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Technical and vocational education training and industry collaboration: a bibliometric review

Marlissa Omar, Fathiyah Mohd Kamaruzaman
STEM Enculturation Research Centre, Faculty of Education, Universiti Kebangsaan Malaysia, Selangor, Malaysia

Article Info	ABSTRACT
	Technical and vocational education training (TVET) is an education and training process with a strong emphasis on industry practices that aims to generate competent workers in particular fields. Collaboration with industry in TVET has the potential to improve the quality and relevance of TVET programmes and equip students with the practical skills and knowledge demanded by employers. Thus, there is a need for a complete bibliometric study of research linked to collaboration between TVET and industry, despite the fact that the number of studies in this field continues to increase. The bibliometric analysis in this research which was extracted from Web of Science database is analyze using VOSviewer. The research conducted a descriptive analysis of the publication number trends, the top authors and leading journals in this field. Next, the researcher also analyzed the co authorship based on authors and countries, research trends, citation and keywords analysis as well as co citation analysis. The article found that most of the articles in this field are published by authors from developed countries where the majority is from the United States. Other than that, the recent research hotspot were also identified indicating the future direction of the research in this field.

Corresponding Author:

Marlissa Omar
STEM Enculturation Research Centre, Faculty of Education, Universiti Kebangsaan Malaysia
Bangi-43000, Selangor, Malaysia
Email: marlissa@ukm.edu.my

1. INTRODUCTION

Technical and vocational education training (TVET) is an education and training process that places significant emphasis on industry practises, with the primary objective of developing a proficient workforce in specialised areas. Industry and TVET institutions can enhance graduate employability by bridging the gap between academic learning and real-world workplace requirements [1]. This collaboration can lead to curriculum alignment, industry-relevant skills development, workplace exposure, guest lectures, internships, apprenticeship programs, industry-enhanced certifications, technology, and equipment access, a continuous feedback loop, soft skills development, and job placement services. By collaborating with industry, TVET institutions can provide students with practical experience, industry-standard tools, and industry-endorsed certifications, ensuring graduates possess credentials that are directly relevant to the industry [2]. Additionally, industry partnerships can facilitate job placement services, connecting graduates with employment opportunities. This mutually beneficial relationship can result in higher employability rates and successful transitions from education to the workforce.

TVET institutions have a significant and extensive historical background in Malaysia. Since it is early stages of development, the nation has prioritised technical and vocational education. The enhanced emphasis on TVET in the present day is manifested in the amplified significance and prominence of TVET in

the 11th and 12th Malaysian Plans [3]. In recent times, the Malaysian government has persistently allocated resources towards TVET, with a specific emphasis on enhancing the calibre of instruction and fostering greater cooperation with the industry. The concept of industry partnership in TVET pertains to the cooperation between TVET institutions and the industry sector with the aim of enhancing the calibre and pertinence of TVET curricula, and providing students with the pragmatic competencies that are essential for meeting the demands of employers. UNESCO places emphasis on enhancing training systems and consistently underscores the necessity of establishing stronger connections between training programmes and the labour market [4]. The establishment of partnerships with industry is crucial for TVET institutions [5] to maintain their relevance and generate graduates who possess the necessary skills to fulfil industry requirements. The significance of the interplay among multiple stakeholders cannot be overstated in the endeavour to effectively design and execute an education and training framework that yields a proficient labour force.

Collaboration refers to the process of interaction between two or more parties, each with a designated role, aimed at successfully planning and implementing a management system that facilitates joint decision-making in the interest of organisational and national development [6]. Collaboration is a strategic alliance that leverages the knowledge and expertise of an educational and training institution in conjunction with industry. The aforementioned statement indicates that collaboration entails the establishment of a cooperative network between educational and training institutions and the industry [7], with the aim of fostering a harmonious ecosystem in the realm of employment and training. The collaboration between the industry sector and TVET institutions is aimed at improving the quality and pertinence of vocational education and training programmes. The process entails a symbiotic relationship characterised by intimate collaboration, effective communication, and reciprocal assistance between the aforementioned entities to reconcile the differences between academic establishments and the demands of the labour market [8].

Numerous scholarly investigations assert that fostering collaboration between educational institutions and industry-based training is crucial and highly necessary in order to attain the goal of generating a proficient workforce. There are studies identified that industrial attachment is the most significant linkage, with challenges like lack of initiative and poor industry response [8]. Industry linkage is not the only aspects in the collaboration between industry and TVET institutions that could benefit both parties as well as students. Therefore, it is imperative to consider strategic collaboration between educational and training institutions and the industry as a crucial approach to augment a proficient workforce that aligns with the industry's requirements. Furthermore, the expeditious advancement of technology has necessitated collaboration between educational and training establishments and industry to impart knowledge and expertise on cutting-edge technologies, thereby facilitating the creation of a proficient and high-caliber workforce. In order to attain the status of a high-income generating country, it is imperative that all stakeholders, including the government, institutions, and industry, engage in effective strategic collaboration. This will enable the workforce to contribute to the economic growth of the nation.

2. RESEARCH METHOD
2.1. Research objective
This article aims to examine the trends and studies related to TVET and Industry collaboration by using a bibliometric mapping method. This method utilized publications retrieved from Web of Science database and analyze the trends, status of the publications in terms of its citation, authors, sources of publications (journals), institutions, countries and keywords used by the author in their publications. Bibliometric techniques employ science mapping on bibliographic data sourced from publication databases such as Web of Science, with the aim of identifying the comparative impact of publications and their contribution to the formation of knowledge clusters, such as major themes, within a network. By doing so, individuals can offer valuable perspectives on the development of the field, including its intellectual lineage, as well as the nascent areas of inquiry. This method is widely used to analyzed and explore a large amount of articles or data in particular field [9].

2.2. Data collection
In May 2023, the Web of Science database yielded a total of 1,442 publications. The Web of Science database was selected based on it is extensive collection of articles pertaining to the field in comparison to other databases. In addition, it is noteworthy that Web of Science is a dependable repository of scholarly literature, wherein a significant proportion of the articles encompassed within this database have undergone rigorous evaluation by specialists within the relevant domain. Birkle et al. [10] asserts that the database in question is not only widely utilised but also holds a position of authority in the field of research publications and citations. The Web of Science is comprised of a diverse array of specialized indexes, which

are categorized based on the nature of the indexed content or thematically emphasized [11]. Table 1 shows the inclusion and exclusion criteria of this article.

Table 1. Inclusion and exclusion criteria

Criteria	Value
Inclusion criteria	a. Keywords search was based on all field
	b. Documents written in English language
	c. Documents published within 2010 to 2023
	d. Documents types only limited to article, proceedings and review article
Exclusion criteria	a. Date of publication before 2010
	b. Documents published in non-English languages

The process of identifying the articles in this study refers to the preferred reporting system for systematic reviews and meta-analyses (PRISMA) [12]. PRISMA is a framework used for conducting systematic reviews and meta-analyses, particularly in healthcare. It provides a structured and transparent reporting format, ensuring well-organized and reproducible studies. PRISMA encourages researchers to develop a detailed protocol, outlining objectives, search strategy, inclusion/exclusion criteria, and data extraction methods. A comprehensive literature search strategy is essential for identifying relevant studies. A transparent selection process is documented, establishing the validity and reliability of the study. Data extraction and synthesis are systematic, extracting relevant information from each publication. The risk of bias assessment can be applied to bibliometric analysis, assessing the quality and reliability of data sources. By adhering to PRISMA guidelines, researchers can improve transparency, rigor, and reproducibility in their bibliometric analyses. Figure 1 shows the PRISMA research protocol for this study.
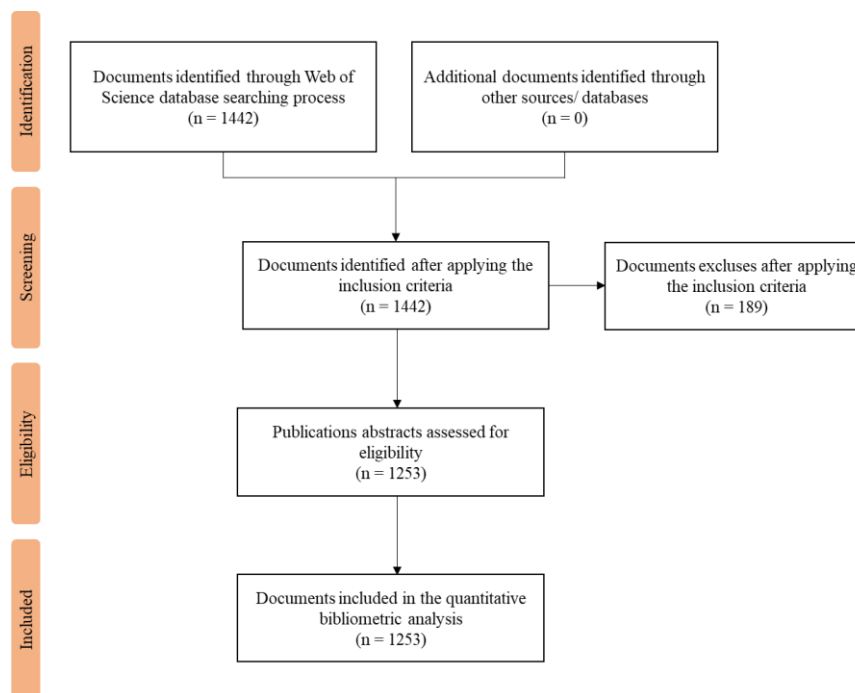

Figure 1. PRISMA research protocol

The data related to the publications was obtained in May of 2023, with the application of inclusion criteria to ensure the relevance of the acquired publications. The study's inclusion criteria are based on the year of publication (2010 to 2023), document type (including articles, proceeding papers, and review articles), and language (English). To obtain relevant publications related to this study, appropriate keywords were employed through the implementation of Boolean search commands to efficiently search for relevant literature. The publications were identified using the following keywords: (TVET OR TVE OR vocational OR training) AND industry AND institution AND collaboration.

2.3. Data analysis

The study starts with the search of the Web of Science database, followed by the application of inclusion criteria to procure relevant publications. Upon identification of relevant publications, the authors proceeded to extract data based on various categories, including but not limited to authors, year of publication, citation count, affiliation, country of origin, and number of publications. Among the chosen publications, 70% consist of articles, 23.4% are proceedings papers, and 6.6% are review articles. The data related to publications obtained from the Web of Science database is then exported to tab delimited file. The process of extracting fundamental data related to publication and citation trends, highly cited articles, top publishing journals, institutions, and countries was conducted using Microsoft Excel. VOSViewer was employed by the author for conducting bibliometric analysis. As explained by van Eck and Waltman [13], VOSViewer is a software tool designed to facilitate the creation and visualisation of bibliometric maps. Van Eck and Waltman [14] state that VOSViewer has been designed to facilitate the examination of clustering outcomes at a higher level of aggregation. Therefore, this software is deemed appropriate for application in this study.

3. RESULTS AND DISCUSSION

3.1. Publication and citation trends

Based on the search process conducted at the early stages of this study, a total of 1,253 publications were identified in the selected database. Figure 2 shows the publication and citation trends based on the 1,253 publications identified through the Web of Science database. Research related to collaborations between industry and TVET institutions originated in the 1990s and gained momentum from 2010 onwards. The graphical representation reveals a notable rise in the quantity of publications within this particular domain, spanning from 2018 to 2022, with a cumulative count of 176 articles. 60% of the total publications is produced between 2010 and 2023 comprise the aforementioned total number of publications. Regarding the quantity of citations, there has been a steady rise in the number of citations over time. The Web of Science database documented 39,383 citations in May 2023, which were attributed to 37,256 articles.
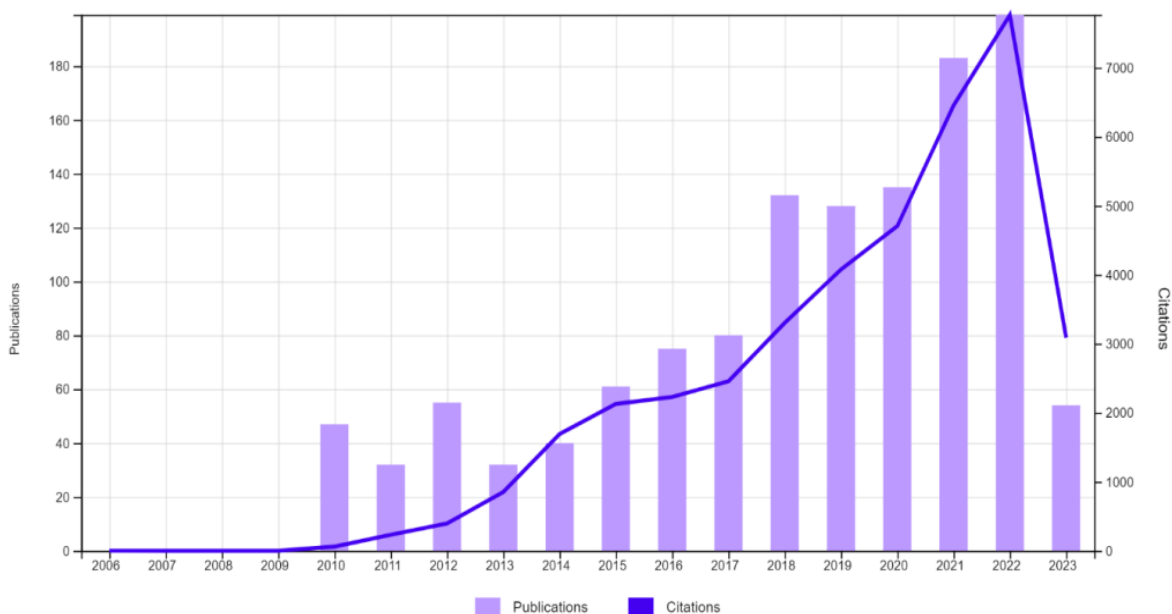

Figure 2. Publication and citation trends

3.2. Highly cited articles

Based on the identified publications, the top articles in this field with highest citation is presented in Table 2. The authors have identified 5 most frequently cited articles in this field and listed the name of authors, document title, sources or the articles and number of citation for each articles. Based on Table 2, Oliveira and Martins [15] article entitled understanding e-business adoption across industries in European countries is at the first place with 283 total citation (20.21 citation per year). The next most cited articles is by Perkmann *et al.* [16] with an articles entitled academic engagement: a review of the literature 2011-2019 with

a total of 100 citation (33.33 citation per year) and followed by Ansari *et al.* [17] article entitled rethinking human-machine learning in industry 4.0: how does the paradigm shift treat the role of human learning with a total of 65 citation (10.83 citation per year). In general, the top 2 most cited articles have more than 100 citation until May 2023.

Table 2. Top 5 highly cited articles

Author(s)	Document title	Source	Total citation
Oliveira and Martins [15]	Understanding e-business adoption across industries in European countries	Industrial management and data systems	283
Perkmann *et al.* [16]	Academic engagement: A review of the literature 2011-2019	Research policy	100
Ansari *et al.* [17]	Rethinking human-machine learning in industry 4.0: how does the paradigm shift treat the role of human learning	Procedia manufacturing	65
Thune [18]	The training of "triple helix workers"? Doctoral students in university–industry–government collaborations	Minerva	61
Povey *et al.* [19]	Engaging parents in schools and building parent-school partnerships: the role of school and parent organization leadership	International Journal of Educational Research	30

3.3. Most prominent journals

In this study, the authors have identified the most prominent journal with high numbers of publications related to the field. Table 3 shows the most prominent journals in this field. According to the results of data extraction, it is identified that there is only 5 journals or sources published more than 10 publications. The highest numbers of publications is from ICERI Proceedings with a total number of 20 articles followed by EduLearn Proceedings with a total number of 16 articles. The next journal or sources with the highest number of publications in this field is Sustainability which is a multidisciplinary journal with a total number or 14 articles. From the top 6 journals, there are one journal from Malaysia, which is Journal of Technical Education and Training at number 6. This journal is indexed both in Scopus and Web of Science (Emerging Science Citation Index). Overall, total number of publications in the top 6 most prominent journals is 83 articles.

Table 3. Top 6 most prominent journals

Sources	Numbers of articles	% of 1,253
ICERI Proceedings	20	1.597
EduLearn Proceedings	16	1.278
Sustainability	14	1.118
Lecture Notes in Computer Science	13	1.038
INTED Proceedings	11	0.879
Journal of Technical Education and Training	9	0.719

3.4. Top institutions

As for institutions, there are various institutions that have published articles related to industry and TVET institutions collaborations. However, the author only focused on the top 6 most productive institutions in this field based on Table 4. Based on Table 4, University of California System is at the top place with 102 articles under their affiliation (8.147% out of total publications). The most productive institutions is followed by Udice French Research Universities with a total of 97 articles (7.748% out of total publications) and University of London with a total of 91 articles (7.268% out of total publications). Based on the findings, it can be seen that France contributes to 2 of the most productive institutions (Udice French Research Universities and Centre National De La Recherche Scientifique (CNRS)) as well as England (University of London and University of Oxford).

Table 4. Top 6 most productive institutions

Institutions	Numbers of articles	% of 1,253
University of California system	102	8.147
Udice French Research Universities	97	7.748
University of London	91	7.268
University of Melbourne	87	6.949
Centre National De La Recherche Scientifique (CNRS)	83	6.629
University of Oxford	72	5.751

3.5. Top publishing countries

The top 6 most productive countries in this field is as shown in Table 5. Based on Table 5, the most productive country with highest publications relevance to this field is United States of America (USA) with 334 articles (26.677%). This finding is parallel to the findings of most productive institutions where the top productive institutions identified in this study is University of California System located in USA. The next productive country is Australia with a total number of 315 articles (25.160%) which is also parallel to the findings of the most productive institutions where University of Melbourne is at the top 4 institutions with 86 numbers of publication only by itself. This is followed by England with 260 articles (20.767%), Peoples Republic of China (PRC) with 219 articles (17.492%), Germany with 203 articles (16.214%) and Italy with 158 articles (12.620%). Based on the data extracted, Malaysia is at 36th place with a total of 42 articles (3.462%). Thus, this shows that this field is not yet widely explored in Malaysia and there is a need to further study on the implementation of industry and TVET institutions in Malaysia towards improving out TVET graduates quality and employability.

Table 5. Top 6 most productive countries

Countries	Numbers of articles	% of 1,253
USA	334	26.677
Australia	315	25.160
England	260	20.767
Peoples Republic of China	219	17.492
Germany	203	16.214
Italy	158	12.620

3.6. Co-authorship analysis

To create a link between researchers or authors of the articles related to industry and TVET institutions collaboration, a co-authorship network analysis is conducted using VOSviewer software. The concept of co-authorship network analysis pertains to the evaluation of the interaction that occurs among multiple scientists within a social setting, enabling the exchange of ideas and accomplishment of objectives in relation to a common aim [20]. In this study, the author identifies the co-authorship analysis of countries and organization. For co-authorship network analysis based on countries, the author have set the minimum numbers of documents of a country to 5 and minimum numbers of citations of an author is set to 5. Figure 3 shows the visualization network of the country co-authorship produce by VOSViewer.
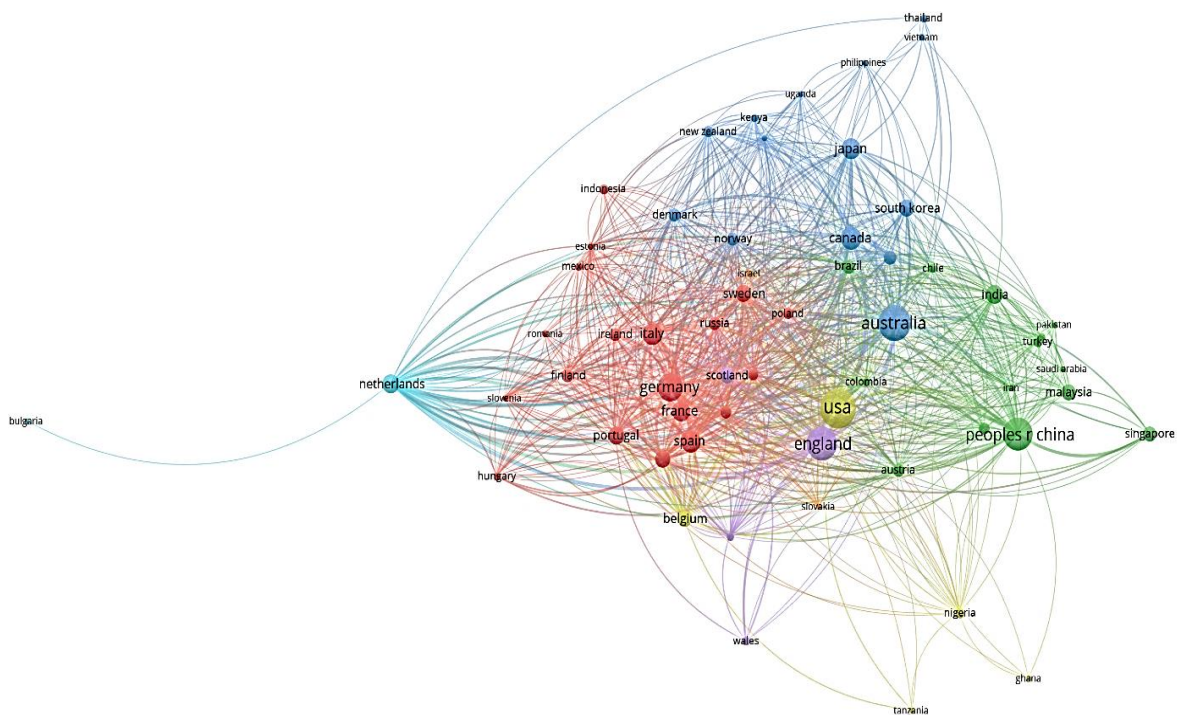

Figure 3. The visualization network of the country co-authorship

Based on the analysis, there are 60 countries/regions that meet the requirements. All the countries included in the analysis are divided into 7 clusters. The first cluster (n=19) in red colour shows Germany (101 publications and 334 total link strength (TLS)) as the largest node followed by Spain (64 publications and 250 TLS), Italy (61 publications and 263 TLS) and France (51 publications and 273 TLS). The second cluster represented by green colour shows collaboration between People's Republic of China (137 publications and 225 TLS), India (49 publications and 94 TLS), Malaysia (33 publications and 42 TLS) and Singapore (28 publications and 34 TLS). Australia (162 publications and 322 TLS), Canada (66 publications and 226 TLS), Japan (57 publications and 122 TLS) and South Korea (36 publiations and 82 TLS) belongs in the third cluster represented by blue cluster. USA (198 publications and 389 TLS), Belgium (32 publications and 183 TLS), Nigeria (14 publications and 31 TLS), Tanzania (5 publications and 7 TLS) and Ghana (5 publications and 5 TLS) belongs to the yellow cluster. England (145 publications and 449 TLS), Scotland (28 publications and 154 TLS), Wales (12 publications and 21 TLS) and Luxemburg (8 publications and 79 TLS) is in the purple cluster. Netherlands (47 publications and 273 TLS) and Bulgaria (5 publications and 1 TLS) is in the ocean blue cluster and Israel (7 publications and 63 TLS) and Slovakia (6 publications and 40 TLS) belongs to the orange cluster. As shown in the visualization map, Australia, USA, England, Germany and People's Republic of China is the largest nodes indicating the productivity of the country parallel to the previous findings related to the most productive countries. Therefore, these countries can be said to be the leading countries in this field of research. The next co-authorship analysis conducted by the author is the co-authorship organization analysis. Figure 4 shows the visualization network of the organization co-authorship.
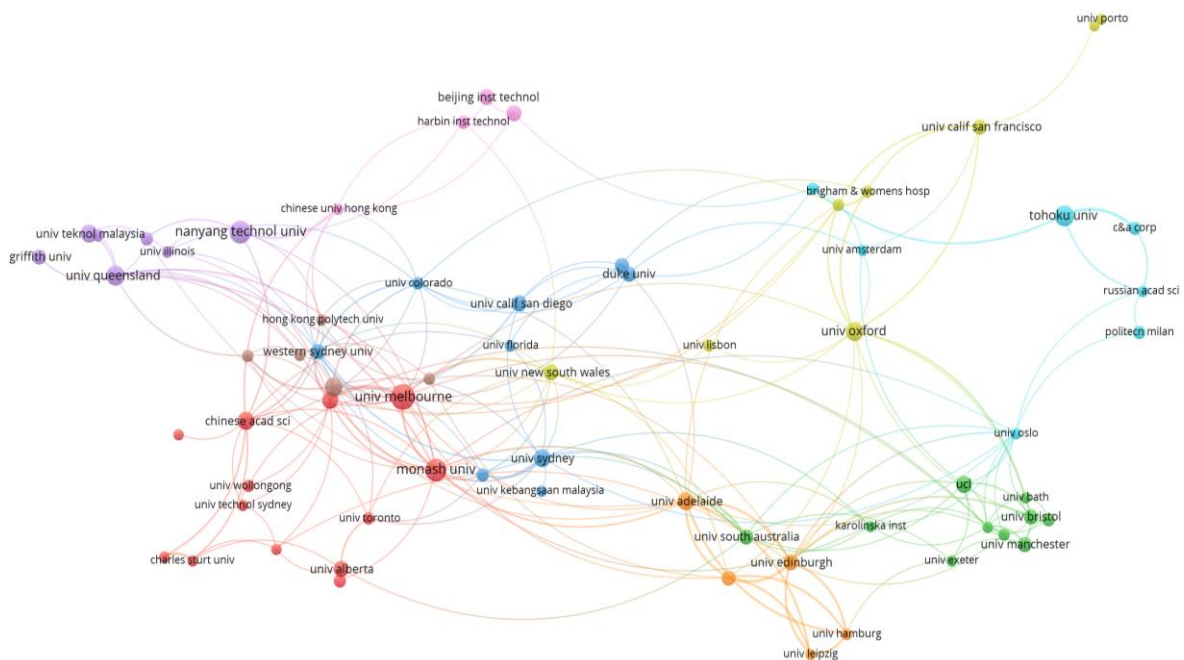

Figure 4. The visualization network of the organization co-authorship

Based on the analysis, there are 73 out of 2,153 organizations that meet the requirements. The author sets the treshold in the analysis to be minimum number of documents of an organization and minimum number of citations of an organization to 5 as the minimum numbers. Based on the analysis, there are 9 clusters formed which indicates the collaborations between the organizations. The first cluster which is the red cluster is comprised of 13 organizations lead by the University of Melbourne (23 publication and 27 TLS) and Monash University (19 publication and 26 TLS). The green cluster is lead by University College London 11 publication and 9 TLS), University of Bristol (8 publication and 11 TLS) and University of South Australia (8 publication and 11 TLS). University of California Sandiego (10 publication and 6 TLS) and Duke University (8 publication and 8 TLS) is represented by the blue cluster. Oxford University (13 publication and 18 TLS) and University of California San Francisco (8 publication and 8 TLS) can be seen in the yellow cluster. Next, cyan clusters consists of Tohoku University (16 publication and 12 TLS) and University of Tokyo (6 publication and 6 TLS). The University of Adelaide (12 publication and 29 TLS),

University of Edinburgh (10 publication and 27 TLS) and University of Liverpool (8 publication and 21 TLS) shows a collaboration between them based on the orange cluster. University of Western Australia (13 publication and 16 TLS) and Curtin University (6 publication and 9 TLS) appears in the purple cluster as one of the organization most productive in this field. The lavender cluster consists of Nanyang Technological University (18 publication and 11 TLS), University of Queensland (14 publication and 16 TLS) and Universiti Teknologi Malaysia (12 publication and 4 TLS). The last cluster which is the violet cluster consist of Beijing Institute of Technology (10 publication and 2 TLS) and The National Institute of Advanced Industrial Science and Technology (9 publication and 5 TLS). This indicates that the most productive organizations based on the sizes of the nodes is Nanyang Technological University, University of Melbourne and Monash University. These three organizations also have a strong collaboration between them as seen in the link between them in the visualization map.

3.7. Keyword analysis

In order to help us identify the hot topics and potential topics to be explored in the future, co-occurrence analysis is conducted in this study [21]. Co-occurrence analysis is conducted using VOSViewer and the network visualization map is shown in Figure 5. Based on the analysis, there are 56 keywords that meed the requirements (out of 3,549). The treshold set for the minimum number of occurrence of a keyword is 5. The most frequently used keywords in this field are collaboration (green cluster), higher education (purple cluster), innovation (red cluster), education (yellow cluster), Industry 4.0 (violet cluster). These results suggest that collaboration, higher education, innovation, education and industry 4.0 are the keywords frequently examined by the researcher in this field. Table 6 shows the most frequently used keywords related to industry and TVET institutions collaboration. As seen in Table 6, collaboration is the most frequently used keywords with 44 occurrences (39 TLS) followed by training (41 Occ, 33 TLS). Other frequently used keywords are higher education (24 Occ, 28 TLS), innovation (25 Occ, 27 TLS), education (18 Occ, 17 TLS), and entrepreneurship (10 Occ, 15 TLS).
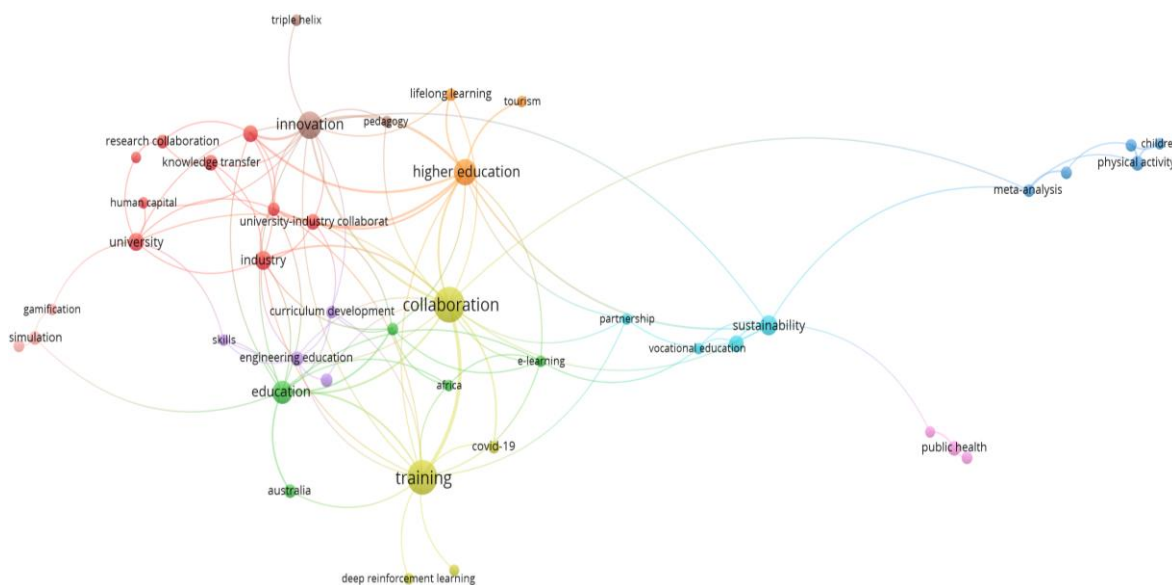

Figure 5. Co-keyword network visualization

Table 6. Most frequently used keywords

Authors' keywords	Occurrences	TLS
Collaboration	44	39
Training	41	33
Higher education	24	28
Innovation	25	27
Education	18	17
Entrepreneurship	10	15
Industry	12	12
Research	7	12
Sustainability	14	10
Engineering	6	8

The primary goal of collaboration in the higher TVET sectors is to enhance the development of skills necessary for employment prior to entering the workforce. Therefore, it is logical that this study has identified "collaboration" as the most commonly used term, and "training" as the second most frequently used keyword. This is primarily due to the prominent collaboration objectives, which include improving technical skills, reducing demand and supply mismatch, enhancing employability skills, and promoting knowledge transfer between institutions and the community [22]. The scope of this study are directly linked to the identified keywords, focusing on skills training as well as knowledge transfer between the industry and TVET institutions which can be effectively achieved through networking and collaborative efforts which includes students and academic staff.

In addition to the collaboration between industries and TVET training institutes, there is a growing focus on the necessity of establishing a linkage between universities and industries, as indicated by the increasing use of the keyword "Higher institutions". Typically, these relationships involve research support, joint research with industries, and technology transfer [23]. This implies that what is currently being studied in this area would focus on the interaction between universities and industry, which might potentially enhance the reputation of TVET. By engaging industries, we might potentially address the discriminatory characteristics of TVET by enhancing its social standing and acceptance, while also providing increased wage prospects and improved mobility [24].

The development of sustainable entrepreneurial skills is crucial for fostering economic and social advancement in both developed and developing societies. Therefore, it is essential for TVET trainees to have sufficient entrepreneurial experience in order to develop the skills necessary to meet the current and future demands of the market [25]. This sentence properly describes another frequently used keywords identified in this study, which is "entrepreneurship". TVET students must acquire entrepreneurial skills in order to cultivate an entrepreneurial mindset. This includes developing their capacity to identify and recognize opportunities for entrepreneurship [26]. By focusing on enhancing students' entrepreneurial skills, this initiative aims to expand career possibilities and thereby enlarge the job market for individuals seeking employment.

4. CONCLUSION

This article examines the trends and studies related to TVET and Industry collaboration from 2010 up to 2023 by using a bibliometric analysis. There were a total of 1,442 publications identifed based on the search process conducted using the Web of Science database and only 1,253 publications were included in the study. Based on the findings, there seems to be an increased in the number of publications starting from 2010 and there is a sharp increase starting from 2018 until present year. 2022 records the highest numbers of publication in this field which indicates an increasing interest in the studies related to industry and TVET institutions collaborations.

The partnership between industry and TVET is a pivotal factor that can enhance the employability of TVET graduates and address the challenge of graduates lacking the requisite competencies that the industry demands. The symbiotic relationship between educational institutions and industries is crucial in the production of skilled workers. Educational institutions are responsible for producing skilled graduates, while industries require skilled workers to meet their operational demands. In addition to this, the phenomenon of globalisation and the rapid progress in technology and communication have been altering the configuration of the labour market on a global scale, thereby transforming the skill prerequisites for extant and forthcoming occupations. Hence, a collaborative approach is imperative to mutually benefit the involved parties and address the fundamental challenges associated with the aforementioned situations.

The research findings suggest that there is potential for further investigation in emerging research areas such as Sustainability, entrepreneurship, and innovation. These are the emerging keywords associated with this particular field. The concept of Sustainability has garnered significant attention worldwide through the sustainable development goals (SDGs) particularly in recent times. SDG 17 recognizes that accomplishing all of the SDGs necessitates cooperation among different stakeholders. Partnerships for common objectives can be formed among governments, companies, and civil society organizations. In order to create a trained workforce that can match industry demands, there is a need to examines long-term collaborations between academic institutions and business. An enhanced comprehension and collaboration among parties might result in more advantageous collaborations where there are several studies that highlights the impact of governance and institutions on sustainable collaboration. Therefore, the keyword sustainable could be the next important aspects to be discussed in this field by future researchers.

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BIOGRAPHIES OF AUTHORS

Marlissa Omar 🆔 📇 SC ◐ is a senior lecturer at Centre for STEM Enculturation, Faculty of Education, Universiti Kebangsaan Malaysia. She obtained her doctor of philosophy in Technical and Vocational Education Training (TVET) from Universiti Teknologi Malaysia (UTM). Besides teaching, she is actively involved in research activities. Her current research interests include vocational education, digitization in TVET, mobile apps in TVET education, and other issues in TVET education. She can be contacted at email: marlissa@ukm.edu.my.

Fathiyah Mohd Kamaruzaman 🆔 📇 SC ◐ is a senior lecturer at the Centre of STEM Enculturation, Faculty of Education, Universiti Kebangsaan Malaysia since 2022. She obtained her doctor of philosophy in Engineering Education from Universiti Kebangsaan Malaysia (UKM). She is a member of the Society of Engineering Education Malaysia (SEEM) since 2017. She has actively conducted research in areas such as the development of generic skills for Industrial Revolution 4.0 (4IR), employability in the TVET sector, TVET competencies and other issues pertaining to TVET education. Her research contribution has been disseminated through publications in indexed journals, as well as national and international conference proceedings in both TVET education and civil engineering education fields. She can be contacted at email: fathiyah@ukm.edu.my.