cooperation. Professionals from related industries and industries specialists can be invited to give special lectures and training courses outside class time and get involved in exchange programs for the faculty members. The main purpose of such activities will be getting acquainted with recent advances in the respective professional areas and needs of industries and enterprises.

Universities should encourage faculty participation in industry-university-research cooperation projects. Participation in practical projects enables faculty members to apply theoretical knowledge in practice, gain practical experience, and acquire an understanding of industrial practices in the related field, which will assist them in delivering practical advice to the students. Working together with industries, faculty can make contacts in industries and help students get internships and jobs in enterprises. Moreover, universities can improve the level of professionalism of teachers through inviting experts of related industries to work at universities as adjuncts or guest lecturers. Experts of industries have rich practical experience, which gives students the possibility to obtain current industry-related knowledge and experience and compensate for the limitations of classical education, allowing the students to learn about the reality and innovation needs of industries.

4.3.3 Optimizing resource allocation

Schools and enterprises in the construction of teaching practice base to make overall arrangements for the base of internship sites and equipment resources for resource optimization and reorganization, maximize the utilization rate of equipment and sites, the use of off-campus practice teaching base for the community to provide technical services and training, to play and realize the role of the base of the organic combination of teaching-production-training three as one. Establish the off-campus practice base management leading group, construction group and working group composed of schools, colleges and enterprises, clarify the responsibilities and division of labor of relevant personnel, formulate a practical management system, and jointly consult to promote the smooth implementation of the tasks of the practice education base. Schools and enterprises to establish a clear division of labor between the organization and management departments, the two sides cooperate with each other to perform their respective duties, and gradually improve the construction of the management system.

In addition to actively participating in the construction of the practice teaching base and jointly supervising the completion of the tasks of the practice teaching base, we hold regular symposiums for teachers, students and technicians of the enterprises to understand and adjust the real problems in the process of practice, and at the same time, we communicate with the enterprises as well as report to the school and the commissioning unit. The school or will be based on the base of the annual activity plan, the organization of experts on the construction of the base as well as the achievements of the situation of the inspection and evaluation, work seminars and exchanges, as well as the quality of off-campus internship bases to monitor and evaluate the establishment of the system and evaluation.

5 Conclusion

Higher education institutions need a renewed approach to talent cultivation in today’s environment, where practical training is integrated with theoretical instruction. This study examines a collaborative framework linking industry–education cooperation with entrepreneurial and innovation-oriented learning in universities, and presents it as a novel pathway for nurturing application-oriented talent. The effectiveness of this framework is assessed through teaching experiments and evaluative analysis. The research findings show that the approach has a positive influence on learners' understanding of innovation and entrepreneurial practice, with participants reporting favorable feedback. The quality of the relevant educational activities during implementation can be regarded as satisfactory. Therefore, to advance this area of education, universities should place greater emphasis on deepening industry–academia integration, optimizing the curriculum system, and improving the efficiency of resource allocation.

About the Author

Xie Yan was born in Jiangxi, China in 1984. She obtained a bachelor's degree from Jiangxi University of Finance and Economics. She is currently studying at the School of Business Administration, City University of Malaysia, with a main research focus on corporate financial management.

Zhiping Li was born in 1983 in Ganzhou, Jiangxi, China. He obtained a master's degree from Jiangxi Normal University and is currently pursuing a PhD in Education at City University Malaysia. His main research areas are educational management and innovation and entrepreneurship education.

Chunxiang Fan was born in Ganzhou, Jiangxi, China, in 1990. I obtained a Master's degree from Gannan Normal University in China. I am currently employed at Jiangxi Vocational College of Applied Technology, engaged in the work of a full-time counselor. My main research direction is ideological and political education.

References

[1] Ding, Y. Y. (2017). The constraints of innovation and entrepreneurship education for university students. Journal of Interdisciplinary Mathematics, 20(6-7), 1431-1434.

[2] Zhu, H. B., Zhang, K., & Ogbodo, U. S. (2017). Review on innovation and entrepreneurship education in Chinese universities during 2010-2015. Eurasia Journal of Mathematics, Science and Technology Education, 13(8), 5939-5948.

[3] Safin, R. S., Shaidullina, A. R., Alikhanova, R. A., Muskhanova, I. V., Yusupkhadzhieva, T. V., Dzhamalkhanova, L. A., ... & Akhmetov, L. G. (2016). Innovative entrepreneurship in education: a new look in the students training content and existing problems. International Review of Management and Marketing, 6(2), 51-56.

[4] Qu, S. H. (2021). Practical exploration on the integration of innovation and entrepreneurship education and professional education. Int. J. Sec. Educ, 9, 45-50.

[5] Jůvová, A., Čech, T., & Duda, O. (2017). Education for entrepreneurship–A challenge for school practice. Acta Educationis Generalis, 7(3), 63-75.

[6] Wang, H. (2023). Research on innovation and entrepreneurship education in applied universities from the perspective of integration of industry and education. Advances in Educational Technology and Psychology, 7(15), 98-110.

[7] Li, Q. (2024). Strategies for Integrating Industry Collaboration into Innovation and Entrepreneurship Education Curricula in China. Journal of Interdisciplinary Insights, 2(2), 19-32.

[8] Alshehri, A., Gutub, S. A., Ebrahim, M. A. B., Shafeek, H., Soliman, M. F., & Abdel-Aziz, M. H. (2016). Integration between industry and university: Case study, Faculty of Engineering at Rabigh, Saudi Arabia. Education for chemical engineers, 14, 24-34.

[9] Gibson, E., Daim, T. U., & Dabic, M. (2019). Evaluating university industry collaborative research centers. Technological Forecasting and Social Change, 146, 181-202.

[10] Fernandes, G., O'Sullivan, D., & Ferreira, L. M. D. (2022). Addressing the challenges to successfully manage university-industry R&D collaborations. Procedia Computer Science, 196, 724-731.

[11] Li, Y., Hsu, W. L., & Zhang, Y. (2022). Evaluation study on the ecosystem governance of industry–Education integration platform in China. Sustainability, 14(20), 13208.

[12] Borges, P., Franco, M., Carvalho, A., dos Santos, C. M., Rodrigues, M., Meirinhos, G., & Silva, R. (2022). University-industry cooperation: a peer-reviewed bibliometric analysis. Economies, 10(10), 255.

[13] Deissinger, T., & Gonon, P. (2021). The development and cultural foundations of dual apprenticeships–a comparison of Germany and Switzerland. Journal of Vocational Education & Training, 73(2), 197-216.

[14] Gessler, M. (2017). The lack of collaboration between companies and schools in the German dual apprenticeship system: Historical background and recent data. International Journal for Research in Vocational Education and Training (IJRVET), 4(2), 164-195.

[15] Meissner, D., & Shmatko, N. (2017). "Keep open": the potential of gatekeepers for the aligning universities to the new Knowledge Triangle. Technological Forecasting and Social Change, 123, 191-198.

[16] Liwei, Y., Chunchen, Y., Ting, H., Jingting, C., Chenchen, S., & Jialing, L. (2024). Collaborative industry-academia integration in local undergraduate institutions: Establishing practical education bases. Int. J. Softw. Eng. Appl, 13(10).

[17] Wright, M., Clarysse, B., Lockett, A., & Knockaert, M. (2008). Mid-range universities' linkages with industry: Knowledge types and the role of intermediaries. Research policy, 37(8), 1205-1223.

[18] Ahmed, F., Fattani, M. T., Ali, S. R., & Enam, R. N. (2022). Strengthening the bridge between academic and the industry through the academia-industry collaboration plan design model. Frontiers in Psychology, 13, 875940.

[19] Mohmood, H., & Tamyez, P. F. M. (2022). RESEARCHERS'MOTIVATION, INTERACTION CHANNELS, AND STRATEGIES TOWARDS UNIVERSITY-INDUSTRY COLLABORATION: A CASE STUDY APPROACH. International Journal of Industrial Management, 15, 17-25.

[20] Van den Berghe, L., & Guild, P. D. (2008). The strategic value of new university technology and its impact on exclusivity of licensing transactions: An empirical study. The Journal of Technology Transfer, 33(1), 91-103.

[21] Çabiri, K. M., & Qosja, E. (2023). Challenges of University-Industry Cooperation in Albania. International Journal of Management, Knowledge and Learning, 12, S13-27.

[22] Schmidt, T. (2019). Industry currency and vocational teachers in Australia: What is the impact of contemporary policy and practice on their professional development?. Research in Post-Compulsory Education, 24(1), 1-19.

[23] Ćudić, B., Alešnik, P., & Hazemali, D. (2022). Factors impacting university–industry collaboration in European countries. Journal of Innovation and Entrepreneurship, 11(1), 33.