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Mapping the helix model of innovation influence on education: A bibliometric review

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As a direct result of the increased significance of knowledge in the various endeavours attempting to implement the triple helix model, higher education institutions have assumed a more prominent position in the processes involved in regional innovation and development. Expanding study on the helix model is currently examining the underlying causes and consequences of the evolution of the helix model in education. This research examines the relationship between the triple helix model and education by using bibliometric analysis on 227 articles subjected to peer review between 1970 and 2022. This investigation concentrated on three aspects of analysis: (1) document citation *via* the use of co-citation analysis that produce 4 clusters; (2) document cited reference through the utilisation of bibliographic coupling that generates 5 clusters; and (3) document keyword through the utilisation of co-word analysis with 4 clusters. These results are essential for academics, practitioners, and other interested parties working to improve the helix model for policymakers by putting it into an education strategy.

KEYWORDS

triple helix model, quadruple helix model, quintuple helix model, education, entrepreneurship education, bibliometric analysis

1. Introduction

The helix models of innovation (triple, quadruple and quintuple) turn over contribution to the innovation study area, emphasising the university's expanded role in the middle of a knowledge-based society (Cai and Lattu, 2022). This emphasis is distinct from previous innovation strategies, which emphasised interactions between firms or between firms and governments (Carayannis et al., 2021). The university ranks first due to its increased importance in technology transfer (TT), company formation, and regional revitalisation inside the knowledge society. In contrast, in an industrial society, it ranks second (Cai and Etzkowitz, 2020). The Helix model of innovation and major innovation theory acknowledges the importance of three main components and their interplay (universities, industry, and government) that nurse innovation and cultivate entrepreneurship (Afzal et al., 2018). However, most innovation theories and models emphasise that industry or company are the main factors influencing innovation (Cai and Amaral, 2021).

Previous helix of innovation models literature views this universities, industry, and government (UIC) as a "block" object that exists without delving deeper into each actor in a globular-object connection. Viewing the connection in sphere-specific actors will open a new perspective that conceals exemplary character, objective, aim, responsibility and challenge. This

new view also will reveal how they affect the interplay dynamics between the actors (Shinn, 2002; Etzkowitz, 2003b; Galvao et al., 2019). One of the university's significant contributions is extending TT. TT will expand and derive university capabilities to produce graduates with entrepreneurial mindsets and skills that will play a significant regional economic role by creating jobs and initiating new businesses (Etzkowitz, 2016). Universities throughout the world now offer a variety of entrepreneurship education programmes to help students cultivate entrepreneurship mindset skills, gain practical and theoretical business development knowledge, inspire new learning paradigms, and cultivate an entrepreneurial mindset as a valuable asset when pursuing careers (Meyer, 2003; Bienkowska and Klofsten, 2012; Boldureanu et al., 2020).

Additionally, academic entrepreneurship is another innovation that will impact the local, regional, and national economies. To boost the entrepreneurial activities and TT within academics, university faculty can maintain the establishment and student participation in research by increasing educational and entrepreneurial research funding. This action will lead to the cooperation of nearby businesses, and entrepreneurs and academics can have an opportunity to test their knowledge outside the university's walls (Shane, 2004; Davey et al., 2016; Hayter, 2016; Sansone et al., 2021).

Therefore, this study aims:

1. To investigate past themes of the helix model on education.
2. To determine the current knowledge structure of the helix model on education.
3. To forecast and predict research trends of the helix model on education.

As far as the author is aware, there is no systematic review based on a bibliometric analysis that captures knowledge structure by mapping and visualising the specific context of the economic contexts of the helix model on education. This study is the first to undertake a quantitative review of the literature on the scope of the helix model and education using the Web of Science database (WOS) to conduct a bibliometric analysis. Such an approach will help researchers explore this area, gain deeper insights and predict future trends in the knowledge economy in higher education. This review also provides an idea of what previous studies have dealt with over the past 22 years and how meaningful clusters and university functional themes in helix models may be significant in the future. Our study explores the helix model in education by looking at universities as one of the main actors in this model and how they function. This study also presents a roadmap for a well-informed research agenda, advocating the use and advancement of helix models to open up new areas of inquiry and theoretical development within helix models on education. This discovery will clarify and direct the helix model's future research on education.

This study is arranged as the following. The helix model and the purpose of the study are introduced in Section 1 of the text. The history of the helix model and its connection to education are discussed in Section 2 of the literature review. In Section 3, the methodology based on bibliometric analysis is described. Results of all studies and comments based on clusters and included themes are provided in Section 4. The theoretical and practical ramifications are covered in part 5. Section 6 discusses the study's limitations, future work and conclusion.

2. Literature review

The Triple Helix (TH) Model was developed in 1995 to describe the fundamental trends in knowledge-based economies (Etzkowitz, 2003b). This strategy highlights the contributions that top universities make to society and the dissemination of knowledge (Ranga and Garzik, 2015). The TH model emphasises regional social development due to its characteristics, which include a strong interplay between three critical social systems: industry, universities, and governments (Cai and Lattu, 2022). It is impossible to overstate the significance of these three direct social systems of interaction and cooperation and their mutual benefits. Academics must analyse social networking as a "neo-intuitive structure" because the interconnection of networks in universities, businesses, and governments is essential (Carayannis and Campbell, 2009; Galvao et al., 2019). The TH model is the basis for the quadruple and quintuple helix models, which include an additional environment helix. Five-helix model is another name for the quintuple-helix model (Carayannis et al., 2012, 2021).

Through the application of knowledge and innovation, interactions between UICs have created a three-dimensional flow of materials and information (Ivanova and Leydesdorff, 2014). The TH model intentionally modifies the knowledge transfer process. Thus, the main objective of universities has shifted from the transmission of knowledge to the production of new ideas and innovations, and this shift is currently taking place in many countries (Ranga and Etzkowitz, 2013). The university is indispensable for innovation development, especially in business development, research, teaching and training for social engagement. In addition to its role as an investor, the institution engages in business activities such as TT and artistic ventures. The TH model is a tool for assessing the economic balance between knowing "when to intervene" and "when not to intervene" in innovation development (Carayannis and Campbell, 2010; Cunningham et al., 2018). Figure 1 represents the interaction of UIC in the TH model.

Participation in technology transfer by universities has also enhanced their capacity to train and develop graduates' entrepreneurial skills (Bercovitz and Feldman, 2005). These graduates have the potential to stimulate economic growth by launching new businesses and filling vacancies. Significant gains have also been observed at the local level, where economic gains from university start-ups, such as

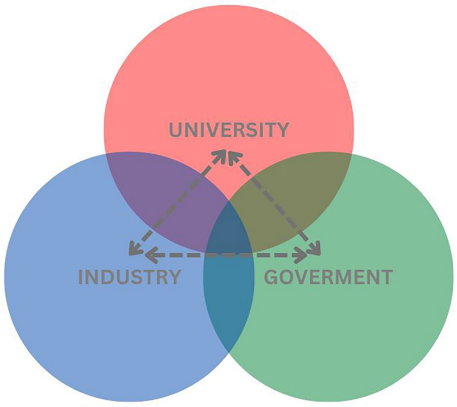

FIGURE 1
TH model.

job creation and tax revenue, are combined with social and cultural gains, such as favourable social perception of entrepreneurs, stronger ties between the university and the community, and a heightened appeal of the university and the region to talent and investors from across the nation and the globe (Siegel et al., 2003a; Fromhold-Eisebith and Werker, 2013; del Giudice et al., 2017; Cunningham et al., 2018; Paoloni et al., 2019). Obtaining the designation of "entrepreneurial university" is crucial for many cities worldwide because it provides access to highly skilled workers, entrepreneurs with rapid growth, and venture capital investment (Boldureanu et al., 2020). This frequently results in the region becoming an entrepreneurial ecosystem of the highest calibre (Ranga and Etzkowitz, 2013). Through entrepreneurship, incubator programmes, and brand-new training modules, universities are expanding their educational capabilities beyond educating individuals to educate organisations (Skute, 2019).

2.1. Bibliometric approach

A bibliometric analysis is a technique utilised to map the structure and development of a specific scientific field. It applies a quantitative methodology to scientific mapping. In order to analyse and evaluate scientific literature, bibliometric tools will enhance qualitative structured literature reviews and meta-analyses by visualising the scientific knowledge in network mapping. The network visualisation uses the bibliometric database to build, analyse, and visualise the scientometric study (van Eck and Waltman, 2014). Bibliometric analysis studies and reports on numerous aspects of the scientific community, including research topics, methodology, notable scholars, organisations, and publications. It helps investigate the impact of research (Serenko et al., 2010), patterns of collaboration, and the conceptual framework of journals (Serenko, 2013; Ramy et al., 2018). According to (Mingers and Leydesdorff, 2015), bibliometrics is transitioning to altmetrics or Scientometrics 2.0, where social networking metrics such as likes, downloads, views, and reads are replacing journal citations. Thus to achieve this study's three objectives, this paper will take up three scientometric analyses: (i) co-citation analysis, (ii) bibliographic coupling, and (iii) co-word analysis.

Co-citation analysis is a method for locating pairs of papers cited in the same source articles (Boyack and Klavans, 2010). When multiple authors simultaneously co-cite the same pair of papers, the seeds of a research cluster are planted. Most of these cited papers have something in common, such as making predictions about a popular topic (Boyack and Klavans, 2010). Bibliographic coupling is the process of linking documents with the same reference of cited documents is referred to as "bibliographic coupling." This method determines how similar two citing articles are (Maseda et al., 2022). This approach is the most forward-thinking of the citation-based methods and is appropriate for analysing current research trends in the field (Boyack and Klavans, 2010). Bibliographic coupling was done by counting the words in the title, abstract and authors, and keywords. The clusters are formed by the inductive interpretation of the authors based on the word connections among them. Co-word analysis: The extraction of keywords from a publication's title, abstract, and keywords is the first step in the co-word analysis (van Eck and Waltman, 2014). It investigates the relationship between various concepts that appear in the keywords simultaneously. Co-word analysis is a content analysis method that uses quantitative descriptions to map the relationship between information items in textual data and to analyse the content of scientific or other types of articles. A co-word analysis can reveal the significance of a field's structure, which can then be used to forecast future trends (Fauzi, 2017). Co-word analysis is the only bibliometric method that performs a similarity analysis based on the primary text (Zupic and Čater, 2014).

2.2. Data collection

The most dependable, trustworthy, and high-quality article database from WOS was utilised to collect data for this study (Mongeon and Paul-Hus, 2016). Numerous scholars have utilised the WOS database for scientometrics and bibliometric research (Mejia et al., 2021; Craiut et al., 2022; López-Rubio et al., 2022). VOSviewer (V1.6.18) is an analytical tool to map the collected data. VOSviewer is the optimal application for constructing a network of research papers using a quantitative database technique, as it can display and navigate scientific maps based on retrieved databases (Flamini et al., 2022). Table 1 lists the search string terms used in this investigation. The expanded list of keywords and concepts in the TH model covers all practical queries in the TH model's current field. Then, to locate all relevant data related to the research objective, education and its associated keywords and concepts act as second keyword strings. The search returned 557 publications published between 2000 to 2022, including journal articles, conference proceedings, periodicals, novels, books, and book chapters. The search was only limited to relevant citation topic meso, which are (1) Management ($N = 473$), (2) education and education research ($N = 49$), (3) bibliometrics, scientometrics and research integrity ($N = 21$), and (4) economics (14). There were 4,507 citing articles, of which 4,264 were not self-citations. A total of 5,695 articles are time cited, and 5,204 are without self-citation. The database h-index is 33, and the average number of citations per article was 10.22.

3. Result and analysis

The concept of the TH model and other helix models for education topics is of intense interest to academicians worldwide, as seen in Figure 2. The first published topic related to study keywords was in 2000; since then, it has grown significantly. The publication and citation trend shows that interest in the topic continues growing as more people become interested in studying the helix model for education and its effect on education and socio-economic development in the region.

TABLE 1 Study keyword search string.

No	Keywords	Explanation
1	"Helix model* of innovation" OR "Triple helix" OR "Quadruple helix" OR "Quintuple helix"	To identify literature related to the triple helix model of innovation
2	"Education*" OR "Montessori" OR "Learning*"	To identify literature related the education

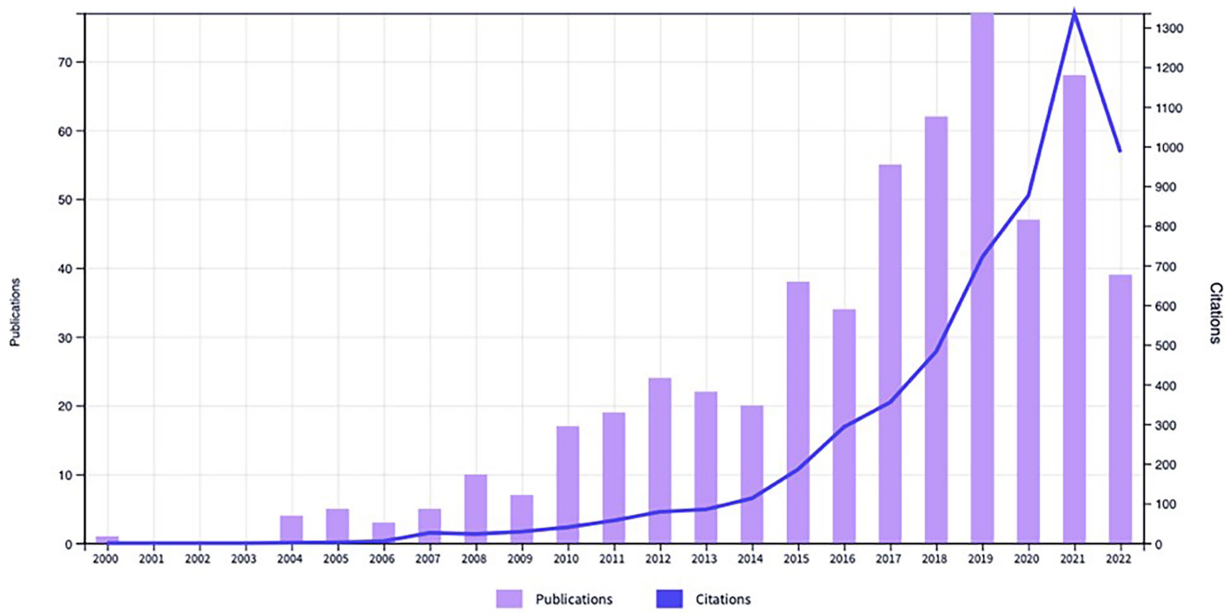

FIGURE 2
Search analysis summary on helix model and education in WOS.

3.1. Co-citation analysis

The analysis threshold value was set for the articles with 20 or above cited references. Table 2 show a summary of the highest cited document where Etzkowitz et al. (2000) (295 times), Etzkowitz (2003b) (112 times), and Etzkowitz et al. (80 times) are the top 3 in 48 cited reference from the total 22,605 cited reference.

The co-citation network of the helix models and education has been envisioned using VOSviewer software in Figure 3. Table 3 presents the helix model and education summary based on the co-citation analysis consisting of the cluster number and colour, cluster labels, number of articles and representative articles.

Based on the co-citation network of the helix model and education result, the authors managed to interpret the cluster shown in Table 3.

• Cluster 1 (red): With 17 articles, cluster 1 represents "Triple helix development."

This cluster explains the expansion of the helix model of innovation as one of the fundamental theories for the knowledge-sharing economy, starting from establishing the TH. Etzkowitz and Leydesdorff (2000) proposed the use of a more dynamic model named the TH of the university-industry-government relationship compared to a non-linear model of innovation like the national innovation system and mode 2. The TH model consists of three actors (UIC). When three selection actors (industry wealth generation, university product novelty and government control) in the TH are involved, more complex dynamics resulting from interplay requiring "bi" or "tri" lateral relations can be expected (Leydesdorff and Meyer, 2006). The evolution of the TH model grew toward the introduction of 'mode 3' and 'quadruple helix' by Carayannis and Campbell (2009). This extension adds another helix (cultured-based public) into the model to evaluate how media and public reality influence the national innovation system. In 2010, a proposed framework of the quintuple helix by Carayannis and Campbell added another actor into the model: the environment. This model broadens out to weigh the factor of sustainability and the opportunity for the model to be used in the transdisciplinary area to understand more about knowledge and innovation development (Carayannis and Campbell, 2010). Ranga and Etzkowitz (2013) explain the TH frameworks, boundaries and distinction between the components and institution as the relationship between the institution and the system's function. Leydesdorff (2012) recommends a complete justification for those who like to evolve the model more than the main three actors. The justification includes relevant data, further development and relevant operationalisation and specification indicators.

• Cluster 2 (green): With 22 articles, cluster 2 represents an "entrepreneurial university."

The entrepreneurial university concept was preliminarily discussed as entrepreneurial activities related to the formation of a new business company by a university academic or joint venture with a private company to commercialise their research (Etzkowitz, 1983). The endless transaction of the TH model brings the future of the university's role in knowledge innovation (Etzkowitz and Leydesdorff, 2000). University intuitional transformation opens a broad new interpretation of university entrepreneurship activity that can be developed within the TH model. The evolution of universities from conserving knowledge to entrepreneurial and innovative activities will not stop the main function of universities in teaching and conducting research (Etzkowitz, 2003b). Entrepreneurial universities play an essential role in improving the university's financial performance, region, and national economy through academic knowledge creation (e.g., company spin-off). Rothaermel et al. (2007) simplify the dynamic process of university entrepreneurship into four central themes, which are (1) entrepreneurial research university, (2) productivity of technology transfer offices (TTOs), (3) new firm creation, and (4) environmental context including networks of innovation. Guerrero and Urbano (2012) identified academic and

TABLE 2 Top 15 from 48 publication with the highest cited reference.

No	Authors	Publication	Citation	Total link strength
1.	Etzkowitz and Leydesdorff (2000)	Res Policy, v29, p109	295	1,030
2.	Etzkowitz (2003b)	Soc Sci Inform, v42, p293	112	509
3.	Etzkowitz et al. (2000)	Res Policy, v29, p313	80	472
4.	Perkmann et al. (2013)	Res Policy, v42, p423	59	331
5.	Leydesdorff and Etzkowitz (1996a)	EASST Review, v15	58	253
6.	Carayannis and Campbell (2009)	Int J Tech Manag, v46, p201	55	225
7.	Ranga and Etzkowitz (2013)	Ind Higher Educ, v27, p237	54	258
8.	Gibbons et al. (1994)	Sage Publication Inc.	54	220
9.	Etzkowitz (2008)	Routledge, New York	53	260
10.	D'Este and Patel (2007)	Res Policy, v36, p1295	45	242
11.	Etzkowitz and Leydesdorff (1998)	Minerva, v36, p203	45	174
12.	Lundvall (1992)	Anthem Press, p85	42	209
13.	Etzkowitz (2003b)	Res Policy, v32, p109	41	277
14.	Etzkowitz (1998)	Res Policy, v27, p823	40	279
15.	Etzkowitz and Klofsten (2005)	R&D Manag, v35, p243	40	210

student mindsets toward entrepreneurship as a critical factor in entrepreneurial university development. Among the factor in the development of academic and student entrepreneurship mindset are (1) entrepreneurship education, (2) teaching methodologies, (3) role models and (4) reward systems. While the entrepreneurial university was established in response to the need for TT and knowledge-based businesses, its role in the entrepreneurial society has evolved to encompass cultivating entrepreneurial behaviour and boosting entrepreneurship capital (Audretsch, 2014).

• Cluster 3 (blue): with 11 articles and cluster 3, known as "knowledge-based economy."

Knowledge transfer is the fundamental knowledge-based economy in the TH model that shows how knowledge is utilised and transferred into wealth. Common knowledge and TT happen through research joint ventures, licensing agreements, intellectual properties, start-ups and spin-offs governed by university TTOs (Siegel et al., 2003a,b). Siegel also identified some barriers that affect the knowledge transfer process: (1) bureaucratic inflexibility, (2) ineffective management of university TTOs, (3) poorly designed reward systems and culture clashes. In the same year, Siegel et al. (2003b) identify that TTOs compensation practices, cultural barriers between universities and industry and faculty reward systems are crucial organisational factors in evaluating TTOs' productivity and performance. Bercovitz and Feldman (2005) proposed a framework to develop a deeper understanding of university-industry relationships and their function within knowledge-based innovation systems. These influences include (1) sponsoring research, (2) hiring of students, (3) spin-off firms, (4) license and (5) serendipity (economic, social, and political factors) that influence universities' ability to generate new knowledge and deploy that knowledge for economic gain. Perkmann and Walsh (2007) identified that in university-industry relationships, most firms want to learn motives and capacity-building (research partnerships, contract research and consulting) in the innovation cycles rather than tangible outcomes such as product and innovation. Perkmann et al. (2013) proposed that growing both the quantity and quality of university-industry contacts would seem possible with the help of fostering individual engagement abilities.

• Cluster 4 (yellow): with eight articles and cluster 4, known as "Mode 2- academic capitalism and society."

This cluster discusses the dynamic relationship between the knowledge economy in academic capitalism and society. Helga et al. (2001) describe the university's role in knowledge production as a scientific and social institution that does not neglect its social roles under the mode-2 condition. The future university will become more open in the sense of their socio-economic, cultural, and scientific roles and remove the internal and external boundaries (de-institutionalisation). Etzkowitz (2002) share how the Massachusetts Institute of Technology (MIT) university's role in entrepreneurial science changed the landscape of American academic institution and their impact not only on the generation of intellectual and social but also on human capital until it became a core institution in society. Slaughter and Rhoades (2004) discuss the concept of social entrepreneurship, in which profit/non-profit blends bring innovation and opportunity, as well as unforeseen change and risk. This type of business can put universities at the forefront of hybridisation.

3.2. Bibliographic coupling analysis

From 557 documents, 149 met the 30 thresholds in the bibliographic coupling analysis. The top 10 highest publication based on the cited document is shown in Table 4. D'Este and Patel (2007) (801 citations), Ankrah and AL-Tabbaa (2015) (338 citations) and, Martinelli et al. (2008) (156 citations) is the top cited article. The remaining top 10 cited articles for study bibliographic coupling analysis are represented in Table 4.

Figure 4 visualises the bibliographic coupling network of the helix models and education. Table 5 presents the helix model and education summary based on the bibliographic coupling analysis consisting of the cluster number and colour, cluster labels, number of articles and representative articles.

Based on the bibliographic coupling network of the helix model and education result, the authors managed to interpret the cluster shown in Table 5.

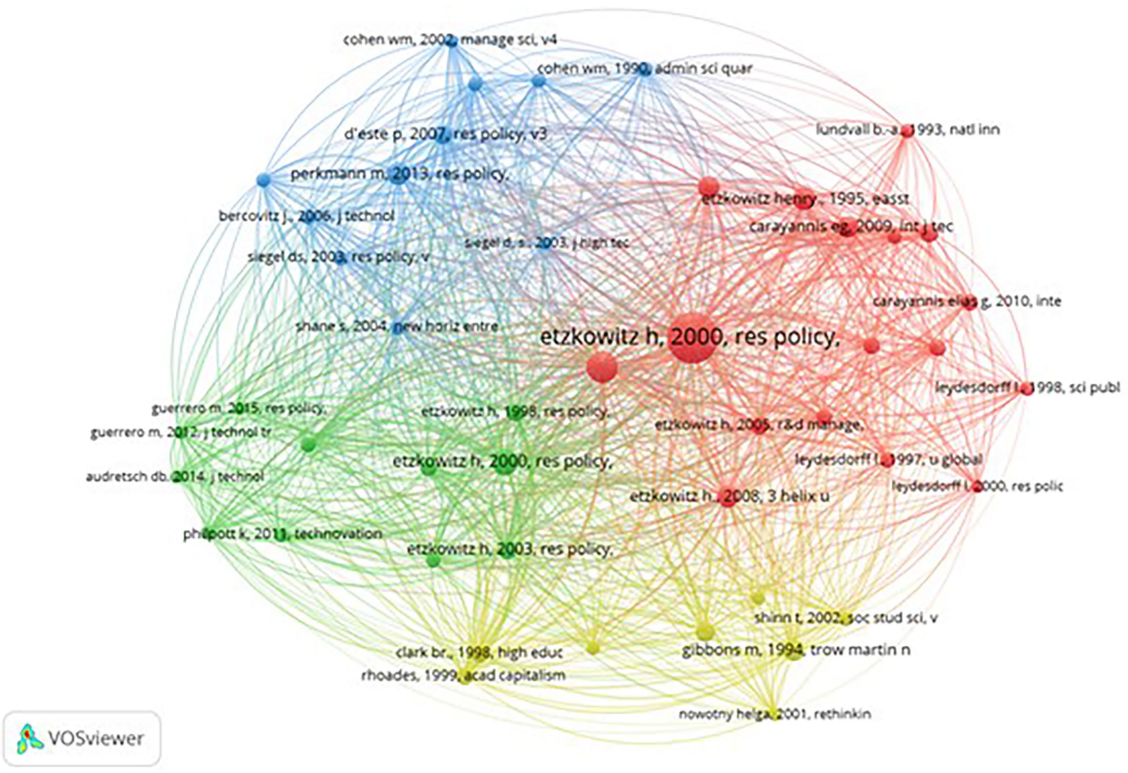

FIGURE 3
Co-citation analysis of the Helix Model and Education.

TABLE 3 Co-citation cluster on helix model and education.

Cluster 1 (Red) – Triple helix development, *N*=17	Cluster 2 (Green) – Entrepreneurial university concept, *N*=11	Cluster 3 (Blue) – knowledge-based economy, *N*=11	Cluster 4 (yellow) – Mode 2 – Academic capitalism and society, *N*=8
Carayannis and Campbell (2009)	Audretsch (2014)	Bercovitz and Feldman (2005)	Clark (1998)
Carayannis and Campbell (2010)	Etzkowitz (1983)	Bruneel et al. (2010)	Etzkowitz and Leydesdorff (1998)
Etzkowitz & Leydesdorff (2000a)	Etzkowitz (1998)	Cohen and Levinthal (1990)	Etzkowitz (2002)
Etzkowitz (2003b)	Etzkowitz et al. (2000)	Cohen et al. (2002)	Gibbons et al. (1994)
Etzkowitz and Klofsten (2005)	Etzkowitz (2003a)	D'Este and Patel (2007)	Helga et al. (2001)
Etzkowitz (2008)	Etzkowitz (2004)	D'Este and Perkmann (2011)	Slaughter and Leslie (1999)
Leydesdorff and Etzkowitz (1996a)	Guerrero and Urbano (2012)	Perkmann and Walsh (2007)	Shinn (2002)
Etzkowitz and Leydesdorff (2000b)	Guerrero et al. (2015)	Perkmann et al. (2013)	Slaughter and Rhoades (2004)
Leydesdorff and Meyer (2006)	Jacob et al. (2003)	Shane (2004)	
Leydesdorff (2012)	Philpott et al. (2011)	Siegel et al. (2003a)	
Leydesdorff and Etzkowitz (1996b)	Rothaermel et al. (2007)	Siegel et al. (2003b)	
Etzkowitz and Leydesdorff (1993)			
Leydesdorff and Etzkowitz (1998)			
Lundvall (1992)			
Lundvall and Edquist (1993)			
Nelson (1993)			
Ranga and Etzkowitz (2013)			

- Cluster 1 (red): With 16 articles, cluster 1 represents "Third mission: Entrepreneurial university co-creation in triple helix."

This cluster explains the function of actors in the TH innovation model for developing an entrepreneurial university. Crespo et al. (2006) identified that the success factor for academic commercialisation

and intellectual properties in universities mainly depends on support from the public and government funding. The third objective has typically emphasised commercial interaction, especially licencing and spin-off operations, intending to foster entrepreneurship within universities (Nelles and Vorley, 2011). Trencher et al. (2014) comment that the growth of the entrepreneurial university and the use of the term "third mission" should therefore be viewed as an expansion or amplification of earlier expectations. Universities management believes that fostering an entrepreneurial culture will result in more new employment and enterprises, and students will require entrepreneurship training to start their businesses or compete in the labour market (Sam and van der Sijde, 2014). In addition to incubators, innovation centres, TTOs, scientific parks, and venture capital operations, entrepreneurship education can be an integral part of any business venture support system that aspires to create jobs. An academic entrepreneurial shift results from the collision between the internal growth of higher education institutions and external impacts on academic structures associated with the advent of "knowledge-based" innovation (Etzkowitz, 2016). Globally, organisations have created policies, processes, and innovations to convert knowledge into economic activity and address societal problems (Lo et al., 2009). Although all parties (UIC) involved appear to agree that graduate employability is of the utmost importance, there is still a considerable lot of difference in how each party views graduate job readiness, such as how the most recent global trend will affect skills such as entrepreneurship (Winterton and Turner, 2019).

TABLE 4 Top 10 bibliographic coupling cited articles.

Articles	Citation	Total link strength
Ranga and Etzkowitz (2013)	287	156
Trencher et al. (2014)	210	90
Carayannis and Campbell (2011)	130	153
Sedlacek (2013)	128	48
Sam and van der Sijde (2014)	127	154
Inzelt (2004)	122	14
Carayannis and Campbell (2012)	102	166
Weckowska (2015)	95	99
Martin (2012)	84	167
Leydesdorff and Meyer (2010)	78	96

- Cluster 2 (green): With 15 articles, cluster 2 represents "knowledge transfer and commercialisation."

Universities' TTOs are crucial in determining how effectively their institutions perform in TT. Previous research overlooked the roles of intellectual capital (IC) in universities to promote the TTP and the function of TTOs as a moderator. Feng et al. (2011) stress the importance of IC roles in universities to promote TT performance, and the function of TTOs as a moderator was overlooked. TTOs at universities require various skills to commercialise research products (Weckowska, 2015). While other TTOs are predominately relations-focused, some TTOs combine commercialisation transactions-focused practise and relations-focused practise styles. Galan-Muros and Davey (2017) develop frameworks to increase the bilateral cooperation between universities and industry that contribute to TTOs policymakers. The main component for the frameworks is (1) inputs, (2) activities, (3) outcomes, (4) outputs, (5) impacts, (6) supporting mechanisms, (7) circumstances and (8) context. Universities may use improved education and human capital to

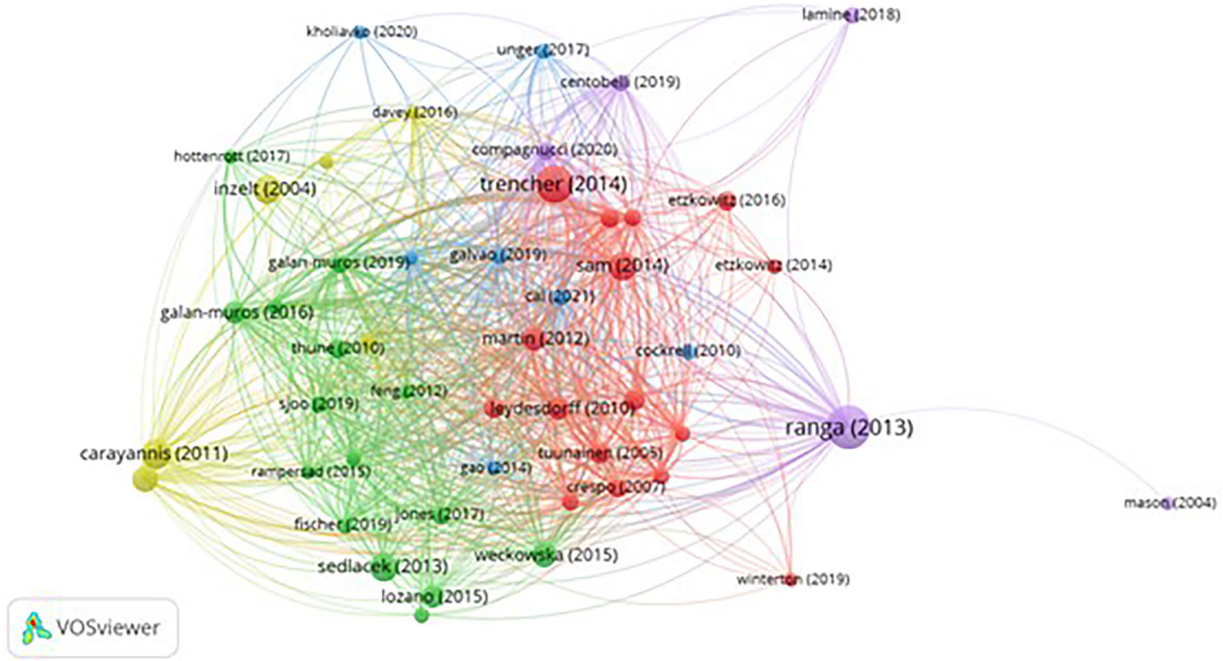

FIGURE 4
Bibliographic coupling analysis of helix model and education.

TABLE 5 Bibliographic coupling clusters on helix model and education.

Cluster 1 (Red) – Entrepreneurial university co-creation in triple helix, *N*=16	Cluster 2 (Green) – knowledge transfer and commercialisation, *N*=15	Cluster 3 (Blue) University Adaptability in innovation strategy–, *N*=7	Cluster 4 (yellow)- University capabilities in technology transfer, *N*=6	Cluster 5 (purple)- The role of universities in entrepreneurship, *N*=5
Bentley et al. (2015)	Beck et al. (2020)	Cai and Etzkowitz (2020)	Bano and Taylor (2014)	Centobelli et al. (2019)
Bernasconi (2005)	de Zubielqui et al. (2015)	Cameron Cockrell and Stone (2010)	Carayannis and Campbell (2011)	Compagnucci and Spigarelli (2020)
Bienkowska and Klofsten (2012)	Feng et al. (2011)	Galvao et al. (2019)	Carayannis and Campbell (2012)	Lamine et al. (2018)
Crespo et al. (2006)	Fischer et al. (2019)	Gao et al. (2014)	Davey et al. (2016)	Mason et al. (2004)
Etzkowitz (2014)	Galán-Muros and Plewa (2016)	Kholiavko et al. (2020)	Inzelt (2004)	Ranga and Etzkowitz (2013)
Etzkowitz (2016)	Galan-Muros and Davey (2017)	Unger and Polt (2017)	Petersen et al. (2016)	
Hemlin and Rasmussen (2016)	Hottenrott and Lawson (2017)	Zhang et al. (2019)		
Huggins (2009)	Jones and Corral de Zubielqui (2017)			
Leydesdorff and Meyer (2010)	Lozano et al. (2015)			
Martin (2012)	Rampersad (2015)			
Nelles and Vorley (2011)	Sedlacek (2013)			
Sam and van der Sijde (2014)	Sjöö and Hellström (2019)			
Tuunainen (2005)	Sugimoto et al. (2011)			
Trencher et al. (2014)	Thune (2010)			
Watermeyer (2014)	Weckowska (2015)			
Winterton and Turner (2019)				

be more receptive to TT programs to transfer researcher knowledge to industry. For example, in Brazil, research-focused universities have taken a more active role in technological upgrading initiatives, building relationships with the business sector and responding to the call for coordinated national efforts to close the gap within 20 years since 1999 (Fischer et al., 2019).

• Cluster 3 (blue): with seven articles and cluster 3, known as "University Adaptability in innovation strategy."

According to a study done for the Chinese Academy of Sciences (CAS), interactions between research institutions and universities have a greater positive impact on the scientific performance of those institutions than connections with industry (Zhang et al., 2019). This proves that university adaptability is important in the need for industries to innovate. Galvao et al. (2019) point out that a key component of relationships between universities and industries is sharing knowledge through technology and scientific communities. The unique characteristics of an established practice of cooperation and financial accomplishment in a particular business may be an important element in the accomplishment of university partnerships with industry. In the case of China, in the last 20 years, China's information and communications technology (ICT) industry has shown a low level of university-industry collaborations (Gao et al., 2014). The need for collaborations should be further emphasised, and more universities and research institutes should be encouraged to participate in university-industry collaborations to support businesses in enhancing their innovative capabilities. This showed that the university needs to adapt more aggressively to the fast-moving technology evolution to catch up with industry innovation needs, especially in the ICT sector. Besides that, to strengthen the adaptability of universities within the basic mechanism of Triple Helix, they must also adapt to various forms of fungible capital, including cultural, human, economic and social capital (Cai and Etzkowitz, 2020).

• Cluster 4 (yellow): with six articles and cluster 4, known as "University capabilities in technology transfer."

It is important for a university as a body of knowledge because it demonstrates an inventive capacity by producing knowledge that results in superior (knowledge-based) economic performance (Carayannis and Campbell, 2011). Thus, Universities are under pressure to play a bigger part in improving the competitiveness of the national economy on the global stage. One of the main items that can improve university capability In TT is the commercialisation of research that is transferred to regional stakeholders in the form of licences or patents and or through the creation of university-industry spin-out companies (Davey et al., 2016). As internalisation can become one interplay in UIC interaction, the university should look forward toward the firm from other countries that could change and shift sectoral innovation patterns, such as firms from China and South Korea, since these firms develop more substantial capabilities in research and innovation (Carayannis and Campbell, 2012).

• Cluster 5 (purple): with five articles and cluster 4, known as "the role of universities in entrepreneurship."

The university's "third mission," which entails commercialising research and participating in socio-economic development, has several facets, including forms, stakeholders, drivers, impediments, advantages, and impact, as well as university TT. This cluster will focus on the university's role in entrepreneurship development. The involvement of universities in TT has also enhanced their capacity to

create graduates with entrepreneurial education and aptitude who can contribute to economic growth by launching enterprises and creating jobs. Most universities nowadays offer various entrepreneurship education to stimulate the acquisition of an entrepreneurial mindset, new learning methods and the development of entrepreneurial skills as a valued career asset (Ranga and Etzkowitz, 2013). University-based business incubators can act as platforms and engines for local entrepreneurial ecosystems (Lamine et al., 2018). Supporting regional growth, accelerating start-ups in the university, and bridging the gap between entrepreneurship education, practical experience, and regional development are just a few of the crucial responsibilities played by university business incubators. In their evolutionary journey toward the entrepreneurial model, universities must strike a balance between exploitation and exploration, while it may not be necessary to invest in both processes simultaneously. Centobelli et al. (2019) proposed a systemic conceptual framework to evaluate entrepreneurial universities with these six constructs: university exploitation, university exploration, internal environment, external environment, university ambidexterity and entrepreneurial university performance. In conclusion, the integration of lifelong learning and entrepreneurship as a talent that can be taught, inspired, and promoted is strengthened through entrepreneurship education in higher education (Compagnucci and Spigarelli, 2020).

3.3. Co-word analysis

The analysis threshold value was set that the articles should have 13 or above keyword occurrences. Table 6 show a summary of the highest 15 keywords out of 54 keyword occurrence, with "triple-helix" (374 occurrences) innovation" (229 occurrences) and "knowledge" (83 occurrences) as the highest occurrence keyword for the total 2,089 keywords.

Figure 5 visualises the co-word network of the helix models and education. Table 7 presents the helix model and education summary based on the co-word analysis consisting of the cluster number and colour, cluster labels, number of articles and representative articles.

Based on the co-word network of the helix model and education result, the authors managed to interpret the cluster shown in Table 7.

• Cluster 1 (red): With 17 keywords, cluster 1 represents "quadruple helix innovation: sustainable development."

TH co-creation has been increased into quadruple and quintuple co-creation (Galvao et al., 2019). Quartey and Oguntoye (2021) explain how the TH might promote African nations' social, economic, and environmental well-being through industrialisation and innovation. Understanding and fostering industrial sustainability is vital for sustainable development. The sustainable development route of a high-tech company in China shows that information technology, resource allocation, and platform operation and management are vital to science-tech intermediaries' long-term success (Yu et al., 2020). The higher education subsystem is uniquely positioned within the Quintuple Helix Model (Kholiavko et al., 2020). Universities produce qualified workers and create a green consciousness among young people through extracurricular activities, which is vital for continuing economic growth. Universities investigate cutting-edge, eco-friendly, regenerative technologies. Universities create knowledge for innovation in renewable energy development (Lerman et al., 2021).

TABLE 6 Top 15 Helix model and education keywords analysis.

Rank	Keyword	Occurrences	Total link strength
1.	Triple helix	374	1,076
2.	Innovation	229	914
3.	Knowledge	83	398
4.	University	82	368
5.	System	70	312
6.	Science	61	298
7.	Industry	59	310
8.	Entrepreneurial University	59	272
9.	Education	56	302
10.	Performance	55	319
11.	Impact	46	241
12.	Entrepreneurship	46	225
13.	Higher education	44	163
14.	Management	43	219
15.	Knowledge transfer	41	223

• Cluster 2 (green): With 14 keywords, cluster 2 represents an "Absorptive capacity in the helix model collaboration."

Absorptive capacity is the capacity of an organisation to utilise extrinsic knowledge. Companies with robust absorptive capacity have a higher chance of obtaining external knowledge, exploiting it, synthesising it and assimilating it (Ryan et al., 2018). The assimilation of external benefits derived from UIC relationships is typically contingent on the company's capacity to exploit university knowledge. In these UIC relationships, a company's absorptive capacity determines the company's learning capacity (Ryan et al., 2018). Innovative small and medium-sized enterprises (SMEs) embedded in the regional setup that do not have strong interactions between universities and businesses are distinguished by their adequate and structured absorptive capacity. To utilise the UICs interaction, policy interventions should encourage the formation of a research and development (R&D) office, which could grow the absorption capacity of SMEs (Apa et al., 2021). Businesses with a larger R&D workforce are more likely to have a knowledge structure in which employees have overlapping information from their long-term collaboration and non-overlapping knowledge from their diverse backgrounds, enhancing an organisation's capacity for absorption (Tang et al., 2019). The absorptive capacity, which considers the variables of higher education, R&D extramural activities, and R&D intramural activities, had a positive and significant effect on the demand for benefits from the EU's public financial support (Moura et al., 2019). External regional absorptive capacity demonstrates that external technical differences cannot aid the spatial separation between businesses and universities in capturing more innovation performance (Yu and Yuizono, 2021).

• Cluster 3 (blue): with 13 articles and cluster 3, known as "The performance of the entrepreneurial university."

Entrepreneurial colleges should be considered transformative forces that can inspire entrepreneurship, promote ecosystem change, and catalyse natural or financial resource utilisation in a particular location (Nicholls-Nixon et al., 2021). Entrepreneurial universities

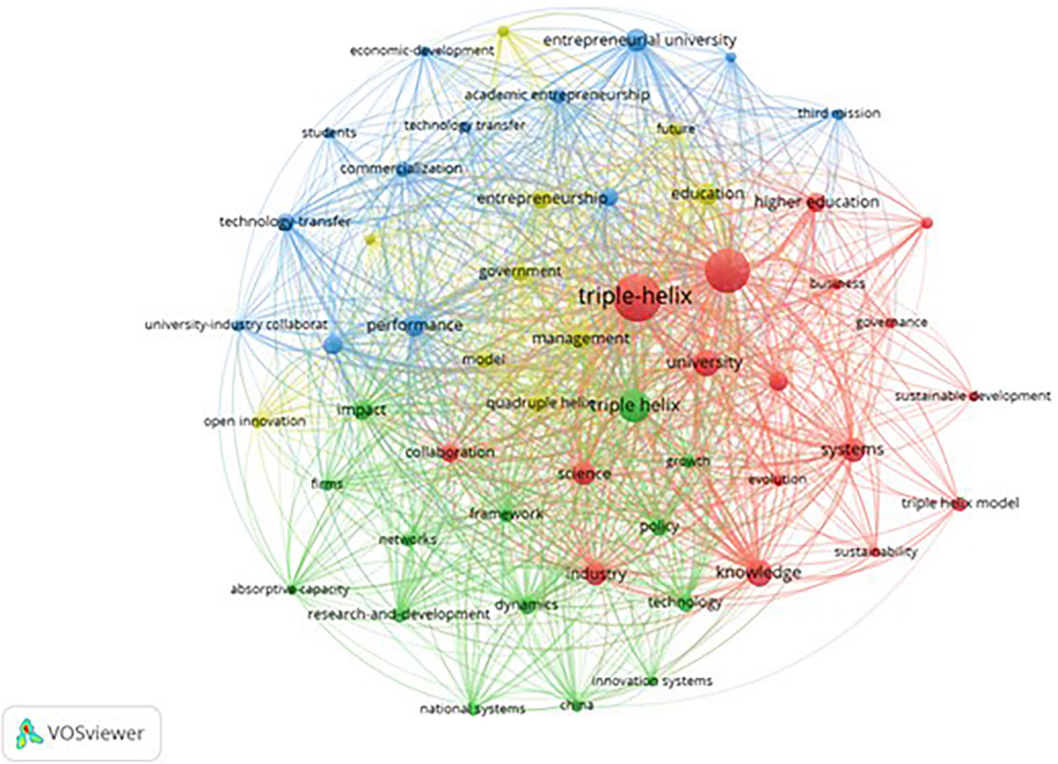

FIGURE 5
Co-word analysis of helix model and education.

are flexible, adaptable organisations that successfully carry out their third mission by modifying their objectives and action plans, seizing new opportunities, and taking calculated risks to integrate themselves into contemporary, competitive, and dynamic knowledge societies (Forliano et al., 2021). Entrepreneurial universities act in answer to this paradigm shift by establishing TTOs that support graduate entrepreneurship, student business plan competitions, university-based accelerators, incubators, and science parks, to name a few. Regional high-tech entrepreneurship is profoundly affected by a policy-driven transformation of universities toward an entrepreneurial paradigm (Nicholls-Nixon et al., 2021). As universities transform into entrepreneurial universities, there are an increasing number of high-tech start-ups in the area. Cerver Romero et al. (2021) focus on the entrepreneurial university concept of literary contribution from the researcher's perspective. The result shows that the connection between entrepreneurship activities and original academic intention is more toward the entrepreneurial university concept that its practicability,

- Cluster 4 (yellow): with six articles and cluster 4, known as "Entrepreneurship education."

According to the objectives of university assistance methods, terms such as "educating," "stimulating," and "incubating" are used to differentiate entrepreneurship education. Included in the categories of "stimulating" and "incubating" are activities such as providing pitching opportunities, office space, and even seed funding. The goals and methods of entrepreneurship education vary. As a result, the practical work methods employed by various colleges may vary considerably depending on the objectives of the programme, course, or support mechanisms (Zaring et al., 2021). According to a study of engineering students' entrepreneurship classes, they emphasised the importance of knowledge and skill development. The reflections highlighted the theoretical foundations of design thinking as a method and the creation of knowledge regarding technology commercialisation. In addition, a substantial portion of the learning was divergent and therefore focused on acquiring generic skills such as teamwork, interpersonal communication, networking, empathy, perspective-shifting, and becoming more comfortable with ambiguity (Lynch et al., 2021). Due to the diverse structure of learning experiences in higher education, research evaluating the influence of entrepreneurship education on students' entrepreneurial mindsets in China reveals that entrepreneurship education influences vary. Student entrepreneurial mindset is positively affected by extracurricular activities but negatively affected by class attendance. Further demonstrating the mediating role of entrepreneurial inspiration, entrepreneurship education influences entrepreneurial motivation, which improves students' entrepreneurial mindset. Thirdly, participation in extracurricular activities has a more significant positive impact on students' emotional intelligence (entrepreneurial mindset) than classroom attendance, highlighting the significance of learning experiences in entrepreneurship education - entrepreneurial mindset connection (Cui et al., 2021). Igwe et al. (2021) demonstrate that the entrepreneurship education and management education mechanism is comprised of a variety of factors, including knowledge and cognitive learning, innovation in teaching pedagogy, a shift in teachers' and students' attitudes, and a shift in their behaviour that will lead to knowledge exchange,

TABLE 7 Co-word clusters on helix model and education.

Cluster no and colour	Cluster label	Number of keywords	Representative keywords
1 (red)	Quadruple helix innovation: sustainable development.	17	"business," "collaboration," "evolution," "governance," "higher education," "industry," "industry-government," "innovation," "knowledge," "science," "sustainability," "sustainability development," "system," "triple helix model," "triple helix," "universities," "university"
2 (green)	Absorptive capacity in the helix model collaboration	14	"absorptive-capacity," "China," "dynamics," "firms," "framework," "growth," "impact," "innovation system," "national system," 'networks," "policy," "research-and-development," "technology," "triple helix"
3 (blue)	The performance of the entrepreneurial university	13	"academic entrepreneurship," "commercialisation," economic-development," "entrepreneurial university," "entrepreneurial universities," "higher-education," "knowledge transfer," "performance," "students," "technology transfer," "technology-transfer," "third mission," "university-industry collaboration"
4 (yellow)	Entrepreneurship education	10	"education," "entrepreneurship," "entrepreneurship education," "future," "government," "management," "model," "open innovation," "quadruple helix," "strategy"

responsible education, a decline in unemployment, and the preparation of the future workforce.

4. Implications

4.1. Theoretical implications

Despite increased interest in the topic over the past few years, spurred by a variety of specific issues and calls for papers, the subject matter of TH and education publications remain dispersed. The use of TH in educational settings is a field that necessitates systematisation efforts such as the one proposed in this study; in the future, more of these efforts should be supported (Siegel and Wright, 2015; Secundo et al., 2019). Participation in TH operations and collaborative research and development initiatives can assist universities in achieving their third objective of social effectiveness while also satisfying the industry participation requirements of finance programmes. Additionally, they should be aware of their innovation-related actions and capabilities (Etzkowitz, 2003a). Entrepreneurial universities received a great deal of attention in primarily technological journal publications. As part of managing relationships between universities, industries, and governments, one topic to consider is expanding knowledge of the performance measurement practises currently used by university authorities in entrepreneurial endeavours. Additionally, the study enhanced our empirical comprehension of the issues surrounding evaluating the success of entrepreneurial institutions' initiatives.

The development of TH is primarily influenced by the regional adoption of novel products, goods, services and technologies with a strong need for the capacity to absorb foreign knowledge spillovers (Lehmann et al., 2022). Consequently, industries maintain their technological innovation leadership. The commercial sector should aggressively pursue the acquisition of high-tech radiation, including research results and the expertise of government and academic institutions. The endogenous growth model can be utilised to calculate absorptive capacity, which can then be applied to the problem of knowledge filtering(Grossman and Helpman, 1994; Galvao et al., 2019). Entrepreneurship alone cannot bridge the gap between the production of new knowledge and increased output. The two components of "absorptive capacity" are cognitive capacity and technical capacity. Technical and critical thinking skills, as well as an entrepreneurial spirit, are potential indicators of the eventual breach of the knowledge filter.

4.2. Practical implications

The TH maximises universities' contributions to intellectual and technological innovation while extending the benefits of these contributions to other areas of innovation (Etzkowitz, 2003b). TH actors (UIC) must abandon the old ivory tower advancement paradigm. These actors need to focus more on application novelty and technological creation and ultimately transform toward an entrepreneurial university. Building a comprehensive TH innovation chain and promoting science and technology professionalisation and connection to intermediate service organisations should be the objective of all regional innovation participants (Ankrah and AL-Tabbaa, 2015). The TH relationship is not as strong as it should be because the networks and diverse organisations created by the interaction of the three central bodies have yet to be fully developed and utilised (Kim and Lee, 2016). The type of interaction includes TTOs, business incubators and venture capital firms. The government must actively support the complete change and industrialisation of R&D achievements, bolster the commercialisation of R&D spin-off firms, permit professionals to do what they do best, and establish a vital connection between the university and the industry.

Zhang et al. (2019) say that tools for developing higher education policy that helps universities become entrepreneurial are suitable for both the universities and the communities where they are located. These policy instruments must offer enough institutional autonomy to help universities realise an entrepreneurial university paradigm while adjusting to regional realities. Institutions should support "economic and social coherence" (Kitagawa et al., 2004). Teaching, studying, and sharing new technologies are the institution's main influences on local high-tech start-ups. Academics must explore how university design encourages individual career advancement, independent of gender, ethnicity, or professional stage.

TABLE 8 Suggestion for future research agenda.

Cluster/theme	Suggestions for future research
Co-citation analysis	
Cluster 1:" Triple helix development"	It needs to be investigated whether the university would benefit more if it continued to be involved in the creation of spin-off companies (financial gains and survival rate)
	The impact of academic engagement in the process of UIC needs to be addressed.
	There is a need to explore the extent to which UIC can be used to enhance the competitive advantages of participating companies.
	There is a need for longitudinal studies to broaden our understanding of UIC.
Cluster 2: "Entrepreneurial university"	Examine the university's position in entrepreneurial society in terms of entrepreneurial capital.
	There is a need to examine the role of the university in promoting entrepreneurial thinking, leadership and action in an evolving entrepreneurial society.
	Should operational knowledge be considered in entrepreneurial universities?
	Most research focuses on science and engineering courses and faculties; other areas need to be investigated.
Cluster 3: "knowledge-based economy"	A outlook toward in-depth analysis of a TTO's skillful communication with both stakeholder groups in TH, focusing on effectively crossing boundaries.
	There is possible extensions of the econometric analysis include the addition of additional environmental and institutional factors as explanatory variables in the inefficiency equation, such as measures of the rigour of state and university technology transfer policies, local venture capital activities, and more specific data on regional R&D.
	There is a need to examine the effect of obstacles on the outcomes of collaborations between Helix model actors and the effect of perceived barriers on subsequent collaborations.
	Should academics become entrepreneurs?
	How might the various incentive systems for academic researchers and industrial colleagues be aligned to create mutually beneficial results?
Cluster 4: "Mode 2-academic capitalism and society"	Are university scholars becoming more reflective in the sense that they are aware of the potential societal consequences of their study and consider this when conducting research?
	Do new criteria connected to the societal relevance of research outcomes now play a significant role in all types of scientific quality control, including not only the awarding of funds, but also the retrospective evaluation of persons, organisations or programmes?
	To confront global challenges to existing global and national hierarchies, is it possible to develop alternative forms of education organisation?
Bibliographic coupling analysis	
Cluster 1: "Third mission: Entrepreneurial university co-creation in triple helix."	There is a need to explore and explain similarities and differences in stakeholder perspectives to promote a shared understanding of entrepreneurial university co-creation in the Triple Helix.
	Do entrepreneurial university policies influence individual norms for implementing the third mission?
	To what extent is the culture of the third mission perceived by university staff and different organisational levels?
	There is a need to assess academic accountability to improve university performance and practise, and also to advance disciplinary support for innovation and entrepreneurship.
Cluster 2: "Knowledge transfer and commercialization"	Does access to knowledge *via* the transfer of human resources and human capital only have a significant positive impact on innovative capacity?
	Is the rate of improvement and linkages with international value chains the same as for domestic knowledge transfer activities?
	The differences between sectors in terms of interaction with universities deserve attention, as sectoral characteristics are pervasive in terms of technological progress.
	The determinants of the integration of universities into productive structures need to be assessed not only from the perspective of the universities, but also from the perspective of the companies.
Cluster 3: "University adaptability in innovation strategy"	There is a need to include the factor of industry cultures as a potential influencing factor for useless knowledge exchange.
	There is a need to explore whether greater stakeholder involvement in the design of entrepreneurial ecosystems in areas of low population density is appropriate.
	There is a need to explore the role of allocating consumer goods in creating start-up models to meet organisational and trans-regional needs
	The impact of linking macro- and micro-level mechanisms in innovation strategy needs to be explored.

(Continued)

TABLE 8 (Continued)

Cluster/theme	Suggestions for future research
Cluster 4: "University capabilities in technology transfer"	Evaluate TT policies and mechanisms and help build trust between Triple Helix actors
	In a private or public context, evaluate and assess the capabilities of universities in creating innovation networks that trigger invention, catalyse innovation and foster creativity.
	Determine the entrepreneurial actors at the university.
	Do universities need more autonomy and less bureaucracy to succeed in TT?
	What is the role of universities in central planning and accountability in the TT process?
Cluster 5: "The role of universities in entrepreneurship"	Is the development of counter-cyclical finance and creative leadership important in the development of entrepreneurship?
	It is necessary to look at the development of incubators in universities based on the nature of the incubator, its objectives, mechanism, context and green technology.
	A study needs to be done on the relationship between regional development, entrepreneurial education and experiential knowledge.
	The importance of universities' ability to diversify their relationships with industry to access a range of expertise and funding from other industries needs to be explored in the future.
Co-word analysis	
Cluster 1: "Quadruple helix innovation: sustainable development."	A future study can assess the impact of another dimension, globalisation, and position it at the centre of the Triple Helix framework.
	There is a need to explore new forms, mutual interests and possibilities of collaboration between the university and its stakeholders, in terms of the social, economic and environmental links that universities can foster and activate at different levels.
	The concept of 'living laboratories' that share opportunities and common interests to bridge the gap between the university and society at large can receive attention.
	There is a need to cultivate the strategic orientation of TH toward co-developing approaches and solutions to forecast and address sustainability challenges in the context of developed and developing countries.
Cluster 2: "Absorptive capacity in the helix model collaboration"	There is a need to advance research on TH by collecting more indicators and data through surveys or statistics to explore TH interactions from different research perspectives and assess the absorptive capacity of actors on TH.
	The role of TTOs could be explored in the light of current environmental, economic, technological and societal challenges to measure the absorptive capacity of universities.
	New forms and channels need to be developed to disseminate scientific results to non-academic audiences to enhance collaboration.
	Does the social capital of an organisation have a major impact on its absorptive capacity toward TH stakeholders?
Cluster 3: "The performance of the entrepreneurial university"	It is necessary to consider the impact of both internal and external organisational factors on the processes of exploitation and exploration in university entrepreneurship.
	Ambidexterity in entrepreneurial universities, how is university ambidexterity achieved over time?
	Is there a relationship between the exploitation or exploration process and the performance of the entrepreneurial university in achieving the university's goals in outreach, research and teaching?
	Entrepreneurial universities should not only focus on commercialisation of knowledge, but also on spin-off creation and patenting.
	The study should not only focus on strong leaders, but also on the micro-practises in evaluating entrepreneurial universities.
Cluster 4: "Entrepreneurship education"	Developing and testing new entrepreneurship education programmes based on interdisciplinary and operational approaches and involving university staff, students and external stakeholders is something to consider.
	Entrepreneurship education should be assessed according to the characteristics and specialisations of each university and the specific socio-economic environment in which the institution operates.
	The development of university entrepreneurship education and its research should also include information on social engagement, entrepreneurship education and training, and the different dimensions of innovation, and not be limited to the technological dimension.

5. Conclusion, limitation and future work

The examination of the bibliometric literature in this study has yielded several important findings and has also highlighted some areas that require further research. The inductive interpretation of the authors makes it difficult to classify the subject of the study. Depending on the context of the study, this interpretation could lead to several different themes. When examining the TH and its impact on education, the authors were able to extract the most important aspects of this research topic thanks to a precise search query. By reviewing the 22 periods of data collection, the result leads to the discovery of current and future research agendas, such as potentially groundbreaking research on the "triple helix" and "universities," which may offer new perspectives. Additional time can be used to achieve this. A future research agenda capable of the further scope of bibliometric analysis through the use of topic modelling and other unsupervised machine learning algorithms. The list of possible research topics on environmentally conscious education and business practices is by no means exhaustive. The data source for this study is

based on the large database of the Web of Science. Many previous studies have used this database over the past decades (Ramy et al., 2018; Flamini et al., 2022; Maseda et al., 2022). It should be noted that recent studies such as Mohammadi and Karami (2020) and Schröder et al. (2015) have adopted a new approach, text mining, to investigate the scope and structure of big data across disciplines. Schröder et al. (2015) noted that text mining or clustering algorithms could be used as a benchmark for research clusters. Future research should incorporate this new approach in the study of TH.

Nevertheless, the results of the bibliometric analysis of this study make it abundantly clear that we need significantly more scientific efforts on sustainability in business education to improve our knowledge base. The increasing acceptance of scholarly work in this area by the leading university journals on business, entrepreneurship and management should encourage scholars to explore these topics further, as mentioned earlier. Table 8 illustrates some areas we believe future helix model development should consider answering all research objectives.

In conclusion, this study aimed to examine the current state of TH development in education and suggest new avenues of inquiry. This research aims to: (1) provide an overview of significant publications in the field of the TH model in education using the co-citation method; (2) present the current framework of the field network using the bibliographic coupling method; and (3) predict the outlook research agenda in the development of the field through co-word analysis. We analysed 557 documents from the WoS database on the development and implementation of the helix model. After conducting an in-depth analysis of the material, this report proposes a comprehensive research agenda for emerging trends that are anticipated to impact academics and policymakers significantly. The research will assist in evaluating and contributing to even more astounding advancements in economic, technological, and social fields, especially collegiate entrepreneurship.

Data availability statement

The original contributions presented in the study are included in the article/supplementary material, further inquiries can be directed to the corresponding author.

Author contributions

HZ and DK contributed to the design of the study. HZ organised the database and wrote the first draft of the manuscript. HZ and MF performed the statistical analysis. HZ and WW performed the theme development. All authors contributed to the manuscript's revision and read and approved the submitted version.

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Conflict of interest

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

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