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Empirical analysis of factors influencing innovation and entrepreneurship education in applied universities

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ABSTRACT

Innovation and entrepreneurship education is critical for fostering economic growth and societal advancement. In applied universities, the effectiveness of such education is influenced by various factors. Here we investigate the key elements affecting innovation and entrepreneurship education through an empirical study of Chinese applied universities, utilizing a structural equation model (SEM). We found that teacher quality (TQ) significantly impacts curriculum design (CD), practical platforms (PP), and policy support (PS). CD influences PP and PS, while PP affect TQ and CD. PS impacts TQ and CD, and student individual characteristics (SI) influence all four primary indicators. Compared to previous studies, our findings highlight the critical roles of TQ and CD in enhancing educational outcomes. By optimizing these factors, along with improving PP and strengthening PS, the effectiveness of innovation and entrepreneurship education can be significantly increased. This research provides vital theoretical and practical guidance for university administrators and educators, underscoring the need for targeted improvements in key areas to foster better educational results. Such insights contribute to the broader discourse on educational innovation, offering strategies that can be applied across various academic settings to promote innovation and entrepreneurship globally.

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1. INTRODUCTION

With the rapid development of the global economy and continuous technological advancements, innovation and entrepreneurship have become key drivers of social progress and economic growth [1]. Innovation and entrepreneurship education, which cultivates students' innovative spirit (IS) and entrepreneurial abilities, has garnered widespread attention globally [2]. Innovation is a key driver of economic development, and an entrepreneurial spirit is equally important. Together, innovation and entrepreneurship drive business growth and economic development [3]. Innovation and entrepreneurship education has gradually become an integral part of higher education [4].

Researchers worldwide have extensively explored the definition and essence of innovation and entrepreneurship education. It is not merely about imparting entrepreneurial skills but, more importantly, about fostering students' innovative thinking, adventurous spirit, and problem-solving abilities [5], [6]. Innovation and entrepreneurship education should encompass comprehensive training in both theoretical

knowledge and PE, covering everything from classroom instruction to hands-on practice to enhance students' overall capabilities and practical skills [7].

Researchers have found that applied universities are more likely to succeed in innovation and entrepreneurship education due to their practical orientation and close ties to the local economy [8], [9]. Chinese researchers have identified several challenges in implementing innovation and entrepreneurship education at applied universities, such as inconsistent teacher quality (TQ) and unscientific curriculum design (CD). A significant limiting factor is the lack of practical entrepreneurial experience among teachers [10], [11]. The practicality and diversity of CC significantly impact students' innovation and entrepreneurship capabilities [12].

Researchers agree that the development of practical platforms (PP) and policy support (PS) are crucial factors influencing the effectiveness of innovation and entrepreneurship education [13], [14]. Facilities such as business incubators, training bases, and university-industry collaborations provide students with valuable practical opportunities and resources [15], [16]. Wang [17] found through empirical research that the quality of both on-campus and off-campus PP is significantly positively correlated with students' entrepreneurial success rates. PS is also seen as a vital guarantee for advancing innovation and entrepreneurship education. Government funding and policy incentives (PI) can significantly enhance the teaching outcomes of such programs, while school incentives can effectively stimulate the enthusiasm of both teachers and students for innovation and entrepreneurship [18]–[20]. Countries are increasingly emphasizing innovation and entrepreneurship education, aiming to cultivate talents with IS and entrepreneurial skills to enhance national competitiveness. As an integral part of the higher education system, applied universities are primarily tasked with training application-oriented, skilled, and innovative talents [21]–[23]. Therefore, studying the factors influencing innovation and entrepreneurship education in applied universities is crucial for improving education quality and enhancing students' overall capabilities.

In China, driven by national policies, innovation and entrepreneurship education is gradually becoming widespread in universities [24]. However, applied universities still face many challenges in implementing this education. For instance, the varying quality of teachers, unscientific CD, inadequate PP, and insufficient PS significantly impact the effectiveness of innovation and entrepreneurship education [25]. Exploring and empirically analyzing these influencing factors is crucial for improving the innovation and entrepreneurship education system in applied universities. While earlier studies have explored the impact of TQ, CD, PP, and PS on educational outcomes, they have not explicitly addressed the interrelationships among these factors and their collective influence on innovation and entrepreneurship education effectiveness.

This study aims to empirically analyze the main factors affecting the effectiveness of innovation and entrepreneurship education in applied universities and to propose corresponding strategies. The research includes a literature review, hypothesis formulation and questionnaire design, survey statistics and results analysis, structural equation modeling (SEM) of the data, and conclusions on key metrics for innovation and entrepreneurship education in applied universities. It is hoped that the findings of this study will provide valuable insights for educators and administrators in applied universities, thereby advancing the development of innovation and entrepreneurship education.

2. METHOD

This paper employs SEM for data analysis. The research design encompasses several steps, including a literature review, research hypothesis formulation, questionnaire design, data collection, and analysis. A structured questionnaire was used to conduct a detailed survey on factors such as TQ, CD, PP, PS, and student individual characteristics (SI). The collected questionnaire data was then analyzed using multiple regression and SEM.

2.1. Research hypothesis

Research hypotheses based on the literature review and preliminary survey and interview results, this paper hypothesizes that the main factors influencing innovation and entrepreneurship education in applied universities include TQ, CD, PP, PS, and SI. SEM will be used to study the relationships between these factors and to explore their interrelationships, as shown in Table 1.

Table 1. Research indicators

Primary indicators	Secondary indicators
TQ	TA, PE, IS
CD	Course content (CC), teaching methods (TM), interdisciplinary integration (II)
PP	Internship base (IB), incubator center (IC), enterprise cooperation (EC)
PS	Funding support (FS), PI, incentive measures (IM)
SI	Gender (G), academic background (AB), family economic status (FE)

2.2. Questionnaire design

This study designed a structured questionnaire. The questionnaire includes basic information and measurement items for various primary and secondary indicators. All items use a five-point Likert scale, ranging from "strongly disagree" to "strongly agree." To ensure scientific validity, educational experts reviewed the questionnaire and provided feedback, leading to modifications and improvements. A small-scale pilot test was conducted to gather feedback on content, format, and length, which further refined the questionnaire.

Basic information: this section collects respondents' G, age, AB, and FE. This information helps analyze the impact of SI on the effectiveness of innovation and entrepreneurship education. TQ: this includes teaching ability (TA), practical experience (PE), and innovative spirit (IS). Respondents assess whether teachers have solid professional knowledge, effectively impart innovation and entrepreneurship knowledge, possess practical entrepreneurial experience, and encourage student innovation. CD: this involves CC, TM, and II. Respondents evaluate whether CC is rich and practical, covers innovation and entrepreneurship knowledge, employs diverse TM, is interactive, includes interdisciplinary content, and involves interdisciplinary teamwork. PP: this includes training bases, business incubators, and EC. Respondents assess whether the university provides on-campus and off-campus training bases, the quality and advancement of training equipment, the presence of business incubators, the comprehensiveness of incubator support, and the extent of university-enterprise cooperation providing internship opportunities. PS: this involves FS, PI, and motivational measures. Respondents evaluate whether the university provides sufficient funding for innovation and entrepreneurship, the presence of special government funding, the existence of favorable policies from the government and the university, the availability of policy benefits for student entrepreneurship, and the effectiveness of motivational measures from both government and university. SI: this includes G, AB, and FE. Respondents indicate whether these factors impact innovation and entrepreneurship education. Through this structured questionnaire design, the study will conduct a comprehensive analysis to explore and identify the main factors influencing the effectiveness of innovation and entrepreneurship education in applied universities.

3. RESULT AND DICUSSION

3.1. Questionnaire statistics and result analysis

3.1.1. Data collection

The survey selected five provincially-affiliated applied universities as samples, located in different regions and covering various types of universities. A combination of online and offline methods was used to distribute 450 questionnaires, with 430 valid responses, achieving a recovery rate of 95.56%. The survey included students (current and graduates) and teachers (full-time and innovation and entrepreneurship management teachers) to ensure the breadth and representativeness of the sample. Additionally, variables such as G, age, AB, and FE among respondents were well-distributed, providing a solid foundation for data analysis.

3.1.2. Descriptive statistical analysis

This paper conducted descriptive statistical analysis on the collected questionnaire data. The basic information of the samples is presented in Table 2, and the scores for the primary and secondary indicators are shown in Table 3. Descriptive statistical analysis of the basic information from the collected questionnaire data shows that male students account for 48.4% and female students for 51.6%. Among teachers, males represent 51.7% and females 48.3%, indicating a relatively balanced G distribution. Regarding AB, 24.7% of students are in sciences, 41.2% in engineering, 15.9% in literature, and 9.5% in agriculture. Among teachers, 23.8% are in sciences, 35.7% in engineering, 11.9% in architecture, 16.7% in literature, and 11.9% in agriculture, with a predominance of science and engineering fields. Concerning students' FE, 21.5 are from affluent backgrounds, 61.8% from middle-income families, and 16.7% from less affluent backgrounds, with the majority being from middle-income families.

In terms of TQ, the highest average score was for TA at 4.21, indicating that respondents generally believe teachers have strong teaching abilities. This finding is consistent with Vermote *et al.* [26] research, which emphasizes the key role of TA in educational outcomes. The average score for IS was 4.15, showing that teachers are effective in fostering student innovation. The average score for PE was 3.98, relatively lower, suggesting that teachers may lack actual entrepreneurial experience.

For CD, CC had the highest average score at 4.18, indicating that the content is practical. The average score for II was 4.08, showing good promotion of interdisciplinary collaboration within courses. The average score for TM was 4.02, indicating diverse methods, though there is room for improvement. This is consistent with findings from other studies which suggest that while diverse TM are employed, there is still potential for further enhancement to better cater to different learning styles [27], [28].

In PP, EC had the highest average score at 4.12, indicating close collaboration between universities and businesses. This finding is consistent with Evans *et al.* [29], which emphasize the importance of university-business partnerships in enhancing practical learning and employability of students. The average score for on-campus training bases was 4.10, suggesting that these facilities are well-equipped. The average score for business incubators was 4.05, reflecting their effectiveness in supporting student innovation and entrepreneurship.

For PS, PI had the highest average score at 4.07, indicating that both school and government offer some favorable policies. The average score for motivational measures was 4.03, indicating effective measures from both school and government. The average score for FS was 4.00, indicating room for improvement in financial support. This is corroborated by other studies that suggest financial constraints can limit the effectiveness of educational programs and initiatives [30], [31]. Regarding SI, AB had the highest average score at 4.11, showing different performances in innovation and entrepreneurship education among students with various academic backgrounds (ABs). Mei *et al.* [32] research also supports this conclusion, showing that students' AB significantly affects their participation and success rate in innovation and entrepreneurship education. The average scores for G and FE were 3.95 and 3.92, respectively, indicating these characteristics have some impact but to a lesser degree.

The standard deviations for TQ, CD, PP, and PS were moderate, indicating that most respondents had similar views with some variation. The standard deviation for AB was relatively small, indicating consistent views among respondents and a significant impact. The standard deviations for G and FE were larger, indicating greater variation in their impact on innovation and entrepreneurship education.

Table 2. Basic information of the samples

Sample categories		Student		Teacher	
		Sample quantity	Precentage (%)	Sample quantity	Precentage (%)
G	Male	180	48.4	30	51.7
	Female	192	51.6	28	48.3
AB	Science	96	24.7	10	23.8
	Engineering	160	41.2	15	35.7
	Architecture	34	8.7	5	11.9
	Literature	62	15.9	7	16.7
	Agriculture	36	9.5	5	11.9
FE	Affluent	82	21.5		
	Middle	230	61.8		
	Less affluent	60	16.7		

Table 3. Scores for primary and secondary indicators

Primary indicators	Secondary indicators	Average	Standard deviation
TQ	TA	4.21	0.62
	PE	3.98	0.70
	IS	4.15	0.65
CD	CC	4.18	0.60
	TM	4.02	0.67
	II	4.08	0.63
PP	IB	4.10	0.68
	IC	4.05	0.66
	EC	4.12	0.64
PS	FS	4.00	0.69
	PI	4.07	0.65
	IM	4.03	0.68
SI	G	3.95	0.72
	AB	4.11	0.64
	FE	3.92	0.73

3.1.3. Reliability and validity testing

To ensure the reliability and validity of the questionnaire, Cronbach's alpha coefficient and factor analysis were used for reliability and validity testing, as shown in Table 4. Reliability testing evaluates the consistency and stability of the questionnaire items. A Cronbach's alpha coefficient above 0.7 is typically considered to indicate good internal consistency. The Cronbach's alpha coefficients for all primary and secondary indicators were tested, and the results showed that all coefficients were above 0.82, indicating high internal consistency.

Table 4. reliability and validity testing statistics

Primary indicators	Secondary indicators	α-value	λ-value
TQ	TA	0.85	0.78
	PE	0.83	0.74
	IS	0.87	0.80
CD	CC	0.86	0.76
	TM	0.84	0.75
	II	0.85	0.79
PP	IB	0.88	0.81
	IC	0.86	0.78
	EC	0.87	0.82
PS	FS	0.85	0.77
	PI	0.84	0.76
	IM	0.86	0.78
SI	G	0.82	0.73
	AB	0.86	0.79
	FE	0.83	0.75

Validity refers to whether the questionnaire items effectively reflect the latent variables being measured. Factor analysis was used to assess the construct validity of the questionnaire. The validity was determined by examining the loadings of each item on the corresponding factors. Factor loadings above 0.7 are generally considered to indicate good validity. The results showed that all item loadings were above 0.7, demonstrating good validity for all items.

3.1.4. Regression analysis

To verify the significance and impact of each hypothesis, a multiple regression analysis was conducted. Table 5 presents the main results of the regression analysis. As shown in Table 5, TQ has a significant positive impact on CD, PP, PS, and SI, with standardized regression coefficients of 0.35, 0.28, 0.31, and 0.26, respectively. The t-values are all above 3.85, and p-values are less than 0.05. This finding is consistent with Fauth *et al.* [33] research, which emphasizes the key role of TQ in educational outcomes and various educational frameworks. CD also has a significant positive impact on PP, PS, and SI, with standardized regression coefficients of 0.32, 0.27, and 0.24, respectively. The t-values are all above 3.64, and p-values are less than 0.05. Amangeldina and Dudovich [34] findings highlight the impact of CD on enhancing educational infrastructure and student achievement. PP significantly positively affect TQ, CD, PS, and SI, with standardized regression coefficients of 0.29, 0.33, 0.30, and 0.28, respectively. The t-values are all above 4.10, and p-values are less than 0.05. This is consistent with Dai *et al.* [35] research, which emphasizes the importance of practice platforms in improving teaching effectiveness and educational outcomes. PS significantly positively impacts TQ, CD, PP, and SI, with standardized regression coefficients of 0.31, 0.34, 0.29, and 0.27, respectively. The t-values are all above 3.98, and p-values are less than 0.05. This result confirms Williams [36] point of view, which illustrates the key role of PS in strengthening various aspects of the education system. SI significantly positively influence TQ, CD, PP, and PS, with standardized regression coefficients of 0.25, 0.27, 0.26, and 0.24, respectively. The t-values are all above 3.64, and p-values are less than 0.05. This finding supports the notion that SI are essential factors in shaping educational outcomes and practices [37]. The regression analysis confirms the significance of each hypothesis, indicating significant interrelationships between TQ, CD, PP, PS, and SI. These results provide a basis for further SEM analysis.

3.2. SEM analysis

3.2.1. Model construction

Based on the previous descriptive statistical analysis and regression analysis results, this paper constructed a SEM to assess the effectiveness of innovation and entrepreneurship education in applied universities. The model includes five primary indicators: TQ, CD, PP, PS, and SI, along with 15 secondary indicators under these primary indicators. The model aims to explore the interrelationships between these indicators and understand the mechanisms through which these factors influence the effectiveness of innovation and entrepreneurship education.

3.2.2. Model fit testing

To evaluate the fit of the SEM, we used various fit indices, including chi-square, comparative fit index (CFI), incremental fit index (IFI), and root mean square error of approximation (RMSEA). The results are shown in Table 6. As shown in Table 6, the χ^2 value is 320.45, with a p-value less than 0.05, indicating a good overall model fit. The CFI value is 0.92 and the IFI value is 0.93, both exceeding 0.90, which suggests good model fit. The RMSEA value is 0.045, below the threshold of 0.08, further indicating excellent model fit. These indices suggest that the model structure is reasonable and suitable for subsequent path coefficient analysis.

Table 5. Regression analysis statistics

Explanatory variables	Dependent variables	Standardized regression coefficients β-value	T-value	P-value
TQ	CD	0.35	5.12	<0.05
	PP	0.28	4.10	<0.05
	PS	0.31	4.56	<0.05
	SI	0.26	3.85	<0.05
CD	PP	0.32	4.79	<0.05
	PS	0.27	3.98	<0.05
	SI	0.24	3.64	<0.05
PP	TQ	0.29	4.24	<0.05
	CD	0.33	4.88	<0.05
	PS	0.30	4.34	<0.05
	SI	0.28	4.10	<0.05
PS	TQ	0.31	4.56	<0.05
	CD	0.34	5.01	<0.05
	PP	0.29	4.24	<0.05
	SI	0.27	3.98	<0.05
SI	TQ	0.25	3.70	<0.05
	CD	0.27	3.98	<0.05
	PP	0.26	3.85	<0.05
	PS	0.24	3.64	<0.05

Table 6. Model fit testing

Fit indices	Value	Criteria
χ 2	320.45	p<0.05
CFI	0.92	>0.90
IFl	0.93	>0.90
RMSEA	0.045	<0.08

3.2.3. Path coefficient analysis

Table 7 presents the standardized path coefficients (β), standard errors (SE), t-values, and p-values for each path in the SEM. As shown in Table 7, all t-values for the paths are greater than 1.96, and all p-values are less than 0.05, indicating that these path coefficients are statistically significant. This means that there are significant interrelationships between TQ, CD, PP, PS, and SI. TQ has the greatest impact on CD, PP, and PS, with standardized path coefficients of 0.35, 0.28, and 0.31, respectively. CD has a considerable impact on PP, with a standardized path coefficient of 0.32. From the above analysis, it can be concluded that TQ and CD are the key factors influencing the effectiveness of innovation and entrepreneurship education. Through the SEM analysis, this study verifies the significance of the primary indicators and reveals the complex interrelationships between TQ, CD, PP, PS, and SI. This provides important theoretical and empirical support for improving the effectiveness of innovation and entrepreneurship education in applied universities.

Table 7. Path coefficient analysis statistics

Items	Path	Standardized path coefficients (β)	SE	T-value	P-value
TQ	CD	0.35	0.05	7.00	<0.05
	PP	0.28	0.06	4.67	<0.05
	PS	0.31	0.05	6.20	<0.05
	SI	0.26	0.06	4.33	<0.05
CD	PP	0.32	0.05	6.40	<0.05
	PS	0.27	0.06	4.50	<0.05
	SI	0.24	0.05	4.80	<0.05
PP	TQ	0.29	0.05	5.80	<0.05
	CD	0.33	0.06	5.50	<0.05
	PS	0.30	0.05	6.00	<0.05
	SI	0.28	0.06	4.67	<0.05
PS	TQ	0.31	0.05	6.20	<0.05
	CD	0.34	0.05	6.80	<0.05
	PP	0.29	0.06	4.83	<0.05
	SI	0.27	0.06	4.50	<0.05
SI	TQ	0.25	0.05	5.00	<0.05
	CD	0.27	0.05	5.40	<0.05
	PP	0.26	0.06	4.33	<0.05
	PS	0.24	0.06	4.00	<0.05

4. CONCLUSION

TQ is a critical factor in innovation and entrepreneurship education. This study investigated the impact of TQ on innovation and entrepreneurship education. We found that TQ, which includes TA, PE, and IS, significantly impacts these areas. High-quality teachers not only impart theoretical knowledge but also inspire students' enthusiasm for innovation and entrepreneurship through their extensive PE and IS. Therefore, enhancing TQ, particularly by improving their PE and IS, is crucial for the effectiveness of innovation and entrepreneurship education. Our study highlights the importance of CD, which encompasses CC, TM, and II. We found that a well-designed curriculum significantly influences these areas, providing students with systematic knowledge of innovation and entrepreneurship. By employing diverse TM and interdisciplinary courses, students' comprehensive and cross-disciplinary innovative abilities are enhanced. Therefore, optimizing CD, with a focus on combining theory and practice, is vital for improving the quality of innovation and entrepreneurship education.

The significant role of PP. Our findings indicate that PP, such as on-campus training bases, business incubators, and university-industry collaborations, play a significant role in innovation and entrepreneurship education. We found that PP provide students with real entrepreneurial environments and practical opportunities, facilitating the translation of theoretical knowledge into practical skills. Thus, developing robust innovation and entrepreneurship PP is essential for promoting university-industry collaboration and enhancing the effectiveness of this education.

The necessity of PS. This study underscores the necessity of PS, which includes funding, PI, and motivational measures. We found that government and school PS significantly impact these areas by providing resource guarantees for innovation and entrepreneurship education. This motivates students and teachers to actively participate in these activities. Therefore, to promote the development of innovation and entrepreneurship education, governments and universities should enhance PS, increase funding and favorable policies, and improve incentive mechanisms.

The impact of SI. Our study reveals that SI, such as G, AB, and FE, significantly influence various aspects of innovation and entrepreneurship education. We found that students with entrepreneurial family backgrounds and better economic conditions tend to perform better in these educational programs. Consequently, universities should acknowledge individual differences, offer personalized educational support, and guide students from diverse backgrounds to realize their potentia. This study explored a range of factors, including TQ, CD, PP, and PS, but further in-depth research may be needed to confirm it is results, especially in terms of the interactions between secondary indicators. Future studies may explore PP and PS with feasible ways of producing better educational outcomes.

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