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Research Article

Triple helix model and its influence on engineering innovation: A study of higher vocational students in China

Yuan Bo Xue[1] and Ooi Boon Keat[2]

[1]*Graduate School of Management, Management and Science University, Malaysia (ORCID: 0009-0007-6773-258X)*
[2]*School of Education and Social Sciences, Management and Science University, Malaysia (ORCID: 0000-0001-8002-1685)*

This study investigates the direct effects of theoretical teaching methods, practical teaching methods and school-enterprise cooperations on engineering innovation ability among higher vocational education students in Henan, China. Using the Triple Helix Model as a framework, the research examines the dynamic collaboration between academia, industry and government in fostering innovation ecosystems within engineering education. Data from 409 students across 13 vocational institutions were analysed using Structural Equation Modelling via AMOS. The findings from hypothesis testing provide clear insights with theoretical teaching methods having a weak and statistically insignificant effect on engineering innovation ability, highlighting the need for more practical integration, practical teaching methodologies show a significant positive effect on engineering innovation ability and reinforcing the value of hands-on, application-based learning in fostering innovation. Moreover, school-enterprise cooperation demonstrates the strongest positive effect on engineering innovation ability, reinforcing the critical role of real-world industry partnerships in enhancing students' innovative capabilities. These findings offer valuable insights for policymakers, educators and industry stakeholders in Henan, suggesting a focus on practical, collaborative approaches to better prepare graduates to meet the dynamic demands of the technological landscape.

Keywords: Engineering innovation ability; Practical teaching methods; School-enterprise cooperation; Theoretical teaching methods; Triple helix model

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1. Introduction

Henan is situated in the heart of China's central plains and has long been recognised for its strategic importance in the education sector, building on a rich legacy of craftsmanship and innovation to become a key contributor to China's vocational education system and engineering industrial output (Wu et al., 2022). Home to approximately 15% of the nation's vocational institutions, with over 150 higher vocational colleges serving more than 400,000 students annually (Ministry of Education of the People's Republic of China, 2020), these institutions are pivotal in supplying skilled talent to diverse engineering-dominated industries, including machinery, electronics and renewable energy (Zhang et al., 2021). This system underpins Henan's impressive industrial output growth of 7.3% annually (Ministry of Education of the People's Republic of

Address of Corresponding Author

Ooi Boon Keat, PhD., School of Education and Social Sciences, Management and Science University, 40100 Shah Alam, Selangor, Malaysia.

bkooi@msu.edu.my

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China, 2020) and facilitates local employment for about 70% of vocational graduates, thanks to training aligned with industry demands (Zhang et al., 2021). However, a notable skills gap persists between vocational training and evolving industry competencies, particularly in green technology and advanced manufacturing, as traditional teaching methods often lack the innovation-oriented practices necessary for modern industries (Yan, 2022). Consequently, engineering innovation is increasingly vital for Henan's development as an industrial hub and its commitment to sustainable industries (Henan Provincial Development and Reform Commission, 2021; Yang et al., 2019), amplifying the demand for innovative engineers.

In response to this demand, Henan's vocational system has initiated innovation platforms and school-enterprise cooperations [SEC], though their full potential in cultivating engineering innovation ability [EIA] warrants further investigation. The Triple Helix Model, which examines university-government-industry collaboration, provides a robust framework for fostering such innovation (Ranga & Etzkowitz, 2013; Wu & Siswanto, 2020). Research, including studies in China by Yang (2015), indicates that integrating academic expertise with industrial practices under government support, especially through SEC, can significantly enhance students' EIA by exposing them to practical challenges. Therefore, this study employs the Triple Helix Model dimensions including theoretical teaching methods [TTM] from universities, practical teaching methods [PTM] supported by government and SEC facilitated by industry to explore their influence on EIA within Henan's higher vocational education. By concentrating on Henan's distinct socio-economic and industrial landscape, this research aims to offer novel insights into advancing vocational education and better equipping engineering graduates with both employable skills and the essential innovative capabilities for a rapidly evolving industrial environment.

2. Triple Helix Model on Engineering Innovation Ability

The Triple Helix Model was introduced by Leydesdorff and Etzkowitz (1996) and represents one of the most widely used models to explain and understand how innovation is fostered. This model theorises the dynamic interactions between government, academia and industry as fundamental to knowledge production, innovation and social evolution (Galvao et al., 2019). In contrast to conventional linear models of innovation that often focus solely on one field in isolation, this model addresses the intertwining dynamics that promote innovation ecosystems The model's academic roots lie in innovation studies across the fields of sociology and economics. Drawing from systems theory and evolutionary economics, Leydesdorff and Etzkowitz (1996) emphasised the importance of interaction among institutional actors in promoting economic development. Over time, the framework has evolved to address the complexities of modern innovation systems, focusing on decentralised mechanisms of knowledge production and the entrepreneurial role of universities, moving beyond traditional hierarchical structures (Cai & Etzkowitz, 2020). Each component of the Triple Helix Model including government, academia (University) and industry has distinct yet complementary functions. Government establishes policies and infrastructure, acting as both a facilitator and regulator. Academia serves as the knowledge producer, conducting fundamental and applied research to deepen understanding and generate new technologies. Meanwhile, industry monetises these innovations, translating academic work into marketable products and services. Collectively, these components form a dynamic system essential for innovation stimulation (Cai & Etzkowitz, 2020).

According to Zuo (2014), EIA is a key objective of many engineering programmes, yet traditional academic approaches often fall short in fostering it. Zuo's (2014) Double Triple Helix Model expands the framework by incorporating additional collaborative dimensions to address the challenges of contemporary engineering education, as this adaptation illustrates the model's flexibility and its capacity to tackle sector-specific issues effectively. Rodrigues et al. (2016) demonstrate the model's practical value through its application to technology transfer activities in Minas Gerais, Brazil, finding how leveraging government-university-industry relationships would foster innovation and economic growth. However, they also point out the need for more systematic, bottom-up approaches to overcome knowledge transfer bottlenecks in underdeveloped innovation ecosystems due to the model's capability in translating academic research into practical applications, particularly in engineering. Moreover, Faria et al. (2019) argue that the model, while under-theorised, offers in-depth insights into how public policies can enhance research and development (R&D) in academia and industry, as their economic model show that government interventions can stabilise collaborative dynamics, encouraging private firms to invest in joint R&D while supporting academia's role as a knowledge generator, demonstrating that the balance between theoretical understanding and technological application is critical for driving engineering advancements.

Kim et al. (2021) examined the implementation of the Triple Helix Model in South Korean universities across engineering departments, finding the model's effectiveness in facilitating knowledge transfer and strengthening government-industry-academia collaborations, given that South Korea's engineering success stems from this culture of collaboration, which has further driven the development and adoption of advanced technologies both locally and internationally. Kim et al. (2021) also highlighted the key role of engineering faculties as bridges between scholarly research and industrial applications, contributing to addressing modern engineering challenges. Feola et al. (2019) expands on the model's relevance, framing the transformation of higher education through the critical roles of institution building, market development and intellectual property protection in fostering innovation. In engineering, these factors ensure that innovations are developed and also safeguarded for successful commercialisation. Feola et al.'s (2019) work reinforces the importance of an entrepreneurial mindset within academia, advocating for research outputs to align with industry needs and government priorities. Studies by Rodrigues et al. (2016) and Kim et al. (2021) offer concrete examples of the model's application in engineering education and innovation systems, as mechanisms such as joint research centres, internships and technology parks are found to facilitate collaboration between universities and industries under indirect government governance. These initiatives are found to enhance the skills and portfolios of engineering students as well as encouraging interdisciplinary collaboration and self-directed learning, effectively bridging the gap between academic inquiry and practical application that directly contribute to improving EIA.

2.1. Theoretical Teaching Methods on Students' Engineering Innovation Ability

In the Triple Helix Model, universities are identified as knowledge-generating institutions that contribute significantly to innovation ecosystems through their academic functions (Hailu, 2024). TTM is a central manifestation of this role, representing the university's emphasis on knowledge creation and dissemination that stimulates critical thinking (Song, 2024). TTM encapsulates the structured delivery of foundational theories and methodologies that underpin students' understanding of complex engineering concepts, preparing them for innovation-driven environments. These methods represent the academic dimension of the model, focusing on the dissemination of foundational knowledge and critical thinking skills through interdisciplinary understanding across a variety of lectures, research-based learning and the integration of theoretical concepts that form the basis of EIA. Furthermore, Diez-Pascual et al. (2018) emphasised on the indispensability of theoretical foundations, illustrating how theoretical principles in photovoltaic energy engineering can serve as the scaffolding for applied innovation through emphasising the alignment of theoretical knowledge with real-world challenges, their findings illustrate how academic dimensions directly contribute to the innovative capabilities of students. Similarly, Daaif et al. (2019) advocated for integrating advanced theoretical teaching tools such as three-dimensional digital modelling to bridge the gap between abstract concepts to enhance innovation across practical applications, exemplifying how theory-oriented teaching, when contextualised within university resources and environments become instrumental in fostering adaptability and an innovative spirit among students.

Henkel et al. (2015) provided further evidence by demonstrating how theoretical underpinnings in bioprocess engineering are essential for developing innovative mindsets. While their work focuses on practical exposure, the theoretical discourse remains indispensable for equipping students with the cognitive tools to comprehend and innovate within complex engineering domains, whereby theoretical instruction provided the critical guidelines necessary for students to engage effectively with multidisciplinary challenges, thus enhancing their capacity for innovation. Sunderland et al. (2014) explored into engineering ethics, illustrating how theoretical methodologies when paired with iterative feedback mechanisms, refine a student's ability to think critically and innovatively. Their findings indicate that theoretical instruction, coupled with reflection and real-world application, serves as a catalyst for producing innovative thinkers equipped to tackle global engineering challenges. Towns and Ashby (2014) further assert that applications of theoretical constructs, particularly in rural engineering planning, deepen students' understanding and bolster their ability to translate abstract principles into innovative solutions. The relationship between TTM and EIA in particular lies at the intersection of theoretical knowledge dissemination and the cultivation of innovative problem-solving abilities as emerging research often recognises the synergy between these two dimensions, with theoretical teaching serving as the foundation for innovation.

Chen et al. (2020) exemplify this dynamic through their study on STEM teaching in the Internet of Things [IoT] Maker Course and propose an integrated teaching model that marries theoretical principles with hands-on learning, demonstrating how iterative engagement with theory and practice amplifies students' capacity for innovation. This approach emphasised the role of TTM in fostering innovative awareness by providing students with a deep understanding of engineering principles, which they can then apply in novel ways. Huang et al. (2021) further elaborated on this relationship by focusing on problem-oriented training in rural innovation workshops, finding that when students are immersed in real-world challenges, theoretical knowledge becomes a springboard for creative solutions. The application of theory to practical scenarios enhances their divergent thinking abilities, organisational skills and propensity for innovation as this direct relationship between TTM and EIA reinforces the university's pivotal role in fostering engineering-specific innovation. However, Zhang et al. (2021) criticise traditional engineering education for often isolating theoretical knowledge from its application, as their design-based learning approach integrates theoretical teaching with tangible outcomes, enabling students to foresee and achieve innovative solutions through ensuring that students are not only proficient in theoretical principles but also adept at using them innovatively, this approach strengthens the bond between TTM and EIA.

Shan et al. (2023) took this further by demonstrating how theoretical teachings, when intertwined with insights from research projects, equip students with advanced innovative capabilities. Their findings suggest that theoretical instruction offers the cognitive scaffolding necessary for understanding engineering principles, while practical insights sharpen students' ability to apply these principles inventively where the synthesis of these elements creates a foundational pathway for fostering innovation. Cheng et al. (2019) similarly highlighted that while theoretical knowledge is foundational, it must be complemented by practical experiences to truly stimulate an innovative ethos within engineers. Revilla-Cuesta et al. (2020) reaffirm the value of multi-stage feedback in engineering education, demonstrating how theoretical instruction, coupled with iterative feedback, leads to the refinement of innovative engineering solutions, as this iterative process enables students to continually enhance their theoretical understanding and practical applications, fostering a deeper integration of TTM with EIA. Therefore, based on these empirical knowledge and findings, we hypothesise that TTM has a direct and significant relationship with EIA of students.

Hypothesis 1: TTM has a significant positive effect on students' EIA in higher vocational education.

2.2. Practical Teaching Methods on Students' Engineering Innovation Ability

Government is one of the three key components of the Triple Helix Model tasked with shaping the broader structural and policy environment necessary for innovation (Cai & Etzkowitz, 2020). PTM are an appropriate representation of government within this framework as they embody the tangible impact of governmental policies and funding on educational practices, whereby through PTM, governments operationalise their role in aligning educational systems with national and industrial needs to foster a skilled and innovative workforce (Mandrup & Jensen, 2017). Governments frequently establish and support practical teaching initiatives through funding, infrastructure and regulatory frameworks, ensuring that education is not only theoretical but also aligned with real-world applications. According to Li et al. (2022), long-term educational frameworks like the 2P3E4R system are underpinned by government policies, have proven effective in driving sustainability-focused teaching practices, as these initiatives demonstrate the government's ability to embed practical components into education, ensuring that learning outcomes are aligned with societal and industrial demands. Moreover, PTM reflects the government's role in fostering collaboration between academia and industry, representing a core principle of the Triple Helix Model likewise to Henkel et al.'s (2015) discussion on the importance of hands-on training programmes, often supported by government policies, in equipping students with the skills needed to innovate within complex domains.

The relationship between PTM and innovation had received considerable academic attention, consistently emphasising how hands-on, application-oriented pedagogies fostered creative thinking and problem-solving abilities in students. Huang et al. (2021) demonstrated the impact of "Rural Innovation Workshops" within college-level rural planning courses, highlighting their effectiveness in enhancing students' divergent thinking abilities and practical skills. These workshops provided an immersive environment where students engaged with real-world problems, fostering their capacity for innovative solutions. However, the scalability and adaptability of such workshops across disciplines remained areas of inquiry. Similarly, Chang (2018) examined how educators' integration of innovative knowledge approaches in tourism and hospitality education influenced students' creative self-efficacy and innovation behaviours. This study revealed that teaching methodologies promoting active engagement significantly shaped students' ability to think creatively. Such findings reinforced the importance of aligning pedagogical strategies with objectives that fostered innovation at an individual level. Mayhew et al. (2021) introduced a temporal perspective by investigating the impact of short-term interventions in leadership courses. These interventions led to a noticeable enhancement in students' innovative capacities, suggesting that even transient shifts in pedagogical strategies had substantial effects on creative thinking. However, the study also noted the need to explore whether these interventions translated into sustained innovation behaviours beyond academic contexts.

Contemporary pedagogical techniques, such as gamification, were also shown to foster innovation. Montenegro-Reuda et al. (2023) examined gamified teaching approaches and their influence on student engagement and creativity. While their findings indicated that gamification could effectively stimulate innovation, they cautioned against equating immediate engagement with deep-rooted innovative outcomes, calling for further research to explore long-term effects. From a systemic perspective, Li et al. (2022) presented the 2P3E4R system, a government-backed model designed to integrate practical teaching with sustainable development principles. Practised for over a decade, this model highlighted how structured and sustained PTM initiatives fostered innovation across diverse educational landscapes. The longevity and adaptability of such systems, however, remained critical considerations as the educational context evolved. Diez-Pascual et al. (2018) also stressed the indispensability of practical teaching in promoting innovation, using simulation tools in photovoltaic energy engineering to illustrate how real-world scenarios honed students' innovative capabilities. Similarly, Daaif et al. (2019) introduced three-dimensional digital modelling in chemistry education, demonstrating how innovative practical teaching tools enhanced students' adaptability and innovative spirit. These studies collectively validated the role of PTM in fostering creativity, critical thinking and problem-solving skills, all of which were essential for innovation.

In relation to the context of engineering, Henkel et al. (2015) examined the teaching of bioprocess engineering through a week-long practical course, emphasising how hands-on exposure to complex engineering concepts fostered an innovative ethos among students. Their findings aligned with broader literature that positioned experiential learning as a key driver of engineering-specific innovation. Sunderland et al. (2014) extended this perspective by incorporating iterative feedback mechanisms in engineering ethics education. Their approach integrated theoretical knowledge with practical application, enabling students to continually refine their understanding and problem-solving abilities. The study highlighted how feedback, rooted in real-world contexts, contributed to the development of innovative engineering solutions. In the realm of rural planning, Towns and Ashby (2014) reinforced the synergy between theoretical constructs and their application through practical teaching. Their phenomenological study demonstrated how practice educators enhanced students' ability to bridge theoretical knowledge with real-world challenges, ultimately fostering engineering innovation. Similarly, Diez-Pascual et al. (2018) and Daaif et al. (2019) illustrated how simulation tools and digital modelling, respectively, prepared students for the complexities of engineering tasks, equipping them with the skills necessary to innovate. Huang et al. (2021) provided additional insights into the role of problem-oriented training in engineering education, showing how immersive workshops enabled students to apply theoretical principles in practical scenarios, thereby enhancing their EIA. Moreover, the multi-stage feedback teaching mode described by Montenegro-Reuda et al. (2023) and Mayhew et al. (2021) further emphasised the iterative nature of PTM in refining students' engineering concepts through continually testing and improving their ideas, students developed the innovative mindset necessary for tackling real-world engineering challenges. Therefore, based on these empirical knowledge and findings, we hypothesise that PTM has a direct and significant relationship with EIA of students.

Hypothesis 2: PTM has a significant positive effect on students' EIA in higher vocational education.

2.3. Industry: School-enterprise cooperation

In the Triple Helix Model, industry serves as the driving force behind innovation, tasked with transforming academic knowledge into practical solutions that benefit society (Cai & Etzkowitz, 2020). SEC is widely used in empirical studies as a representation of this role, showcasing how industries and educational institutions collaborate to align theoretical education with real-world needs (Chanthes, 2022; Dudin et al., 2015). These partnerships provide students with hands-on experiences while enabling industries to benefit from academic research, creating a dynamic exchange that fosters innovation. The rationale for using SEC as a proxy for industry lies in its unique ability to bridge the academic-industrial divide. Leydesdorff and Etzkowitz (1996) discussed industry's vital role in innovation ecosystems, particularly in translating knowledge into market-ready applications, whereby SEC facilitates this translation by immersing students in industrial environments where they can apply their academic training. Dudin et al. (2015) described SEC as a mutually beneficial framework that allows industries to access academic insights while equipping students with practical, job-ready skills, directly supporting and enhancing the relevance of educational outputs to industrial demands. Beyond skill-building, SEC cultivates a mindset of innovation as collaborations with industry expose students to real-world challenges, prompting them to think creatively and solve problems effectively (Chanthes, 2022).

Empirical studies have repeatedly highlighted how these SEC partnerships foster an environment conducive to innovation, as Yao et al. (2023) demonstrated the importance of institutional support, such as the Innovation and Entrepreneurship Demonstration Bases [IEDB], in promoting collaboration between academia and industry. This research illustrated how SEC, underpinned by government initiatives, creates a spillover effect that fosters a culture of innovation across institutions. The synergy between academia and enterprises, a hallmark of SEC, was explored by Mandumpal et al. (2022) in the context of innovation-based learning. Although not explicitly focused on SEC, their findings reinforced the necessity of real-world applications to enhance innovative thinking. Enterprises provide these scenarios, enriching the academic curriculum with practical challenges that compel students to adopt creative problem-solving approaches. Similarly, Charosky et al. (2022) emphasised the diversity of pathways through which SEC fosters innovation competencies, highlighting how tailored collaborations can address varied aspects of the innovation spectrum. Wu and Siswanto (2020) extended this discussion to the broader triple helix framework, addressing the transformative potential of university-industry-government partnerships, as their findings reaffirmed the key role of industry in nurturing student innovation by offering real-world exposure and facilitating the transfer of advanced knowledge. Shi et al. (2021) specifically highlighted SEC's role in cultivating innovative talent in engineering, illustrating how strategic partnerships prepare students to address contemporary challenges through hands-on experience.

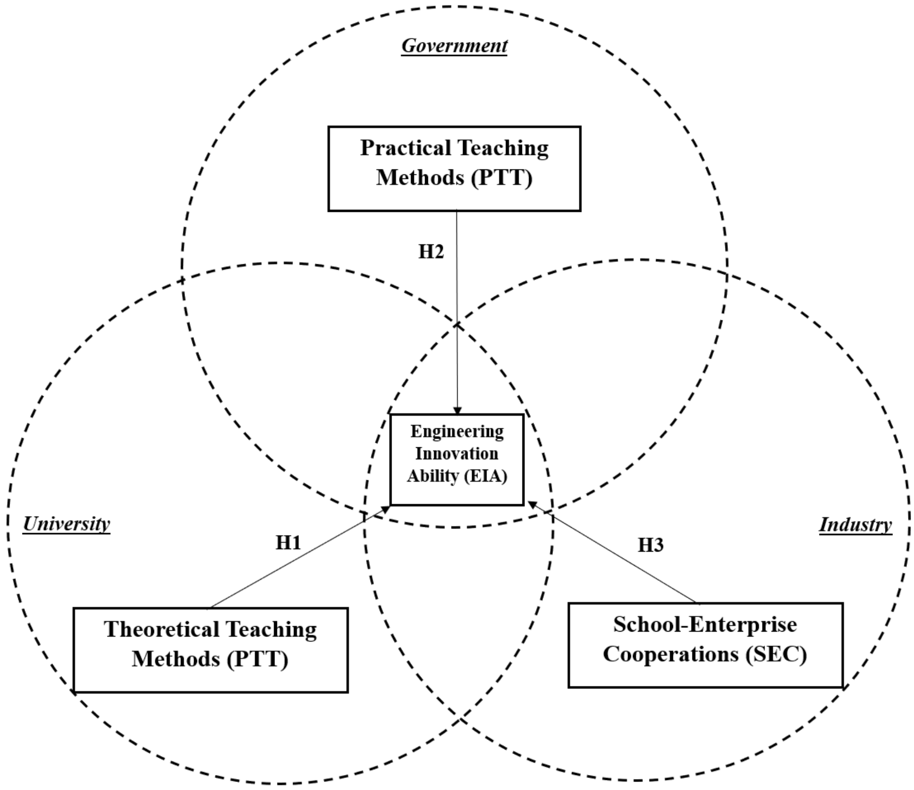
The practical impact of SEC on EIA was further validated by Costa et al. (2021) in the renewable energy sector. Their study revealed that collaborations between universities and industries provided students with access to cutting-edge technologies, fostering an innovative mindset aligned with real-world demands. Yang (2015) corroborated these findings, demonstrating that SEC initiatives significantly enhanced innovation among vocational students in Heilongjiang, China. The exposure to industrial practices, coupled with academic support and government policy, equipped students to innovate effectively, particularly in prototyping and ideation. Ranga and Etzkowitz (2013) offered a theoretical blueprint for understanding SEC's role in innovation. Their research showed that the convergence of academic and industrial expertise, supported by governmental frameworks, facilitated effective knowledge transfer. This integration not only bolstered students' innovative capacities but also laid the foundation for sustainable educational ecosystems. Similarly, Cai and Amaral (2021) observed that SEC improved students' domain-specific skills, enhancing their industry readiness and ability to address traditional challenges with innovative solutions. Despite its proven benefits, some challenges associated with SEC were highlighted. Gadasina et al. (2022) pointed out issues such as misaligned goals and communication gaps between academia and industry. These discrepancies, while not diminishing the value of SEC, suggest the need for more structured approaches to maximise its potential in fostering innovation. Therefore, based on these empirical knowledge and findings, we hypothesise that SEC has a direct and significant relationship with EIA of students.

Hypothesis 3: SEC has a significant positive effect on students' EIA in higher vocational education.

2.4. Research Conceptual Framework

The Triple Helix Model serve as the foundational framework in this study to measure the impacts on EIA through three dimensions including TTM representing universities, PTM representing government and SEC representing industry. The conceptual framework as shown in Figure 1 integrates these dimensions to examine how their individual and collective contributions influence the development of EIA in higher vocational education, positing that TTM (H1), primarily focused on disseminating foundational engineering knowledge, forms the academic basis of innovation by equipping students with critical thinking and theoretical understanding to improve EIA. PTM (H2), driven by policy and government-supported initiatives, provides hands-on, application-oriented learning that bridges theoretical knowledge with real-world scenarios to improve EIA. SEC (H3) links students with industry, exposing them to practical challenges and fostering innovation through collaborative projects, internships and exposure to cutting-edge technologies that enhances EIA.

Figure 1
Research conceptual framework



Note. Illustrates the research conceptual framework, depicting how TTM representing universities, PTM representing government and SEC representing industry are hypothesised to influence EIA.

3. Method

3.1. Research Design

In this study, we collected quantitative data across the three dimensions of the Triple Helix Model including TTM, PTM and SEC and how it influenced EIA among final-year students in higher vocational institutions in Henan, China. This study employed a quantitative, cross-sectional survey design and data were analysed using Structural Equation Modelling [SEM], as detailed in the data dialysis section. Moreover, this study adopts a positivist philosophy, assuming that while an objective reality exists, the understanding of it is developed through empirical evidence and is subject to ongoing refinement. A deductive research approach was employed, where hypotheses were derived from the existing Triple Helix Model and prior empirical studies to be tested against newly collected data.

3.2. Participants

The target population consisted of final-year engineering students from 13 high-level vocational institutions in Henan, identified for their strong industry-education integration. These institutions collectively enrol approximately 48,000 engineering students annually, as reported by the Department of Education of Henan Province (2023). Final-year students were selected as they would have accumulated sufficient exposure to the teaching methodologies and cooperative programs under investigation and are closest to transitioning into the engineering workforce. Given the impracticality of surveying the entire population, a purposive sampling approach was used to focus on students from institutions demonstrating effective SEC, regional significance and strong employment outcomes, focusing on inclusion of participants representative of the study's aims. While purposive sampling is effective for targeting specific populations, it may introduce selection bias. To mitigate this, deliberate efforts were made to include a diverse range of 13 institutions representing various engineering programs and geographical locations within Henan. This diversity helps to capture a broader spectrum of student experiences and institutional practices pertinent to industry collaboration and teaching methodologies. Using Yamane's (1967) formula with a 5% margin of error, a minimum of 397 valid responses were calculated and 409 participants were recruited to achieve statistical reliability. Data were collected through structured online surveys and analysed using SEM in AMOS. The inclusion and exclusion table for participants is shown in Table 1.

Table 1
Inclusion and exclusion table

Criteria type	*Description*
Inclusion	• Final-year engineering students. • Enrolled in one of 13 selected Henan higher vocational institutions. • Attending institutions with effective SEC, regional significance and strong employment outcomes. • Provided informed consent for survey participation.
Exclusion	• Not final-year engineering students. • Not enrolled in one of the 13 selected Henan institutions. • Enrolled in non-engineering programs.

Note. The specific inclusion and exclusion criteria used to define the selection of final-year engineering students from 13 designated Henan higher vocational institutions for this study.

The participant profile comprised 409 engineering students from 13 vocational institutions in Henan. The majority were aged 18–20 (59.4%) and male (66.5%). Most students reported academic performance within the 3.1–4.0 GPA range (60.4%) and 77.5% anticipated employment post-graduation as summerised in Table 2.

Table 2
Henan engineering students' profile

Student profile	*Frequency(N=409)*	*Percentage (%)*
Age		
18-20	243	59.4
21-23	117	28.6
24-26	27	6.6
27 and above	22	5.4
Gender		
Male	272	66.5
Female	137	33.5
Academic performance		
Below 2.0	27	6.6
2.0-2.5	36	8.8
2.6-3.0	93	22.7
3.1-3.5	104	25.4
3.6-4.0	143	35.0
Employment after graduation		
Yes	317	77.5
No	92	22.5

3.3. Measures and Instrument Development

The data collection instrument represents a structured online survey comprised of several sections designed to measure the key constructs. EIA acted as the dependent variable and TTM, PTM, SEC as independent variables. All items for these constructs were rated on a five-point Likert scale, anchored from 1 (Strongly Disagree) to 5 (Strongly Agree).

3.3.1 Dependent variable - EIA

Our dependent variable EIA represents students' ability to generate creative engineering solutions, apply knowledge in practical contexts and innovate within their fields. To measure EIA, we developed a self-assessment questionnaire adapted from existing studies, primarily Albayrak-Serin and Yalciner (2021), whose work focused on engineers' perspectives on innovation and Industry 4.0. The adaptation involved reviewing original items for relevance to the Henan vocational education context, followed by rephrasing items to reflect student-level innovative activities and problem-solving within academic projects or internships typical of vocational training, rather than broader professional engineering or advanced Industry 4.0 scenarios. For instance, students rated items such as their problem-solving skills in coursework, critical thinking abilities when faced with technical challenges and capacity for applying engineering principles learned in a vocational setting using a five-point Likert scale. The core concept of assessing innovative capacity was maintained, but the language and examples were tailored to be accessible and relevant to the experiences of higher vocational students.

3.3.2. Triple helix variables (Independent variables)

We selected three independent variables to represent the Triple Helix Model components. To capture the role of universities, we focused on TTM as a measure of the theoretical knowledge imparted to students. This was assessed through survey items examining curriculum depth, lecture quality and alignment with industry demands, drawing on and adapting from existing questions from Frick et al. (2007). Frick et al. (2007) provided general scales for teaching and learning quality. For this study, these general items were contextualised to specifically address the theoretical engineering subjects within Henan's higher vocational education. Modifications included ensuring items reflected the students' experience with the structure and delivery of foundational theories and how these related to the practical demands of local industries.

To examine the government's role, PTM reflects hands-on learning opportunities facilitated through policies and infrastructure. Items measured the availability and quality of lab experiments, simulations and practical training as inspired by Walker and Rocconi's (2021) study on experiential learning. The adaptation involved tailoring broader concepts of experiential learning to the specific practical training environments of Henan's vocational institutions. For example, general items about hands-on activities were focused to inquire about the effectiveness of specific lab equipment, simulation software and workshop sessions relevant to the engineering disciplines common in these colleges.

To accurately measure industry involvement, we measured SEC using questions about internships, collaborative projects and industry-integrated curricula, adapting from questions used by Yang (2015). Yang's (2015) work also focused on school-enterprise cooperation and vocational students in a Chinese context (Heilongjiang), making it highly relevant. The adaptation for the Henan context involved ensuring the terminology for internships, types of enterprise collaborations and curriculum integration accurately reflected the specific SEC models and practices prevalent in Henan's vocational sector, thereby providing regional applicability while leveraging a contextually similar foundational instrument.

The adaptation process for all scales involved careful review of original items for contextual fit within Henan's higher vocational engineering education. Items were rephrased where necessary to enhance understanding and relevance for the target student population, while ensuring the core constructs were preserved. Prior to full-scale data collection, the adapted questionnaire was pilot-tested with 30 engineering students from a non-participating vocational institution to refine item wording and ensure clarity. Feedback from the pilot test led to minor phrasing adjustments for five items. Additionally, the instrument was reviewed by two academic experts in engineering education in Henan to ensure content validity and relevance. The empirical literature support and the number of items for each measurement construct are summarised in Table 3.

Table 3
Empirical literature support for instrument development

Variable/ Measurement construct	*Literature support*	*Total questions*
EIA	Albayrak-Serin & Yalciner (2021)	20
TTM	Frick et al., (2007)	16
PTM	Walker & Rocconi (2021)	9
SEC	Yang (2015)	18

Note. The foundational empirical literature and the corresponding number of items used for the development of the measurement instruments for EIA, TTM, PTM and SEC.

3.4. Data Collection and Ethical Considerations

Data were collected through structured online surveys administered to the recruited 409 final-year engineering students across the 13 selected vocational institutions in Henan, China. Prior to participation, students were provided with information regarding the study's purpose, the voluntary nature of their involvement and assurances of anonymity and confidentiality of their responses. Informed consent was obtained from all participants by requiring them to agree to a consent statement at the beginning of the online survey. While formal institutional ethical review board approval was not mandated for this type of survey research in the participating institutions at the time of data collection, all procedures were conducted following MUS's ethical principles for research involving human subjects. This included ensuring no harm to participants and protecting their data through secure storage.

3.5. Data Analysis

Upon collection, the raw data from the online surveys were systematically reviewed for completeness and potential issues. This initial screening involved verifying that each of the 409 submitted questionnaires had sufficient responses across all critical sections pertaining to the independent (TTM, PTM, SEC) and dependent (EIA) variables. We specifically looked for instances of substantial missing data, for example, if a respondent left any questions unanswered this was flagged. Given the online format, validation rules were also implemented at the point of entry (ensuring responses were within the 1-5 range for Likert items and prompting for unanswered mandatory items) to minimise inadvertent omissions by participants during the survey completion process. This post-collection check served as a final verification to ensure the integrity of the dataset prior to statistical analysis. Survey responses were analysed using SPSS version 27 and AMOS version 24 statistical tool to measure the direct effects between the Triple Helix components and EIA. SEM using AMOS was chosen as it allows for the simultaneous examination of dynamic relationships among multiple latent constructs and their observed indicators, providing a comprehensive test of the proposed theoretical model.

The analysis began with descriptive statistics to summarise the data and establish preliminary trends through distribution means and standard deviations. Exploratory factor analysis was conducted including KMO and Bartlett's testing to confirm sampling adequacy, communalities testing to evaluate shared variance among items and total variance explained testing to assess construct dimensionality. Reliability was assessed using Cronbach's alpha to ensure internal consistency. Confirmatory Factor Analysis [CFA] followed to validate the measurement model. Model fit was assessed using indices such as Chi-square [CMIN], Degrees of Freedom [DF], relative Chi-square [CMIN/DF], Standardised Root Mean Square Residual [SRMR], Root Mean Square Error of Approximation [RMSEA], Tucker-Lewis Index [TLI], Comparative Fit Index [CFI], Parsimony Fit Index [PFI] and Parsimony Comparative Fit Index [PCFI]. AMOS structural modeling was then applied to examine the hypothesised relationships between TTM, PTM, SEC and EIA, identifying the relative strength and significance of each path. Final hypothesis testing using regression analysis quantified these effects.

3.5.1. Normality testing

The normality testing results in Table 4 indicate that all variables EIA, PTM, TTM and SEC fall within acceptable ranges of skewness and kurtosis, with skewness values between −0.37 and −0.7 and kurtosis values between −0.184 and 0.831. These results suggest that the data for all constructs exhibit a near-normal distribution, supporting the suitability of subsequent parametric analyses.

Table 4
Normality testing

Data set	*Skewness*	*Kurtosis*
EIA	−0.57	−0.184
PTM	−0.70	0.368
TTM	−0.42	0.831
SEC	−0.37	−0.127

Note. Skewness and kurtosis values for the composite scores of all variables confirmed for data normality.

4. Results

4.1. Descriptive Statistics

The descriptive statistics reveal insightful trends across the variables measured. These trends are shown in Appendix 1 comprised of all measurement items across measured independent and dependent variables. The mean, standard deviation and percentages of below/ above mean statistics are shown.

For EIA, the majority of responses across items indicated above-average scores with EIA8 and EIA16 yielding the highest means of 3.83 and 3.78, respectively, highlighting consistently strong perceptions of innovation ability among respondents. For PTM, the data indicate consistently high mean scores. PTM2 and PTM8 achieved the highest means at 3.89, followed by PTM1, PTM4 and PTM5 at 3.87, reflecting the significant value placed on these methodologies. The percentage of respondents scoring above the mean was notably high, ranging from 63.81% (PTM6) to 68.22% (PTM7), reinforcing the positive perceptions of PTM. Regarding TTM, the mean scores were similarly high, with TTM4 standing out at 3.86, followed by TTM3 and TTM7 at 3.83 each. These results emphasise the perceived effectiveness of theoretical methods in supporting engineering education. The proportion of respondents scoring above the mean ranged from 64.55% (TTM6) to 66.99% (TTM7) indicating strong overall approval. For SEC, SEC1 and SEC5 recorded the highest mean scores at 3.85, followed closely by SEC3 and SEC12 at 3.83 each. These findings highlight the key role of collaborations in fostering innovation. The percentage of respondents scoring above the mean was consistently high, ranging from 59.41% (SEC11) to 62.10% (SEC3), reflecting the importance of school-enterprise partnerships. Across all variables, the standard deviations ranged between approximately 1.00 and 1.14, indicating a moderate level of variation in responses. Furthermore, the proportion of respondents scoring above the mean remained consistently high, ranging from 59% to 68%, affirming the generally positive evaluations of all constructs.

4.2. Exploratory Factor Analysis, Validity and Reliability Testing

The results of the KMO and Bartlett's tests in Table 5 confirm the suitability of the data for factor analysis. The Kaiser-Meyer-Olkin Measure of Sampling Adequacy is 0.907, indicating excellent sampling adequacy, while Bartlett's Test of Sphericity yields a significant chi-square value of 1942.914 (df = 15, p < .001). These findings demonstrate that the data is well-suited for identifying underlying factor structures.

Table 5
KMO & Barlett's testing

Kaiser-Meyer-Olkin Measure of Sampling Adequacy.		0.907
Bartlett's Test of Sphericity	Approx. Chi-Square	1942.914
	df	15
	Sig.	< .001

Note. The KMO measure and Bartlett's Test of Sphericity results confirms the suitability of the data for factor analysis.

The communalities testing results presented in Table 6, derived through Principal Component Analysis reflect considerable shared variance among the variables. EIA shows the highest extraction value at 0.797, indicating its strong contribution to the factor structure. PTM and TTM follow closely with extraction values of 0.779 and 0.773, respectively. SEC also exhibits a robust communal value of 0.762, confirming that all variables are well-represented in the underlying factor model, demonstrating their meaningful contribution to the analysis.

Table 6
Communalities testing

	Initial	*Extraction*
EIA	1	0.797
PTM	1	0.779
TTM	1	0.773
SEC	1	0.762
Extraction Method: Principal Component Analysis.		

Note. The communalities testing results demonstrate considerable shared variance among the variables, confirming their contribution to the factor structure.

The results of the total variance explained testing in Table 7, using Principal Component Analysis, reveal a well-defined factor structure. Component 1 accounts for the highest variance, with an initial eigenvalue of 3.254, contributing 54.24% to the total variance. When combined with Component 2, which explains an additional 19.07% of the variance, the cumulative variance reaches 73.31%. The remaining components, while contributing smaller proportions (15.96% and 10.73%, respectively), collectively bring the cumulative variance to 100%, suggesting that the first two components capture the majority of the variance in the data, providing a strong foundation for subsequent analyses.

Table 7
Total variance explained testing

Component	*Initial Eigenvalues*			*Extraction Sums of Squared Loadings*		
	Total	*% of Variance*	*Cumulative %*	*Total*	*% of Variance*	*Cumulative %*
1	3.254	54.240	54.240	4.454	54.240	54.240
2	1.144	19.074	73.314			
3	0.957	15.957	89.271			
4	0.65	10.729	100.00			
Extraction Method: Principal Component Analysis.						

Note. The results indicate that the first two components account for the majority of the variance (73.314%), suggesting a well-defined factor structure.

The Cronbach's alpha results presented in Table 8 highlight excellent internal consistency across all constructs. EIA achieved a reliability score of 0.959 across 20 items, demonstrating strong coherence. PTM and SEC showed exceptional reliability with scores of 0.949 and 0.966, respectively, over 9 and 18 items. Similarly, TTM displayed robust internal consistency, achieving a Cronbach's alpha of 0.895 for its 9 items. These results confirm the reliability of the constructs, reinforcing their suitability for subsequent analysis.

Table 8
Cronbach's alpha

Construct	*No of questions*	*Cronbach's alpha*
EIA	20	.953
PTM	9	.949
TTM	9	.895
SEC	18	.966

Note. The high Cronbach's alpha values across all constructs shows excellent internal consistency and reliability of the measures used.

4.3. Confirmatory Factor Analysis

The CFA results presented in Table 9 indicate that the model does not exhibit an ideal fit according to standard criteria. Absolute fit indices show a high CMIN/DF value (213.454) and an RMSEA of 0.723, suggesting apparent discrepancies between the observed and predicted covariance matrices, while the SRMR of 0.292 is also above standard thresholds. Incremental fit indices including TLI (0.112) and CFI (0.444) are slightly below the commonly accepted threshold of 0.90, indicating limited improvement over the null model. Parsimony indices via PNFI and PCFI (both 0.222) highlight a lack of parsimony in the model. However, these results can be justified by the high sensitivity of chi-squared-based indices to sample size and the complexity of the model. Furthermore, the theoretical foundation of the model aligns with the research objectives and the analysis provides a basis for refining the measurement structure in subsequent iterations. Therefore, the results remain valuable for guiding further research and model development.

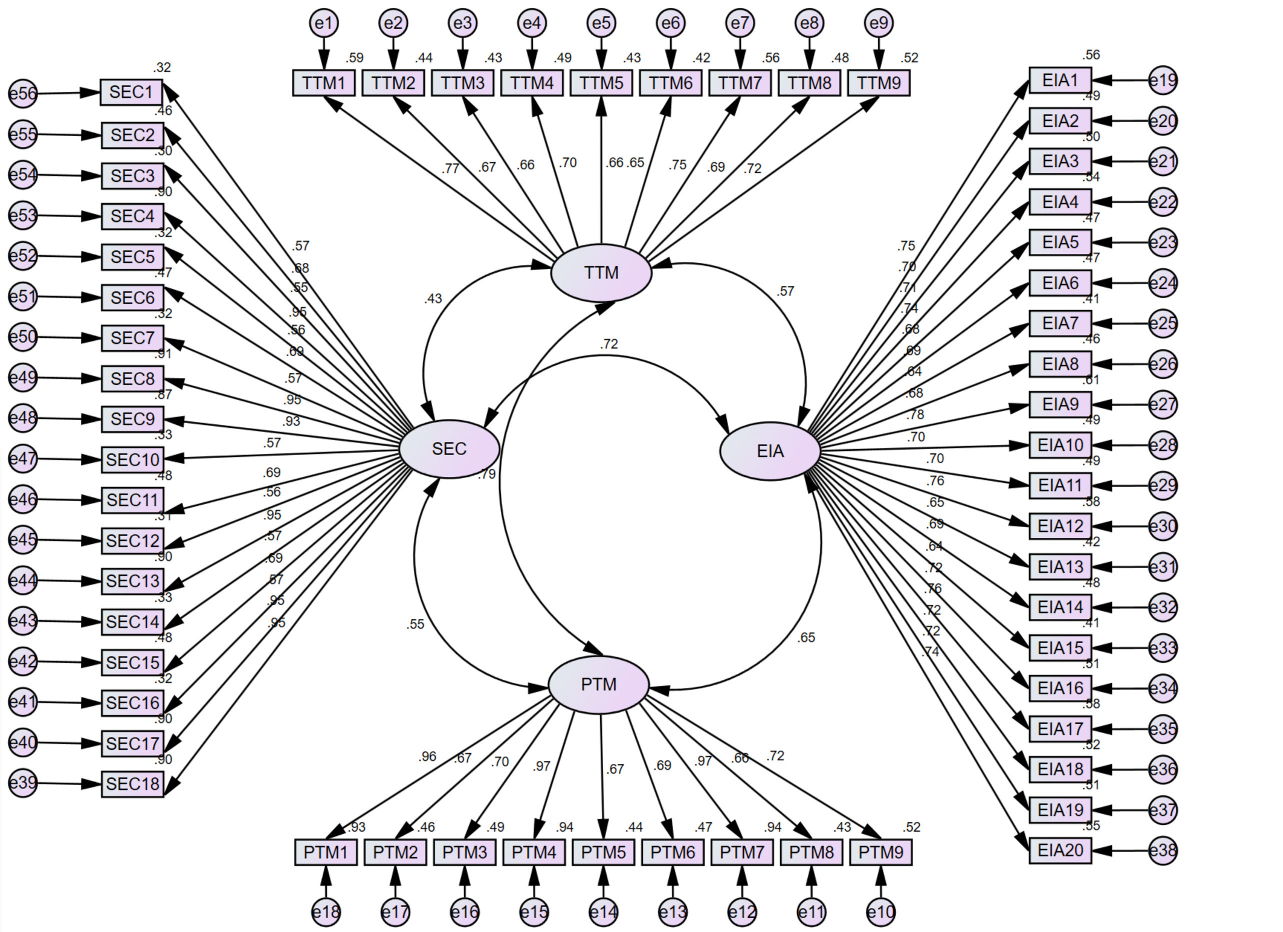
Table 9
CFA Index category and levels of fit

Goodness of fit indices		*Test statistics*
Absolute fit indices	CMIN	643
	df	3
	Chi-squared P-value	.001
	CMIN/DF	213.454
	SRMR	.292
	RM-SEA	.723
Incremental fit indices	TLI	.112
	CFI	.444
Parsimony fit indices	PNFI	.222
	PCFI	.222

Note. While some indices like CMIN/DF (213.454) and RMSEA (.723) suggest discrepancies, the CFA results provide a basis for model evaluation and potential refinement.

The CFA model in Figure 2 reveals significant patterns in the relationships between the constructs and their observed indicators. SEC shows strong factor loadings on its indicators (SEC1 to SEC18) ranging from 0.32 to 0.96, while TTM demonstrates strong loadings across its indicators (TTM1 to TTM9) with values from 0.42 to 0.77. Similarly, EIA and PTM exhibit strong loadings such as EIA10 at 0.74 and PTM1 at 0.93, confirming the validity of the constructs. The model also indicates meaningful covariances between the constructs with the relationship between SEC and TTM at 0.72, while the covariance between SEC and EIA is 0.79 suggesting a strong association between these dimensions. Additionally, SEC and PTM show a moderate covariance of 0.55 pointing to their interdependence. These covariances are again consistent with the theoretical framework, illustrating the interconnected nature of the constructs which confirm the robustness of the model, effectively reflecting the relationships between the constructs and their observed measures.

Figure 2
CFA model



Note. The CFA model presents the relationships between the latent constructs (SEC, TTM, EIA, PTM) and their respective observed indicator variables, as well as the covariances among the constructs.

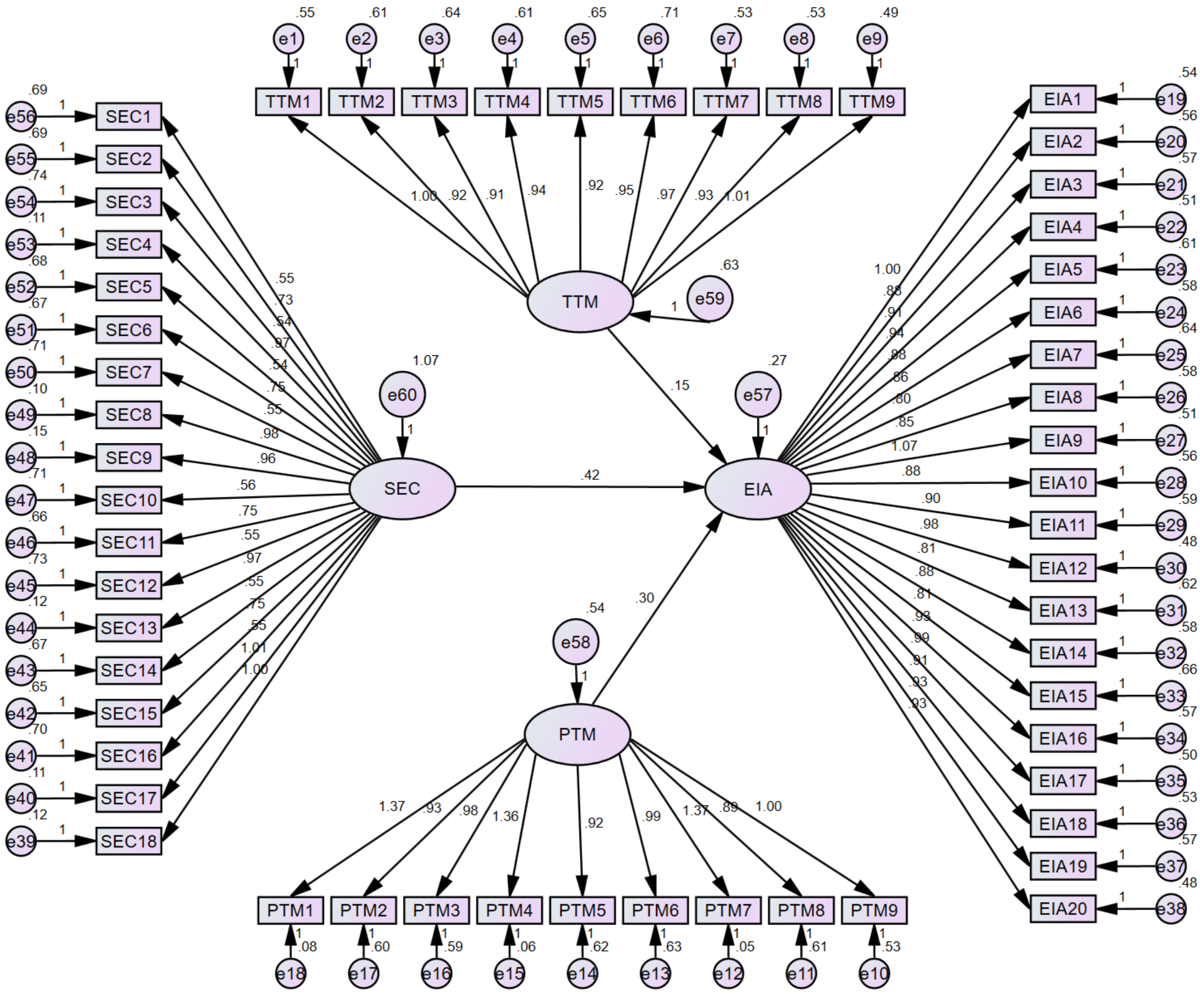
The structural model in Figure 3 demonstrates that SEC has the strongest impact on EIA (path coefficient = 0.42), followed by PTM (0.30), while TTM has a weaker influence (0.15). Factor loadings for most observed variables are strong with TTM ranging from 0.49 to 0.94, PTM from 0.59 to 1.37 and SEC from 0.11 to 1.07, though weaker contributions are evident for SEC17 (0.11) and TTM9 (0.49). These findings emphasise the influential role of practical and collaborative approaches in fostering innovation, while the lesser impact of TTM aligns with the shift toward experiential learning in education. Moreover, refining weaker indicators like SEC17 and TTM9 inn future studies could enhance measurement accuracy and the results provide a more solid theoretical foundation for promoting innovation through active collaboration and practical learning strategies.

4.4. Hypothesis Testing

The hypothesis testing results in Table 10 provide mixed support for the proposed hypotheses. Hypothesis 1 which posited that TTM has a significant positive effect on students' EIA, is not supported, as TTM shows a weak, statistically insignificant effect ($\beta = 0.073$, $t = 1.664$, $p = .097$). Hypothesis 2 is supported with PTM demonstrating a significant positive effect on EIA ($\beta = 0.222$, $t = 4.254$, $p < .01$), reinforcing the importance of hands-on and experiential learning in fostering innovation. Similarly, Hypothesis 3 is strongly supported as SEC exhibits the most substantial and highly significant effect on EIA ($\beta = 0.638$, $t = 17.806$, $p < .01$), emphasising the critical role of real-world collaborations in enhancing students' innovative capabilities. The findings reinforce the critical roles of practical teaching and school-enterprise partnerships in fostering innovation, while highlighting the limited direct impact of theoretical methods in this context amongst higher vocational education institutions in Henan.

Figure 3

AMOS structural model



Note. The direct effects of TTM (0.15), PTM (0.30) and SEC (0.42) on EIA, alongside the factor loadings for each observed variable.

Table 10

OLS Regression on EIA

Model		Unstandardised Coefficients		Standardised Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	0.423	0.115		3.685	<0.01
	PTM	0.195	0.046	0.222	4.254	<0.01
	TTM	0.071	0.043	0.073	1.664	.097
	SEC	0.587	0.033	0.638	17.806	<0.01
a. Dependent Variable: EIA						

Note. The regression results indicate that SEC has the strongest significant positive effect (Beta = 0.638, $p < .01$) on EIA, followed by PTM (Beta = 0.222, $p < .01$), while TTM shows a statistically insignificant effect (Beta = 0.073, $p = .097$).

5. Discussion

The findings reveal insightful implications for the role of TTM, PTM and SEC in fostering EIA within the framework of the Triple Helix Model. Hypothesis 1 which proposed a significant positive relationship between TTM and EIA, was not supported. This aligns with critiques such as those from Zhang et al. (2021), who argue that traditional theoretical methods often fail to integrate with real-world applications effectively. While TTM remains foundational for building students' cognitive frameworks, its lack of direct influence on EIA may reflect the need for greater alignment between theoretical principles and practical innovation demands, as suggested by Huang et al. (2021) and Shan et al. (2023). Conversely, Hypothesis 2 suggested a positive effect of PTM on EIA was confirmed. This finding reinforces empirical studies like Henkel et al. (2015) and Diez-Pascual et al. (2018), who argued how hands-on, application-focused teaching fosters innovation by bridging the gap between abstract knowledge and practical problem-solving. The statistical significance of PTM reinforces its influential role as a mechanism through which governments as outlined in the Triple Helix Model, can align educational practices with industrial and societal needs. Finally, Hypothesis 3, which posited that SEC significantly influences EIA, emerged as the most strongly supported. With the highest beta coefficient, SEC demonstrates its capacity to bridge academia and industry effectively, fostering innovation ecosystems as envisioned by Leydesdorff and Etzkowitz (1996). This finding is corroborated by empirical studies such as Yang (2015) and Yao et al. (2023), which illustrate the transformative potential of SEC initiatives in equipping students with real-world experience and industry-relevant skills. However, challenges such as misaligned objectives between academia and industry, as noted by Gadasina et al. (2022) addressed areas for improvement to maximise the benefits of such collaborations.

The empirical findings particularly the distinct efficacy of SEC (β=0.638) and PTM (β=0.222), necessitate a critical re-examination of prevailing strategic orientations within Henan's higher vocational education landscape. The strong influence of SEC aligns with extensive research emphasising how such partnerships foster innovation by bridging academic learning with real-world industrial demands (Chanthes, 2022; Dudin et al., 2015; Wu & Siswanto, 2020). Specifically, the findings suggest that provincial and institutional policies must cultivate deeply embedded, symbiotic partnerships moving beyond superficial engagements. This also resonates with studies by Yao et al. (2023) and Shi et al. (2021), who emphasised the role of institutional support and strategic partnerships in cultivating students' EIA. Such collaborations should entail co-determination of curricula, as advocated by Cai and Amaral (2021) for enhancing industry readiness, the establishment of shared research and development platforms where students confront authentic industrial challenges, echoing the value of real-world exposure found by Costa et al. (2021) and Yang (2015), and the systematic facilitation of personnel exchanges. Concurrently, the significant contribution of PTM, representing the governmental helix's influence (Cai & Etzkowitz, 2020; Mandrup & Jensen, 2017), highlights the imperative for sustained capital investment in advanced workshops, laboratories and simulation environments akin to those described by Diez-Pascual et al. (2018) and Daaif et al. (2019). This also calls for rigorous pedagogical upskilling for faculty in delivering experiential, problem-centric modules, as demonstrated by initiatives like "Rural Innovation Workshops" (Huang et al., 2021) and the 2P3E4R system (Li et al., 2022). The statistically insignificant direct impact of TTM (β=0.073), rather than diminishing its foundational role (Hailu, 2024; Song, 2024), mandates a strategic pivot. It points towards intrinsically integrating theoretical constructs within practical and industry-oriented contexts, as suggested by Chen et al. (2020) and Zhang et al. (2021), thereby enabling theory to serve as an indispensable scaffold (Diez-Pascual et al., 2018; Henkel et al., 2015) for applied innovation, rather than a detached antecedent and unlocking its potential indirect contributions to students' EIA.

From a theoretical standpoint, these findings offer a refined articulation of the Triple Helix Model's (Leydesdorff & Etzkowitz, 1996) operational dynamics within the distinct setting of higher vocational education in a transitional economy such as Henan's. The observed hierarchy of influence (SEC > PTM > TTM) intimates that in educational paradigms focused on immediate workforce preparedness, direct industry engagement (Ranga & Etzkowitz, 2013) and government-facilitated practical training (Faria et al., 2019) may exert more immediate leverage on students' EIA than conventional academic instruction. This highlights the model's contextual adaptability

(Cai & Etzkowitz, 2020; Galvao et al., 2019), where the accentuation of its constituent helices is contingent upon specific socio-economic conditions. The significant agency of PTM particularly emphasises the proactive role of state actors in architecting a vocational training ecosystem conducive to innovation, aligning with Faria et al.'s (2019) arguments on how public policies can enhance R&D. These insights also suggest avenues for further scholarly inquiry. Future research should scrutinise potential mediating and moderating variables, such as institutional resource allocation or faculty expertise, that might condition the impact of PTM and SEC on EIA. Moreover, while quantitative data reveal effect magnitudes, in-depth qualitative case studies, perhaps similar in approach to the examinations by Kim et al. (2021) or Rodrigues et al. (2016) in different contexts are warranted in Henan's vocational institutions. This would help discern other dynamic mechanisms and optimal practices for SEC and PTM implementation, addressing challenges like those noted by Gadasina et al. (2022) in SEC. Longitudinal research, tracking student cohorts into their early professional lives, would be invaluable for appraising the sustained effects of these pedagogical approaches on EIA and career trajectories, thereby contributing to a more robust evidence base for educational reform.

6. Conclusion

In summary, these findings affirm the critical roles of PTM and SEC in fostering EIA while questioning the isolated efficacy of TTM in the absence of practical integration. This study reinforces the applicability of the Triple Helix Model in advancing innovation ecosystems within higher vocational education, particularly in Henan. To further enhance EIA, there is a pressing need to integrate theoretical approaches with practical applications, creating stronger synergies between government, academia and industry. Nonetheless, despite the study's' contributions several limitations exist. First, the focus on higher vocational institutions in Henan may limit the generalisability of the findings to other regions or contexts with differing educational, industrial or policy environments. Second, the reliance on self-reported survey data introduces the potential for bias such as over- or under-estimation of the impacts of TTM, PTM and SEC on EIA. Third, while this study focused on direct effects, it did not explore potential moderating or mediating variables, such as student motivation, institutional resources, or regional policy dynamics, which could influence the relationships between the variables. Future research should expand the geographical scope to include diverse regions, allowing for cross-comparative analysis and broader generalisability. Additionally, longitudinal studies could better capture the long-term impacts of TTM, PTM and SEC on EIA development. Incorporating qualitative methods including interviews or case studies, could provide richer insights into the dynamic interactions between theoretical knowledge, practical applications and industry collaboration. Finally, exploring the role of moderating factors such as innovation platforms or government incentives, could offer a more holistic understanding of the mechanisms driving EIA in higher vocational education.

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Declaration of interest: The authors declared that there were no potential conflicts of interest.

Data availability: The datasets generated during and/or analysed during the current study are available from the corresponding author on reasonable request.

Ethical statement: This study received ethical approval from Management and Science University (MSU) on 18 June 2024 with the reference code: EA-L1-01-SESS-2024-06-0001. All participants provided informed consent before taking part in the research.

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Appendix 1. Descriptive statistics

				< *Mean*		>*Mean*	
Variables	*Acronym*	*Mean*	*Std. Deviation*	*Frequency*	*Percentage*	*Frequency*	*Percentage*
EIA	EIA1	3.75	1.11	155	37.90%	254	62.10%
	EIA2	3.48	1.048	192	46.94%	217	53.06%
	EIA3	3.6	1.069	183	44.74%	226	55.26%
	EIA4	3.72	1.06	157	38.39%	252	61.61%
	EIA5	3.61	1.073	184	44.99%	225	55.01%
	EIA6	3.74	1.048	154	37.65%	255	62.35%
	EIA7	3.7	1.043	183	44.74%	226	55.26%
	EIA8	3.83	1.043	163	39.85%	246	60.15%
	EIA9	3.71	1.139	165	40.34%	244	59.66%
	EIA10	3.49	1.046	190	46.45%	219	53.55%
	EIA11	3.61	1.075	184	44.99%	225	55.01%
	EIA12	3.69	1.073	166	40.59%	243	59.41%
	EIA13	3.66	1.036	182	44.50%	227	55.50%
	EIA14	3.74	1.055	158	38.63%	251	61.37%
	EIA15	3.68	1.058	187	45.72%	222	54.28%
	EIA16	3.78	1.083	167	40.83%	242	59.17%
	EIA17	3.76	1.09	162	39.61%	247	60.39%
	EIA18	3.47	1.052	195	47.68%	214	52.32%
	EIA19	3.58	1.082	190	46.45%	219	53.55%
	EIA20	3.72	1.039	163	39.85%	246	60.15%
PTM	PTM1	3.87	1.047	135	33.01%	274	66.99%
	PTM2	3.89	1.035	141	34.47%	268	65.53%
	PTM3	3.83	1.058	139	33.99%	270	66.01%
	PTM4	3.87	1.033	138	33.74%	271	66.26%
	PTM5	3.88	1.041	137	33.50%	272	66.50%
	PTM6	3.8	1.083	148	36.19%	261	63.81%
	PTM7	3.87	1.035	130	31.78%	279	68.22%
	PTM8	3.89	1.022	142	34.72%	267	65.28%
	PTM9	3.84	1.038	141	34.47%	268	65.53%
TTM	TTM1	3.81	1.084	137	33.50%	272	66.50%
	TTM2	3.8	1.072	138	33.74%	271	66.26%
	TTM3	3.83	1.079	141	34.47%	268	65.53%
	TTM4	3.86	1.079	136	33.25%	273	66.75%
	TTM5	3.81	1.09	140	34.23%	269	65.77%
	TTM6	3.84	1.129	145	35.45%	264	64.55%
	TTM7	3.83	1.061	135	33.01%	274	66.99%
	TTM8	3.81	1.033	139	33.99%	270	66.01%
	TTM9	3.77	1.065	144	35.21%	265	64.79%
SEC	SEC1	3.85	1.006	158	38.63%	251	61.37%
	SEC2	3.73	1.126	163	39.85%	246	60.15%
	SEC3	3.83	1.025	155	37.90%	254	62.10%
	SEC4	3.77	1.059	159	38.88%	250	61.12%
	SEC5	3.85	1	157	38.39%	252	61.61%
	SEC6	3.72	1.129	164	40.10%	245	59.90%
	SEC7	3.82	1.021	158	38.63%	251	61.37%
	SEC8	3.76	1.067	157	38.39%	252	61.61%
	SEC9	3.76	1.067	157	38.39%	252	61.61%
	SEC10	3.82	1.024	161	39.36%	248	60.64%
	SEC11	3.71	1.124	166	40.59%	243	59.41%
	SEC12	3.83	1.027	156	38.14%	253	61.86%
	SEC13	3.77	1.063	156	38.14%	253	61.86%
	SEC14	3.84	0.998	161	39.36%	248	60.64%
	SEC15	3.73	1.117	163	39.85%	246	60.15%
	SEC16	3.82	1.014	156	38.14%	253	61.86%
	SEC17	3.72	1.096	160	39.12%	249	60.88%
	SEC18	3.72	1.092	163	39.85%	246	60.15%

Note. The descriptive statistics for all individual items measuring EIA, PTM, TTM and SEC including their means, standard deviations and the frequency distribution of responses relative to the mean.