

Literature Review

Communication, Collaboration, Critical Thinking, and Creative (4Cs) in TVET: A Bibliometric Analysis and Systematic Literature Review

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ABSTRACT

This article maps research trends, key contributors, and thematic structures of the 4Cs—communication, collaboration, critical thinking, and creativity—within Technical and Vocational Education and Training (TVET), while synthesizing experimental efforts to enhance these skills. It addresses a documented gap by combining bibliometric performance analysis and science mapping (RQ1–RQ6) with a systematic review of intervention studies (RQ7). A total of 3,246 documents were obtained, of which 1,655 documents were analyzed bibliometrically, and 32 documents were analyzed through a systematic literature review after screening and applying inclusion/exclusion criteria. The 4Cs–TVET research shows a continuous surge with “communication skills” as the driving theme and creativity relatively unexplored, indicating a thematic focus that still leans toward social competencies. In general, 4Cs–TVET research involves many researchers from various institutions and countries, showing that this research has become a global focus. However, the findings indicate that participation is concentrated in developed and middle-income countries, whereas least developed countries (LDCs) remain underrepresented in this research area. Experimental efforts to improve the 4Cs are spread across five approaches (technology/online, collaborative-interprofessional, gamification, project-based/active learning, simulation), but 56.25% target only one skill—collaboration being the most dominant—and only 6.25% integrate all 4Cs, indicating the need for more holistic intervention design.

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1. INTRODUCTION

Technical and Vocational Education and Training (TVET) has become an essential part of education that emphasizes the cultivation of technical and practical skills to equip learners for employment in diverse industrial areas. TVET plays an important role in improving workforce skills (Tuenpusa et al., 2021; Yamada & Otchia, 2021), supporting economic development (Caves et al., 2021; Okoth, 2023), reducing unemployment (Jiboku et al., 2021; Wami, 2024), encouraging innovation and creativity (Ab Hamid et al.,

2024; Keelson et al., 2025; Pavlova & Askerud, 2024), increasing global competitiveness (Auta & Auta, 2022; Kahiga et al., 2024), reducing socioeconomic inequality (Leong, 2024; Mirabel et al., 2022), and supporting economic independence (Benshak et al., 2024; Olabiyi, 2023), through vocational education that is relevant to industry needs. In other words, TVET contributes significantly to the development of a country (Legusov et al., 2022; Raby et al., 2023). On the other hand, in the rapidly evolving landscape of the 21st century, the demand for a workforce equipped with essential skills such as communication, collaboration, critical thinking, and creativity has become a top priority. These skills, often referred to as the “4Cs,” are crucial for individuals to succeed in a knowledge-based economy and effectively tackle complex real-world problems (Saimon et al., 2023; Valverde et al., 2020; Ye & Xu, 2023). TVET systems worldwide are increasingly recognizing the importance of integrating these skills into their curricula to enhance the employability and adaptability of their graduates (Affandi et al., 2024; Cabreros, 2023; Siti et al., 2023).

Currently, many researchers are focusing their research on the topic of 4Cs skills. This is supported by several recent studies showing an increase in the number of research studies on this topic. Research related to 4Cs focuses on the development of relevant curricula (e.g., Almazroa & Alotaibi, 2023; Rana & Ha-Brookshire, 2019; Sontag, 2009), supportive learning designs (e.g., Hadiyanto, 2019; E. Y. Pratama, 2016), the integration of technology in learning (e.g., Arief, 2019; Umryk et al., 2024), and appropriate assessment techniques (e.g., Fathimah et al., 2019; M. A. Pratama et al., 2020). Given the rapid development of research on the 4Cs topic, it is necessary to conduct an analysis that provides comprehensive insights into research trends from the past few years to the present and suggestions for future research directions that can be developed. Bibliometric analysis is the most appropriate method for providing comprehensive insights into 4Cs research trends because it can systematically map the development of the topic, measure the impact and quality of research, identify research gaps, analyze collaboration networks, and provide objective quantitative data for planning future research directions.

Previous articles have conducted bibliometric analyses on one (e.g., Aktoprak & Hursen, 2022; Park & Lee, 2022), several (e.g., Sahin et al., 2023), or all (e.g., Hidayat et al., 2024; Nimmala & Sultana, 2025; Wijayanti et al., 2025) of the 4Cs skills. So far, bibliometric analyses of research trends on individual 4Cs skills in TVET are still rare, and no bibliometric analysis has yet been conducted on the research trends concerning all four 21st-century skills (4Cs) in TVET. However, these four skills are essential in preparing students to be competitive in the workforce. The bibliometric analysis in this article aims to respond to the urgent need to fill this gap by conducting performance analysis and science mapping.

In addition to conducting a bibliometric analysis, it is equally important to carry out a Systematic Literature Review (SLR) to examine the extent of efforts made to improve 4Cs skills in TVET. Several literature reviews have been conducted previously. Several articles have reviewed learning strategies in TVET, but they do not focus on strategies to improve 4Cs skills (Ahmed et al., 2022; Deep et al., 2020; Tshong & Yasin, 2023). On the other hand, some articles focus on reviewing specific 4Cs skills in TVET but do not discuss learning strategies that can improve those skills (Dzia-Uddin et al., 2024; Wahab et al., 2022). To respond to the urgency of filling this gap, this article analyzes research that has attempted to improve 4Cs skills through experimental studies. The SLR will offer a deeper understanding of the learning designs implemented to develop communication, collaboration, critical thinking, and creativity skills within TVET. Through this review, we can identify various strategies that have proven effective, as well as the challenges encountered during their implementation. Moreover, an SLR will help uncover gaps that remain in both the literature and practical applications regarding the enhancement of 4Cs skills in TVET. Consequently, the findings from this SLR will provide a solid foundation for developing more focused policies and strategies aimed at improving the quality of vocational education, ensuring that TVET students are well-prepared to meet the demands of an increasingly complex and dynamic workforce.

This is the first comprehensive and systematic analysis exploring research trends and directions in 4Cs skills in TVET, and efforts that have been made to improve these skills through experimental studies. There are several questions answered in this article, including:

- RQ 1) What are the main information and dynamic trends based on the number of publications and citations in publications on 4Cs skills in TVET?
- RQ 2) What are the contributions of the most prolific authors on the subject of 4Cs skills in TVET?
- RQ 3) Which sources are most active in producing publications on 4Cs skills in TVET?
- RQ 4) Which affiliations are leading the productivity of publications on 4Cs skills in TVET?
- RQ 5) Which countries are at the forefront of research in 4Cs skills in TVET?
- RQ 6) What are the most commonly used keywords in papers on 4Cs skills in TVET?
- RQ 7) How have previous studies attempted to improve 4Cs skills in TVET through experimental approaches?

2. METHOD

This study uses bibliometric methods and a systematic literature review (SLR). Bibliometric methods are quantitative approaches used to analyze scientific publications in large quantities in a particular field (Öztürk et al., 2024; Van Raan, 1996; Wallin, 2005), which in this study focuses on research documents with a focus on 4Cs skills in TVET. On the other hand, SLR was conducted because it is a relevant method for answering specific questions about previous research efforts to improve 4Cs skills in TVET. As is well known, the main purpose of SLR is to identify, evaluate, and synthesize all relevant research on a specific topic or question. This helps map current developments in a field, identify gaps in knowledge, and provide a comprehensive summary of the existing evidence (García-Peñalvo, 2022).

2.1. Data collection and extraction

This study uses the PRISMA method to identify, evaluate, and synthesize literature (Page et al., 2021), which in this study is literature related to 4Cs skills in Technical and Vocational Education and Training (TVET). The following is an overview of the steps involved in obtaining literature, as shown in Figure 1.

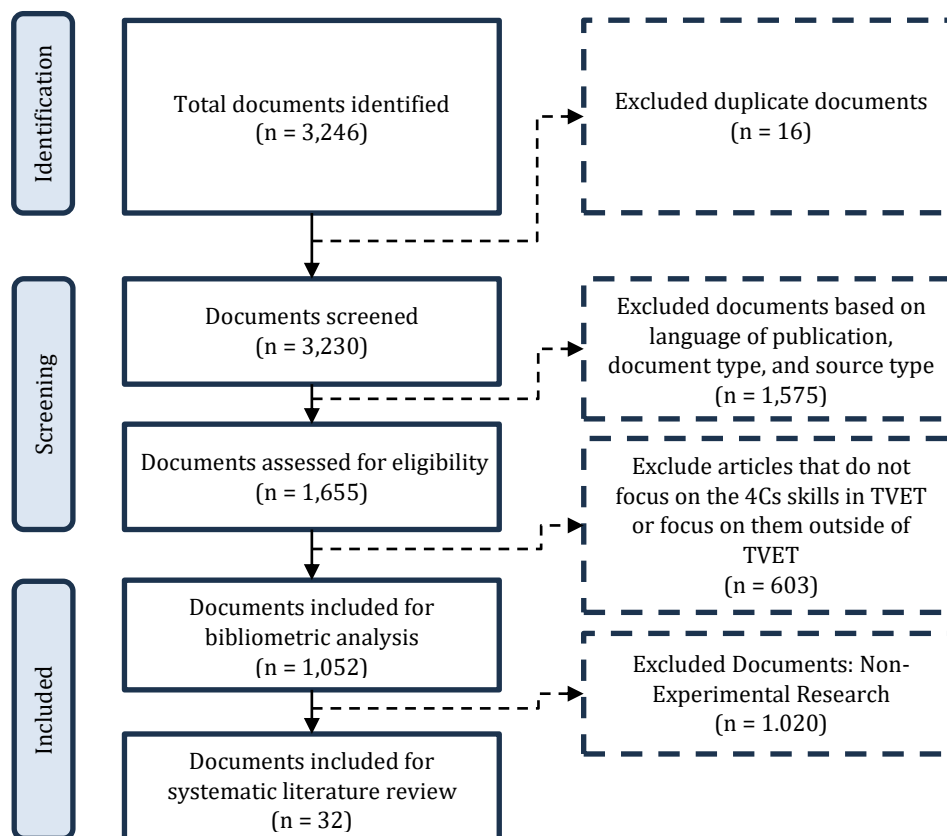


Figure 1. PRISMA flow diagram

The data analyzed in this study were sourced from the Scopus database, which is a rigorous indexer known for publishing high-quality articles and is considered the largest abstract and citation database, covering a wide range of topics. Document search is conducted using search terms (TITLE-ABS-KEY (“critical thinking” OR “creative thinking” OR collaboration OR communication OR “21st century skill*” OR “21st-century skill*”) AND TITLE-ABS-KEY (“Technical and Vocational” OR “Technical and Vocational Education and Training” OR ‘TVET’ OR “Technical Education*” OR “Vocational Education*”)).

After identifying relevant sources, selection was carried out by applying the inclusion and exclusion criteria as listed in Table 1. Inclusion and exclusion were based on specific criteria that supported the research objectives and scope of the study. The selection process was followed by data extraction from the selected articles.

Table 1. Inclusion/Exclusion Criteria in Determining Documents Relevant to The Study Objectives

Category	Inclusion criteria	Exclusion criteria
For bibliometric analysis:		
Publication year interval	2005-June 14, 2025	Before 2005
Document type	Document type in the form of articles	Document type in the form of a review, conference paper, editorial, letter, note, book chapter, erratum, short survey, conference review, book, data paper, and retracted
Source type	The source type is a journal	The source types are conference proceedings, book series, books, and trade journals
Language	The document is published in English	The document is published in a language other than English.
Research focus	4Cs skills in TVET	Apart from the 4Cs skills in TVET
For a systematic literature review:		
Research type	Experimental or quasi-experimental research to improve 4Cs skills in TVET	Not experimental or quasi-experimental research, such as literature studies, descriptive research, comparative studies, correlational studies, etc.

2.2. Data analysis

To address Research Questions 1 through 6, a bibliometric approach was applied within the research domain of 4Cs skills in Technical and Vocational Education and Training (TVET). The analysis encompassed two primary techniques: performance analysis and science mapping (Noyons et al., 1999; Pessin et al., 2022). Performance analysis was conducted to assess the productivity and scholarly impact of key scientific actors, including countries, institutions, journals, and individual researchers contributing to the 4Cs–TVET literature. This involved the systematic extraction and evaluation of bibliographic data to generate quantitative indicators such as the number of publications, citation counts, and authorship trends. The Bibliometrix package in R was employed to facilitate the computation and visualization of these metrics. Through performance analysis, the study aimed to identify influential contributors, understand research output patterns, and map the development of scientific activity within the 4Cs–TVET field. On the other hand, science mapping focuses on visualizing the structural and dynamic aspects of scientific research. The aim is to describe research fields, identify subfields, and visualize relationships within scientific literature through techniques such as co-word analysis. Science mapping in this study aims to provide an overview of thematic maps, thematic evolution maps, and term co-occurrence networks. Bibioshiny software (using the “bibliometrix” package of the RStudio software to install) was used to analyze and graph the data obtained on publication networks, collaboration networks between researchers, participating organizations, main and emerging keywords

To address the seventh research question, this study adopted a Systematic Literature Review (SLR) approach, within which a qualitative content analysis was conducted on 32 empirical studies employing experimental or quasi-experimental research designs in the context of TVET. Each article was systematically examined to identify the specific instructional treatments or pedagogical interventions implemented to promote the development of 4Cs skills. These interventions were subsequently classified into five overarching categories based on their methodological orientation: (1) technology-enhanced and online learning, (2) collaborative and interprofessional learning, (3) gamification and game-based learning, (4) project-based and active learning, and (5) simulation-based learning. Furthermore, each study was coded according to the targeted 4Cs skill(s), distinguishing whether the intervention focused on a single skill, a dyadic combination, a triadic combination, or a comprehensive approach addressing all four skills concurrently. Frequencies and percentages were calculated to determine the prevalence of each skill combination, thereby offering insights into the extent to which integrated approaches to 4Cs development have been adopted in experimental TVET research. This dual-layered analytical framework—encompassing both the typology of pedagogical interventions and the distribution of targeted skills—provides a nuanced understanding of how the 4Cs have been operationalized in empirical efforts to enhance 21st-century competencies within the vocational education landscape.

3. RESULTS

3.1. Performance analysis through bibliometric analysis

3.1.1. Main information and publication trends (RQ1)

Publication trends refer to the fluctuations and patterns in the number of publications and citations of documents within a specific field or topic over time, offering insights into the extent of scholarly attention and interest devoted to that area of research. Research on 4Cs skills in TVET has increased over the last two decades (2005 to 2025). Table 2 illustrates that, over the past two decades, a total of 1,052 articles have been

published across 608 journal sources, with an annual growth rate of 9.81%. In terms of citations, the average citation per document for this topic is 11.32. This data highlights the significant attention this topic has garnered from researchers and underscores its substantial academic impact within the scientific community.

Significant new contributions to the topic of 4Cs in TVET have also been observed, as indicated by the article's average age of 6.5 years. The relatively low average age of articles suggests that this topic is a central focus of emerging research, with numerous relevant and innovative contributions centered on the development and application of 4Cs skills in TVET. Equally important in this study is the total number of references, which amounts to 39,116. This implies that, on average, each article cites 37 references. This finding suggests that the articles encompass a wide and comprehensive range of literature. Based on the identified document content, there are 3,336 Keywords Plus (ID) and 3,144 Author's Keywords (DE), highlighting the rich diversity of research foci within the 4Cs topic in TVET.

A total of 3,770 authors have contributed to research on 4Cs skills in TVET, with 141 (3.74%) of them authoring documents independently. This data suggests that the majority of articles are the product of collaborative efforts. The collaborative nature of the research is further supported by the average of 3.86 co-authors per document. Furthermore, the level of international collaboration stands at 16.83%, highlighting the global significance of this research.

This study focuses on articles published in journals as the document type for analysis. Journal articles are selected because they undergo a rigorous peer review process and follow a standardized format, ensuring the provision of rich and structured data essential for bibliometric analysis. This process guarantees the dissemination of high-quality research with significant impact and broad accessibility within the academic community.

Table 2. Main Information of Documents on the Topic of 4Cs Skills in TVET

Description	Results
Main Information About Data	
Timespan	2005:2025
Journal Sources	608
Documents	1,052
Annual Growth Rate %	9.81
Document Average Age	6.5
Average citations per doc	11.32
References	39,116
Document Contents	
Keywords Plus (ID)	3,336
Author's Keywords (DE)	3,144
Authors	
Authors	3770
Authors of single-authored docs	141
Authors Collaboration	
Single-authored docs	144
Co-Authors per Doc	3.86
International co-authorships %	16.83
Document Types	
Article	1,052

The data on annual scientific production presented in [Figure 2](#) further supports the findings from the main analysis. Between 2005 and June 14, 2025, the number of published articles exhibited a significant increase. Over the past two decades, the number of articles grew from 24 in 2005 to 177 in 2024, reflecting a 637.5% increase, with 2024 marking the year with the highest number of publications. Notably, by mid-2025, 120 articles had already been published, indicating that the number is expected to continue rising throughout the remainder of the year. Although the number of publications fluctuates significantly each year, the data demonstrate that, overall, researchers are increasingly focusing on the 4Cs in Technical and Vocational Education and Training (TVET).

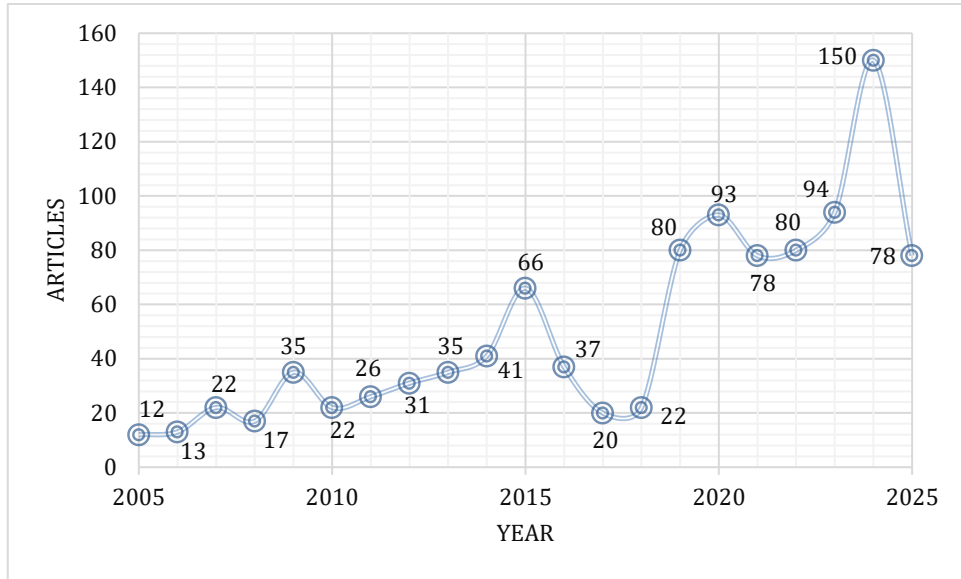


Figure 2. Annual Scientific Production

Figure 3 illustrates the data for the Mean Total Citations per Year (MTCpY) and Mean Total Citations per Article (MTCpA), both of which exhibit notable fluctuations from 2005 to 2025. In 2006, a sharp increase was observed in both MTCpY (on a scale of 0.1) and MTCpA. This surge is likely attributed to the publication of pivotal or innovative research within the field, which garnered substantial attention from the scientific community. MTCpY peaked at 33.38 in 2006, while MTCpA reached its highest value of 2.23 in 2018, indicating a high citation frequency for publications in these years.

Following its peak in 2006, MTCpA experienced a steady decline. This suggests that although articles continue to be published, citations for these publications have either declined or stabilized at lower levels. In contrast, MTCpY demonstrates greater consistency, as indicated by the trendline (dashed line). The stable pattern in MTCpY implies that, over the past two decades, the topic of 4Cs in TVET has consistently attracted considerable attention from researchers. Conversely, the ongoing decline in MTCpA is understandable, as newer articles typically receive fewer citations in their early years; however, citation numbers are expected to rise over time.

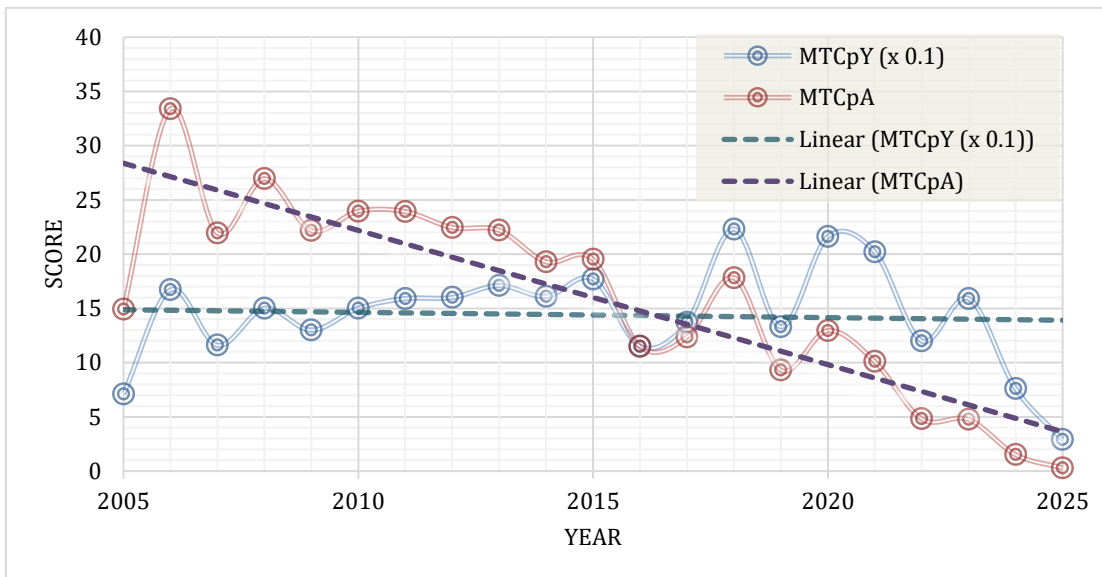


Figure 3. Mean Total Citation per Year and per Article

3.1.2. Top 10 authors contributing to research on 4Cs skills in TVET (RQ2)

Table 3 presents the 10 most productive authors in the field of 4Cs skills research within TVET over the past two decades, highlighting key findings. Alberti Cattaneo, from the Swiss Federal University for Vocational Education and Training (Switzerland), emerges as the leading author in terms of both the number of articles published and the Articles Fractionalized (AF) score. A high AF score indicates a broad and well-distributed contribution across various co-authors or institutions within the same publication, underscoring the collaborative nature of Cattaneo's work. Notably, Cattaneo is the sole Swiss representative among the top 10, signifying his prominent role and influence in this research domain.

The 10 most productive authors in the field of 4Cs skills research in TVET over the past two decades come from five different countries: Switzerland, Indonesia, Malaysia, Finland, and China. This international diversity highlights the variety of perspectives and research methodologies brought by scholars from diverse cultural and educational contexts, enriching the global scientific discourse in this area. Among them, Muhammad Nurtanto, affiliated with Politeknik Negeri Jakarta (Indonesia), stands out with the highest citation count. With a total of 169 citations from just five published articles, Nurtanto achieves an impressive average of 33.8 citations per article. This remarkable achievement not only underscores the high quality of his research but also emphasizes his substantial contributions to advancing the field, particularly in the context of vocational education in Indonesia.

An intriguing finding is that Fatiyah Mohd Kamaruzaman from Universiti Kebangsaan Malaysia, despite receiving only one citation across four published articles, is still recognized as an influential author in this field. Although her citation count is relatively low, Kamaruzaman exhibits a notably high Articles Fractionalized (AF) score. This high AF value indicates her broad and well-distributed contributions across various publications, suggesting that, while her direct citations may be limited, her overall impact and influence within the academic community remain substantial. This underscores the notion that a high AF can serve as a valuable indicator of scholarly influence, even when the number of direct citations does not fully capture it.

Table 3. The Data of the Top 10 Authors Contributing to Research on 4Cs in TVET

Rank	Author	Institution	Country	Articles	TC	AF
1	Cattaneo, Alberto	Swiss Federal University for Vocational Education and Training	Swiss	5	56	1.39
2	Kholifah, Nur	Universitas Negeri Yogyakarta	Indonesia	5	166	0.99
3	Kiong, Tee Tze	Universiti Tun Hussein Onn Malaysia	Malaysia	5	33	0.90
4	Nurtanto, Muhamamd	Politeknik Negeri Jakarta	Indonesia	5	169	1.02
5	Yoto	Universitas Negeri Malang	Indonesia	5	15	1.28
6	Ana, Ana	Universitas Pendidikan Indonesia	Indonesia	4	14	0.47
7	Hämäläinen, Raija	University of Jyväskylä	Finland	4	97	1.83
8	Kamaruzaman, Fatiyah Mohd	Universiti Kebangsaan Malaysia	Malaysia	4	1	1.42
9	Li, Hui	Xiamen City University	China	4	7	0.92
10	Saud, Muhammad Sukri	Universiti Teknologi Malaysia	Malaysia	4	5	0.76

The articles produced by leading authors in the field of 4Cs skills in TVET exhibit diverse trends, reflecting the dynamic nature of academic research. While some authors have maintained consistent productivity, others have demonstrated an increasing or decreasing output over time. This phenomenon is not uncommon in scholarly work; certain researchers persist in a specific field, contributing steadily, while others adapt their focus to emerging issues within their expertise in response to evolving challenges. Figure 4 offers valuable insights into the publication and citation patterns of the ten most prolific authors in the domain of 4Cs skills in TVET, spanning the years 2008 to 2025. The data reveals a considerable variability in the volume of publications across these authors, with authors such as Kholifah N and Nurtanto M showing a steady increase in their contributions from 2020 to 2025, underscoring their continued dedication to advancing knowledge in this critical area. This trend highlights the growing prominence of these researchers in recent years, with nine authors contributing actively over the past decade. Notably, Kholifah N, Nurtanto M, Kamaruzaman FM, and Li H have all published articles as recently as 2025, signaling that the research focus on 4Cs skills in TVET remains vibrant and is likely to remain a key topic of academic inquiry in the years to come.

Conversely, Hämäläinen's contributions to the 4Cs skills in TVET were prominent between 2008 and 2015, but there has been a noticeable absence of publications in this area after 2015. Such shifts in research focus are a common occurrence in academic careers, where scholars often pivot to new research interests or respond to the changing landscape of their field. In Hämäläinen's case, this shift could indicate a strategic move towards addressing emerging issues within their broader expertise. Despite the absence of recent publications in this specific area, Hämäläinen's past contributions remain significant, reflecting the evolving nature of academic research priorities.

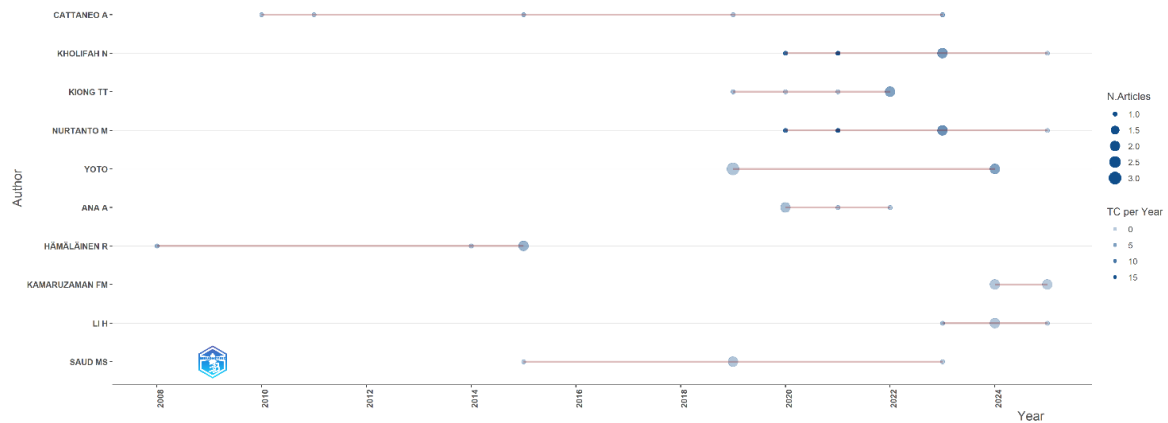


Figure 4. Authors' Production over Time

The author collaboration network depicted in Figure 5 illustrates the intricate relationships and collaborations within the scientific community. This network reveals several interconnected clusters of researchers, with some authors standing out as collaboration hubs, as well as smaller groups indicating more specific collaborative relationships. Analyzing this collaboration network offers valuable insights into the structure of scientific cooperation, enabling the identification of influential research groups and potential avenues for interdisciplinary collaboration. Furthermore, recognizing these central figures can serve as a guide for emerging researchers, providing them with the opportunity to identify potential mentors or collaborators to foster their academic development.

The data presented in Figure 5 illustrates the positioning of the ten most prolific authors within the collaboration network. A particularly notable finding is the strong collaborative relationship between Kholifah N and Nurtanto M, as evidenced by the comparatively thicker connecting lines between their nodes. It reflects a high frequency of joint publications, suggesting that their research efforts are consistently aligned, particularly in contributing to the advancement of 4Cs skills in the context of Technical and Vocational Education and Training (TVET).

Interestingly, despite being among the top ten most productive authors, Yoto and Kamaruzaman FM do not appear prominently within the collaboration network visualization. This is primarily due to the dispersed nature of their co-authorship patterns. While their publications are indeed collaborative, the diversity and distribution of their collaborators limit the formation of a cohesive network structure with measurable centrality metrics—particularly betweenness centrality—within the Bibliometrix analytical framework. Consequently, their collaboration patterns are not captured in the visual network representation. Nevertheless, this dispersion can be interpreted positively, as it indicates that Yoto and Kamaruzaman FM engage in broad-based scholarly interactions across various research groups. Such patterns may reflect interdisciplinary engagement and a wider dissemination of knowledge, contributing to the robustness and outreach of TVET-related research.

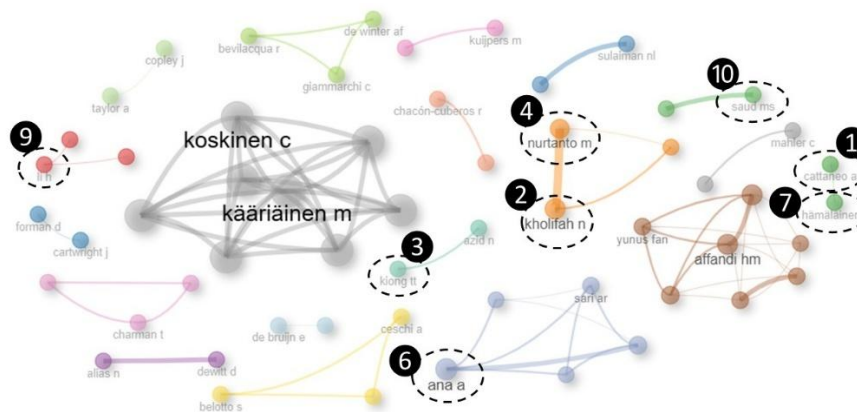


Figure 5. Authors' Collaboration Network

3.1.3. Top 10 sources most active in producing publications on 4Cs skills in TVET (RQ3)

Journals publishing articles on 4Cs skills in TVET come from various renowned publishers, such as Taylor & Francis, Routledge, SAGE, Elsevier, as well as university and association publishers (see Table 4).

This reflects that the topic of 4Cs in TVET has become a global and cross-regional concern, attracting interest from reputable academic publishers. The journals also vary in quartile level, from Q3 to Q1. This means that there are extensive publication opportunities for researchers at various levels of experience, both novice and senior. These findings underscore that the distribution of articles across different types of journals reflects that the topic of 4Cs in TVET is multidisciplinary in nature, spanning the fields of education, vocational training, human resource management, and educational technology. It also signifies epistemic inclusivity, where issues of 21st-century skills transformation are discussed from various perspectives.

Based on the h-index and total citations, all journals included in the 10 most productive journals show a good reputation. Journal of Interprofessional Care, categorized in quartile Q2, is the journal with the highest h-index (16) and total citations (1,238), indicating strong scholarly influence. Other journals categorized in quartile Q3, such as the Journal of Technical Education and Training and the Journal of Allied Health, also demonstrate solid academic standing with an h-index of 8 and total citations of 189. These metrics reflect consistent scholarly engagement in niche or practice-oriented fields. While Q1 journals show higher SJR (up to 1.483) and CiteScore (up to 8.6), the presence of Q2 and Q3 journals with substantial impact metrics highlights that high-quality and influential research on 4Cs in TVET is also published in well-regarded journals beyond the top quartile.

Table 4. The Data of the Top 10 Sources Most Active in Producing Publications on 4Cs Skills in TVET

Rank	Source	Publisher	Scopus Q	h-index	TC	NP	SJR 2024	CiteScore 2024
1	Journal of Interprofessional Care	Taylor & Francis	Q2	16	1,238	24	0.878	4.6
2	Journal of Vocational Education and Training	Routledge	Q1	10	290	32	0.809	5.2
3	Journal of Technical Education And Training	Penerbit UTHM	Q3	8	189	42	0.291	2.2
4	Journal of Allied Health	Science and Medicine Inc.	Q3	8	189	11	0.234	0.9
5	Vocations and Learning	Springer Netherlands	Q2	7	164	10	0.671	4.8
6	International Journal for Research in Vocational Education and Training	European Research Network Vocational Education and Training	Q2	6	102	20	0.544	3.1
7	Nurse Education Today	Elsevier	Q1	6	116	7	1.483	8.6
8	Work	SAGE Publications Ltd	Q2	6	221	6	0.563	3.0
9	BMC Medical Education	BioMed Central Ltd.	Q1	5	102	10	0.947	4.4
10	BMJ Open	BMJ Publishing Group	Q1	5	76	6	1.016	4.5

3.1.4. Top 10 affiliations leading research in 4Cs skills in TVET (RQ4)

Based on an analysis of institutional affiliations in publications focusing on 4C skills in TVET (see [Figure 6](#)), Universiti Tun Hussein Onn Malaysia (UTHM) emerged as the leading contributor, with a total of 60 publications. It was followed by Universitas Pendidikan Indonesia with 48 publications, and Universitas Negeri Padang with 28 publications. Interestingly, the research productivity landscape extends beyond Southeast Asia, encompassing several globally renowned institutions such as The University of Queensland, The University of Sydney, University of Toronto, and Maastricht University, each contributing more than 20 scientific articles to this field. These findings indicate that universities from various countries, both developing and developed, have made significant contributions to advancing research on the 4Cs skills topic in TVET.

The visualization of the collaboration network reinforces these findings, showing that UTHM, Universitas Pendidikan Indonesia, and other regional institutions occupy central positions within the global research network (see [Figure 7](#)). UTHM emerges as a key node, maintaining extensive connections with both national and international universities, such as Sultan Idris Education University, Universiti Teknologi Malaysia, Universiti Putra Malaysia, Stockholm University, Yogyakarta State University, Universitas Pendidikan Indonesia, and Universitas Negeri Padang. This network suggests that research on 4Cs skills in TVET is not only evolving at the local level but is also becoming integrated into the global research ecosystem through intensive multinational collaboration—a crucial factor in enhancing the quality and impact of scientific publications. Furthermore, UTHM's research productivity appears closely tied to its active partnerships with diverse academic institutions. Such collaboration is essential for advancing scientific knowledge by bringing together researchers with complementary expertise across institutions.

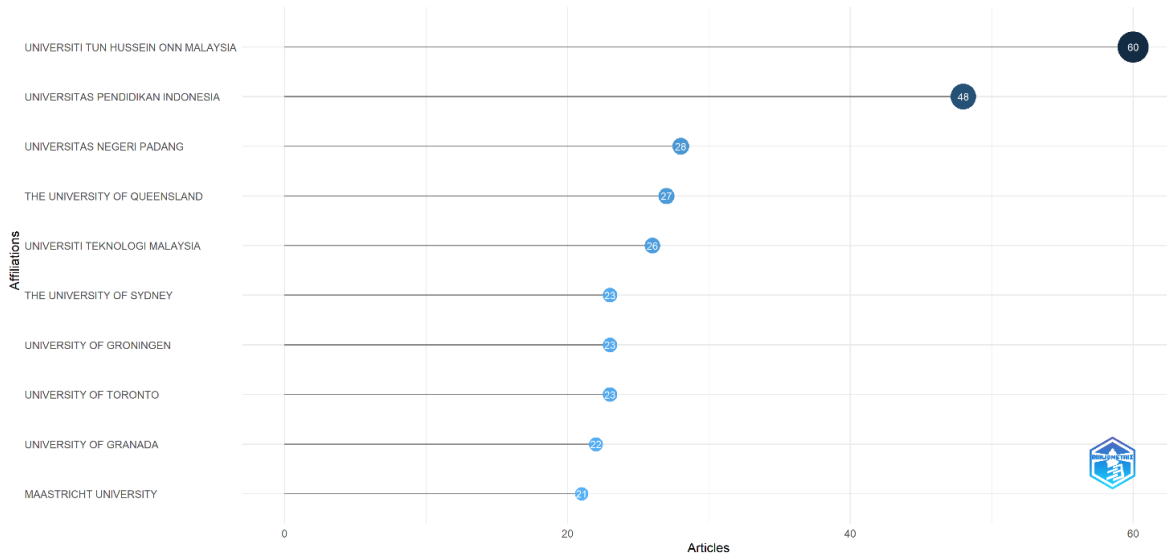


Figure 6. List of the 10 Most Productive Affiliations

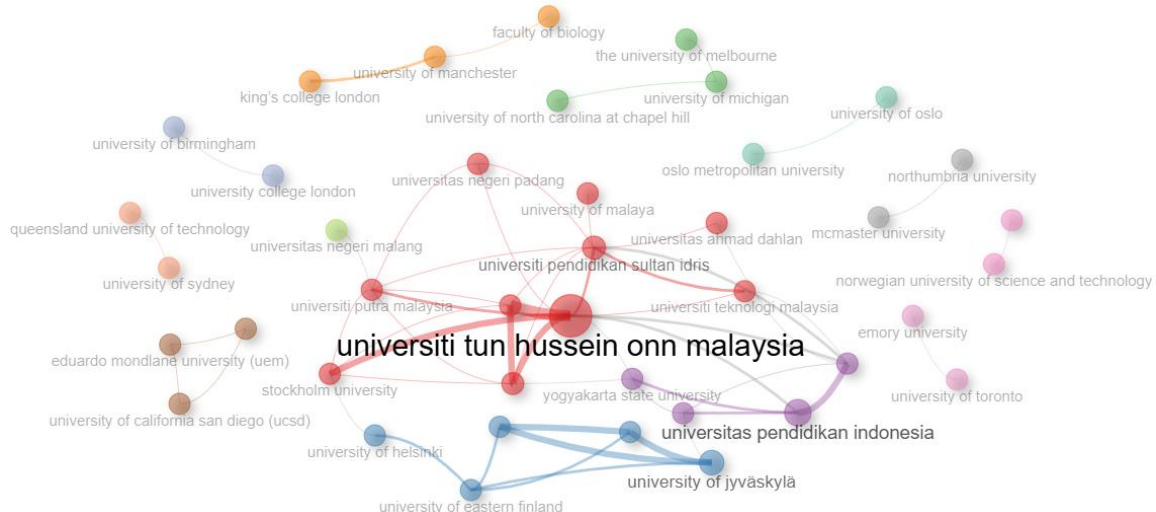


Figure 7. Visualization of Collaboration Networks between Affiliations

3.1.5 Top 10 countries leading research in 4Cs skills in TVET (RQ4)

Based on the data presented in Table 5, there are several interesting patterns and trends in the contribution of countries to research on 4Cs skills in TVET. This analysis not only identifies the most productive countries in terms of the number of publications, but also how each publication is evaluated based on its influence and impact within the academic community.

Out of a total of 1,052 documents analyzed, the United States emerges as the leading contributor to research on 4Cs skills in Technical and Vocational Education and Training (TVET), accounting for 122 publications, or 11.6% of the global output. The U.S. also leads in terms of total citations (TC = 2,175) and maintains a high mean citation per article (MTCpA = 17.83), reflecting both productivity and influence. Its publication profile is predominantly domestic (SCP = 115), indicating a strong internal research ecosystem with limited international co-authorships (MCP = 7). The United Kingdom, contributing 67 documents (6.4%), demonstrates a different model of impact—its high international collaboration rate (MCP = 20), combined with the highest MTCpA (18.42) among the top 10 countries, suggests that cross-border partnerships may enhance research visibility and citation performance. China (66 articles) shows comparable productivity but significantly lower citation impact (MTCpA = 4.56), suggesting potential issues with research visibility.

Indonesia and Malaysia, each contributing 50 articles (4.8%), follow similar patterns—relatively high output within emerging research systems, but still developing in terms of international recognition (MTCpA = 5.88 and 4.28, respectively). Australia (57 articles) and the Netherlands (41) offer a more balanced profile, combining productivity, moderate collaboration levels, and respectable citation metrics (MTCpA = 9.39 and 14.32, respectively). Notably, Canada, though ranked 8th by output (32 articles),

records the highest average citation per article (MTCpA = 31.44), indicating selectively impactful research contributions. Germany (28 articles) also stands out with a high average citation rate (17.96) despite relatively modest output, similar to Canada. Finally, Spain (21 articles) completes the top 10 with a solid citation performance (MTCpA = 9.90), further affirming the diverse geographical base of high-impact research in this domain.

Table 5. The Data of the Top 10 Countries Most Active in Producing Publications on 4Cs Skills in TVET

Rank	Country	Articles	Articles %	SCP	MCP (%)	TC	MTCpA
1	USA	122	11.6	115	7	2,175	17.83
2	United Kingdom	67	6.4	47	20	1,234	18.42
3	China	66	6.3	55	11	301	4.56
4	Australia	57	5.4	47	10	535	9.39
5	Indonesia	50	4.8	34	16	294	5.88
6	Malaysia	50	4.8	34	16	214	4.28
7	Netherlands	41	3.9	35	6	587	14.32
8	Canada	32	3	26	6	1,006	31.44
9	Germany	28	2.7	18	10	503	17.96
10	Spain	21	2	19	2	208	9.90

Figure 8 presents a visualisation of international collaboration networks in the 4Cs skills research in the TVET context. The structure of the network reveals the dominant position of the United States as the central hub, indicated by its large node size and extensive connections across regional clusters. This centrality suggests that the USA plays a pivotal role not only in research production but also in facilitating transnational knowledge exchange, acting as a bridge between otherwise loosely connected countries.

Surrounding the USA are two notable secondary hubs: the United Kingdom and Malaysia. The United Kingdom anchors a dense European cluster comprising countries such as Germany, Switzerland, Belgium, Italy, and Spain. These countries demonstrate high levels of interconnectedness, likely supported by shared research frameworks, funding mechanisms, and long-standing institutional partnerships within the European Higher Education Area. Meanwhile, Malaysia serves as a regional connector for Southeast Asia and the Middle East, linking actively with Indonesia, Saudi Arabia, Singapore, and others. This reflects Malaysia's emerging leadership in educational research within the Global South and its strategic efforts to position itself as a regional academic node.

Australia and Canada occupy structurally significant positions as intermediary countries, linking the core hubs of the U.S., the U.K., and Malaysia. These countries facilitate multilateral collaboration, thereby reducing the fragmentation of the network and supporting broader inclusivity across regions. Additionally, Nordic countries such as Finland, Norway, and Portugal act as bridges between the global North and South, contributing to the diffusion of educational innovation beyond regional confines.

The outer edges of the network feature countries such as Ethiopia, Kenya, Jordan, and India. Their peripheral placement indicates limited but emerging participation in 4Cs-TVET research. While these countries currently exhibit fewer collaborations, their inclusion in the network signals potential for future engagement and the opportunity to diversify global research contributions, particularly from underrepresented regions. Overall, the network reflects a core-periphery structure, where high-income countries dominate collaborative activity and occupy central positions, while middle-income countries—most notably Malaysia and Indonesia—are increasingly integrated into the global research landscape. This structure underscores the correlation between a country's network centrality and its research impact. Strengthening interregional ties and supporting more inclusive collaborations, especially those involving emerging contributors, could enhance not only the visibility but also the epistemic diversity and quality of research on 4Cs skills in TVET.

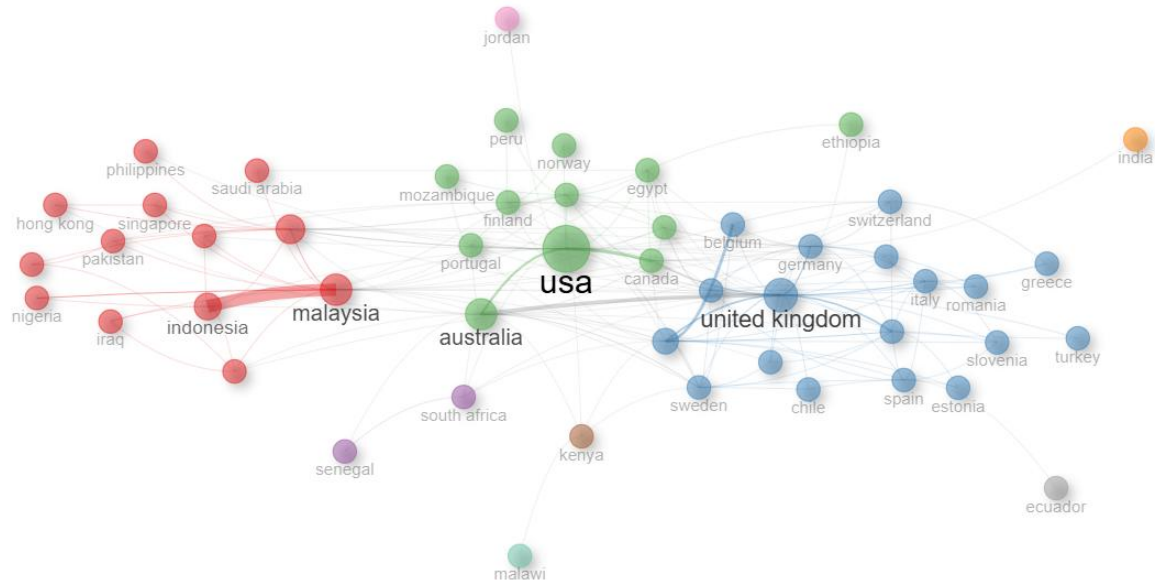


Figure 8. Visualization of Collaboration Networks between Countries

3.2. Science mapping through bibliometric analysis: The most commonly used keywords

Figure 9 shows a thematic map depicting the position and characteristics of various themes within the 4Cs skill area in TVET. The vertical axis represents the degree of development (density), which indicates the level of internal development of a theme (e.g., consistency and depth of research). The higher the position on this axis, the more developed or mature the theme is. The horizontal axis represents the degree of relevance (centrality), indicating how strongly a theme is connected to or important for other themes in the field. The further to the right a theme appears, the more central or relevant it is to the overall field.

The Motor Themes quadrant (top right) is occupied by veterans, communication skills, interpersonal communication, education, professional, and curriculum development. These five themes are not only the most frequently mentioned (as indicated by large bubbles), but also the most interconnected and well-developed, making them the primary drivers of TVET discourse. The Niche Themes quadrant (top left) includes Industry 4.0 and work-based learning—themes that are already quite mature but remain concentrated in specific contexts with limited external linkage. Just below, secondary vocational education, sustainable development, and technical and vocational education and training demonstrate high domain expertise but moderate relevance at the broader systemic level. The Basic Themes quadrant (bottom right) contains core topics that still require further exploration, such as soft skills, employability skills, technical education, 21st-century skills, and distance education. These themes are important to the field but lack consistent and in-depth research. Finally, the Emerging or Declining Themes quadrant (bottom left) is nearly empty, indicating an absence of keywords that are truly marginal during the analysis period. Overall, this map highlights the dominance of themes related to communication and curriculum, while topics concerning work readiness, technical education, and 21st-century competencies still require more intensive research to reach similar levels of maturity. This finding is also supported by the results of the thematic evolution map analysis in Figure 10.

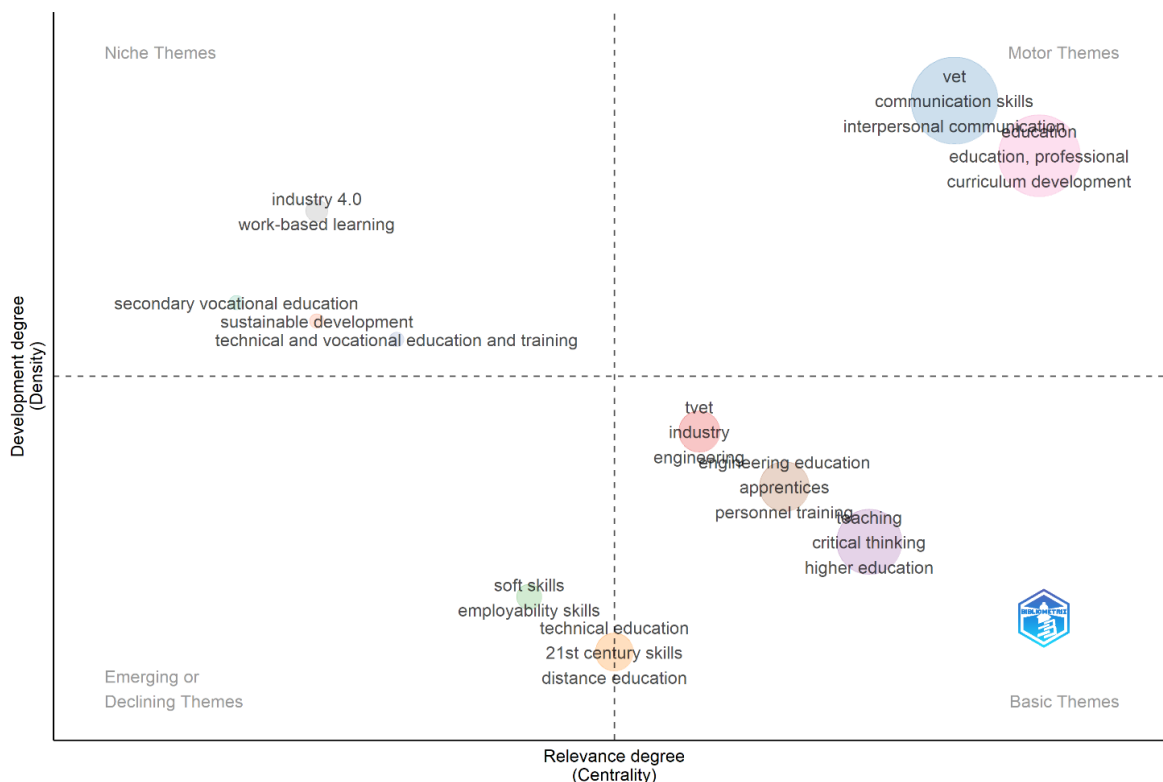


Figure 9. Thematic Map of Research on 4Cs Skills in TVET

Figure 10 shows the Thematic Evolution Map of research on 4Cs skills in the context of TVET from 2005 to 2025, divided into three periods: 2005–2010, 2011–2020, and 2021–2025. This map visualizes the transformation of research themes that have developed over time and their interrelationships. In the 2005–2010 period, the dominant topics included classic vocational education themes such as TVET, training, education, professional knowledge, and personnel training. These themes indicate a focus on strengthening basic capacities and technical training. During this period, critical thinking emerged as a prominent 21st-century skill. However, in the transition to the 2011–2020 period, there was a shift toward more contextual and strategic issues such as communication skills, innovation, public relations, and soft skills, which began to incorporate elements of 21st-century skills.

The 2021–2025 period indicates a more progressive direction. Themes such as 21st-century skills, communication skills, interpersonal communication, and lifelong learning are highlighted, indicating that the focus of research has shifted significantly toward strengthening social, communication, and lifelong learning aspects within the TVET system. The TVET theme itself remains consistent and serves as a common thread across periods, but is now more integrated with soft skills and digital learning (online learning) dimensions. Overall, this map highlights the evolution of TVET research from a technical and procedural approach toward the integration of broader 4Cs skills, underscoring the importance of adapting to the ever-changing needs of the workforce and the growing emphasis on non-technical competencies in the digital and global era. Furthermore, it is necessary to examine the interrelationships between terms in the 4Cs skills in TVET research as a whole to identify key topics, analyze the interrelationships between concepts, and find dominant research clusters or themes.

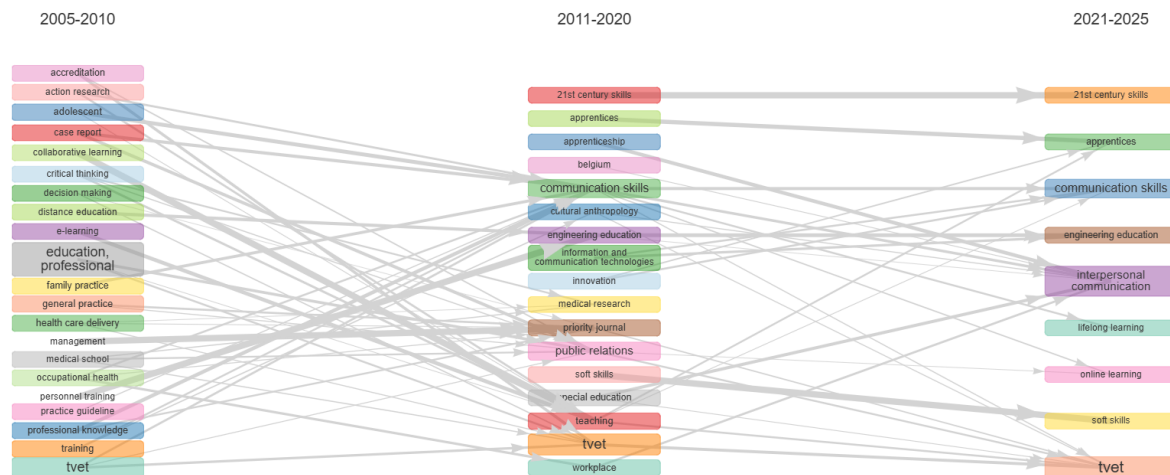


Figure 10. Thematic Evolution Map of Research on 4Cs Skills in TVET

Figure 11 and Table 6 synergistically present an in-depth analysis of the map of interrelationships between terms that appear in research related to 4Cs skills in the context of TVET. Figure 11 shows that TVET is the term with the largest node, followed by communication skills. These two nodes are connected by very thick lines. This indicates that research related to 4Cs skills in the context of TVET focuses more on communication skills than on the other three skills. Based on the analysis results, the terms that appear are divided into three thematic clusters, each representing a distinct research focus that overlaps with the others.

Cluster 1 (red) is related to communication and professional development in education. This cluster is characterized by the dominance of the term interpersonal communication skills, which is the largest and most central node in the network. Other terms such as interpersonal communication, critical thinking, professional development, and higher education reinforce that the research focus in this cluster is on the development of soft skills, especially communication and critical thinking skills, in the context of higher education and professional training. Terms such as “young adult,” “middle-aged,” and “adolescent” indicate that the population studied covers a wide range of ages, signifying the broad scope of communication skills development in the vocational education ecosystem.

Cluster 2 (blue) relates to interprofessional collaboration and healthcare education. This cluster focuses on interprofessional collaboration in healthcare education. Central terms such as education, professional, health care personnel, interprofessional relations, teamwork, and collaboration indicate that collaborative skills are at the heart of the discussion, especially in the context of healthcare services. This cluster also shows the close connection between educational program development, healthcare personnel attitudes, and program evaluation, all of which contribute to the formation of effective collaborative skills in an interdisciplinary work environment.

Cluster 3 (green) relates to TVET and professional competence in healthcare and education. This cluster revolves around the term “TVET” and reflects the integration between curriculum development, professional competence, and learning technology. Terms such as “curriculum development,” “teaching,” “professional competence,” “decision making,” and “internet” indicate an emphasis on strengthening the cognitive and digital dimensions in the implementation of TVET. The presence of terms such as ‘leadership’ and “health care delivery” also indicates a focus on strengthening managerial and service capacities in vocational education.

Overall, Figure 11 and Table 6 confirm that 4Cs skills research in TVET is most intensive in the aspects of communication and collaboration, which are clearly represented in Clusters 1 and 2. Meanwhile, critical thinking appears in the context of communication and decision-making but is not yet dominant as a separate focus. The element of creativity does not appear as a key term in any of the three clusters, indicating that creativity remains an under-researched area in 4Cs studies within the TVET domain. This presents an important opportunity for further comprehensive and balanced research on all four elements of the 4Cs framework.

WhatsApp and Moodle, have been shown to significantly enrich students' learning experiences by facilitating more interactive and immersive educational environments. Furthermore, the incorporation of collaborative and interprofessional learning underscores the critical role of communication and teamwork, essential competencies for professional practice across diverse fields. Approaches like gamification and game-based learning not only enhance student motivation and engagement but also provide dynamic contexts for fostering critical thinking and creativity through the complex challenges embedded within games. Project-based learning and flipped classroom models offer students opportunities to engage directly with real-world problems, thereby sharpening their analytical and creative thinking skills in practical contexts. Moreover, the integration of simulation-based learning provides students with the chance to develop hands-on, practical skills in environments that closely replicate real-world scenarios, fostering effective collaboration and communication in team-based tasks. Collectively, these diverse pedagogical strategies emphasize the importance of a holistic approach to enhancing the 4Cs in TVET, thereby equipping students with the necessary skills to thrive in an increasingly complex and rapidly evolving professional landscape.

Table 8. 4Cs Skills Targeted for Improvement in Experimental Research

Number of 4Cs Skills Targeted	Targeted 4Cs Skill(s)	f	Percentage	
Single 4Cs skills	Critical thinking	2	6.25	56.25
	Creative thinking	1	3.13	
	Collaboration	10	31.25	
	Communication	5	15.63	
Combination of two 4Cs skills	Critical and Creative thinking	2	6.25	34.38
	Critical thinking and collaboration	1	3.13	
	Critical thinking and communication	1	3.13	
	Creative thinking and collaboration	0	0.00	
	Creative thinking and communication	0	0.00	
	Collaboration and communication	7	21.88	
Combination of three 4Cs skills	Critical thinking, creative thinking, and collaboration	1	3.13	3.13
	Critical thinking, creative thinking, and communication	0	0.00	
	Critical thinking, collaboration, and communication	0	0.00	
	Creative thinking, collaboration, and communication	0	0.00	
All four 4Cs skills	Critical thinking, creative thinking, collaboration, and communication	2	6.25	6.25
Total		32	100.00	100.00

Table 8 presents the distribution of the 4Cs skills (Critical Thinking, Creative Thinking, Collaboration, and Communication) that were targeted for improvement throughout the experimental intervention. Of the 32 observed activities, a significant majority (56.25%) focused on enhancing a single 4C skill. Among these, Collaboration emerged as the most frequently targeted individual skill, appearing in 10 activities (31.25%), followed by Communication (15.63%), while Critical Thinking and Creative Thinking were addressed in only 6.25% and 3.13% of the activities, respectively. This suggests a pedagogical emphasis on fostering interpersonal and teamwork-oriented competencies, which are often central to contemporary learner-centered approaches such as project-based or collaborative learning models.

In contrast, dual-skill integration accounted for 34.38% of the activities. Notably, the combination of Collaboration and Communication dominated this category, with seven instances (21.88%), indicating a recurring focus on interrelated social competencies. Other combinations involving Critical Thinking were observed but in much smaller frequencies, and interestingly, no activity was found to integrate Creative Thinking with either Collaboration or Communication. This absence may reflect a potential underemphasis on creativity when designing collaborative or communicative learning tasks, which warrants further investigation. On the other hand, the implementation of three-skill (Triple 4Cs) and four-skill (All 4Cs) combinations was remarkably limited. Only one activity (3.13%) incorporated Critical Thinking, Creative Thinking, and Collaboration, while just two activities (6.25%) addressed all four 4Cs simultaneously. These findings underscore the limited application of a holistic 4Cs framework in the experimental design, suggesting that while certain individual and dual skills were prioritized, comprehensive integration remains scarce.

Overall, the data reveal a pronounced focus on collaboration, both as a standalone competency and in conjunction with communication, whereas creative thinking was the least addressed across all categories. This indicates an imbalance in the implementation of 21st-century skills, potentially limiting students' exposure to the full spectrum of competencies necessary for future-ready learning. For future instructional designs, greater emphasis on creativity—especially in integrative, multi-skill tasks—may enhance the breadth and depth of students' skill development.

4. DISCUSSIONS

Overall, the period from 2014 to 2024 shows strong growth in research on communication, collaboration, critical thinking, and creativity (4Cs) in the field of Technical and Vocational Education and Training (TVET), despite fluctuations in the number of publications. This expansion signals a paradigm shift in education, where cognitive, collaborative, and communicative capacities are no longer considered complementary but central to vocational training. The 4Cs skills represent essential competencies that vocational students must acquire to effectively navigate the complexities of real-world industrial environments, thereby underscoring the significance of research in this area (Boonpu & Chaisuk, 2022; Syahril et al., 2022). The significant decline in the number of publications in 2016–2017 and 2021–2022 may have been influenced by several factors, such as the COVID-19 pandemic (Chadwick & McLoughlin, 2022; Maia et al., 2021; Yapicioğlu, 2020), political changes (Fages & Albe, 2015; Hodson, 2020), and economic crises (Hoeg et al., 2015). These fluctuations are common in a research area, and overall still indicate the level of interest among researchers in the topic of 4Cs in TVET.

An analysis of the most influential contributors to 4Cs research in TVET—including authors, institutional affiliations, and countries—reveals that the top ten contributors are predominantly affiliated with institutions located in both developed and developing countries. The limited involvement of Least Developed Countries (LDCs) in research on 4Cs skills in TVET is indicative of persistent structural inequalities in the global education and research landscape (Chowdhury et al., 2024). This phenomenon should not be viewed solely as an academic gap, but rather as a critical development challenge (Leong, 2024). Advancing sustainable and inclusive economic growth requires concerted international efforts to support TVET reforms in LDCs through strategic research collaborations, technology transfer initiatives, and targeted investments in educational capacity building.

LDCs often face significant limitations in research and educational infrastructure (Caliari et al., 2020; Niraula et al., 2005), including restricted access to laboratories, digital technologies, funding mechanisms, and academic databases. Research focused on the 4Cs demands pedagogical innovation and adequate institutional support, such as teacher professional development, project-based curricula, and the integration of educational technologies. However, educational priorities in many LDCs remain centered on foundational competencies like literacy and numeracy, which often delay the mainstreaming of 21st-century skills (Regmi, 2019). Furthermore, limited national investments in TVET and research and development (R&D) hinder both the quantity and quality of scholarly output in this domain (Tuenpusa et al., 2021). Without coherent policy frameworks that prioritize future-oriented skill development, the participation of LDCs in 4Cs research is likely to remain marginal, thereby perpetuating global disparities in educational innovation and workforce readiness.

The visualization of collaboration networks among institutions and countries in 4Cs skills research within the TVET sector illustrates that research activity remains predominantly concentrated in developed and developing countries, such as the United States, the United Kingdom, Malaysia, and Indonesia, which form dense and highly interconnected collaboration nodes. In contrast, the participation of countries categorized as Least Developed Countries (LDCs), including Mozambique, Nigeria, and Ethiopia, although beginning to emerge on the global research landscape, remains notably limited and peripheral. Notably, only Eduardo Mondlane University from an LDC appears in the visualization, highlighting the minimal representation of institutions from these contexts. This lack of connectivity with leading research centers reflects significant structural barriers to fostering inclusive cross-national collaboration (Haßler & Haseloff, 2022; Shi & Bangpan, 2022). In fact, the importance of collaborative networks between academic institutions is crucial in the context of scientific development and innovation (Fayzullina et al., 2023). A key contributing factor is the considerable disparity in research frameworks and policy orientations concerning the integration of 4Cs competencies into TVET curricula, which constrains innovation and limits learners' adaptability in LDCs (Tripney & Hombrados, 2013). As a result, there is a heightened risk of exacerbating global disparities in vocational education quality and workforce readiness, particularly as countries that are not meaningfully engaged in the global knowledge ecosystem are likely to face delays in adopting pedagogical approaches aligned with the demands of the digital era and ongoing technological disruption. To address this imbalance, coordinated efforts from international donor agencies, national governments, multilateral organizations, and research excellence centers are urgently needed to expand and strengthen collaborative networks with less-engaged countries, thereby ensuring that the global transformation of TVET is inclusive, equitable, and sustainable.

The development of 4Cs research in TVET is inherently linked to the role of media in disseminating research findings, the majority of which are published in academic journals. High-quality journals uphold stringent peer review and editorial standards to ensure the integrity and scholarly value of the research they publish (Leal Filho et al., 2021; Ruiz-Corbella, 2018). This process serves to filter out substandard research, thereby preserving the credibility and reliability of the academic record. As a platform for academic

exchange, journals also contribute to setting the research agenda, shaping policy debates, and providing input for educational practices at the national and global levels. In the context of 4Cs integration into TVET curricula, the presence of high-impact publications facilitates the accumulation of empirical evidence, theoretical refinement, and cross-national comparisons, which are essential for addressing the dynamic needs of modern labor markets and technological transformation. Furthermore, the visibility and accessibility provided by reputable journals help amplify the voices of researchers globally, thereby fostering a more inclusive and globally informed discourse on how TVET systems can evolve to meet the challenges of the 21st century. This is proven by our findings that journals such as the *Journal of Interprofessional Care*, *Journal of Vocational Education and Training*, *Journal of Technical Education and Training*, etc., published in various countries, have high h-indices, citation counts, SJR, and CiteScores.

Another important finding in this study is the visualization of theme development and the interrelationships between terms in the research on 4Cs skills in TEVT. Based on the results from the Thematic Map (see Figure 9), it is evident that, among the 4Cs skills, communication skills emerged as the motor theme. This suggests that communication skills are both an influential and widely researched topic. The extensive research on communication skills in Technical and Vocational Education and Training (TVET) can be attributed to the critical role these skills play in facilitating the exchange of technical information essential for the workplace (Ramamurthy et al., 2021). However, communication skills are often identified as a specific area of weakness, which may adversely affect job interviews and professional opportunities (Dzia-Uddin et al., 2024). In contrast, critical thinking skills emerged as the basic theme, which signifies that, although this skill is highly relevant, it exhibits a low degree of development (density). This finding indicates that, despite the high relevance of critical thinking skills, there have been limited new advancements or in-depth explorations related to this theme in the existing literature. These findings are further corroborated by the thematic evolution map (Fig. 10), which illustrates that communication skills emerged prominently during the periods of 2011–2020 and 2021–2025, while critical thinking skills first emerged in the earlier period of 2005–2010. Additionally, the term co-occurrence network (Fig. 11) reveals a similar pattern, with communication skills exhibiting the strongest association with TVET and becoming the main cluster. In contrast, critical thinking is visible in the visualization but shows a lower co-occurrence, while creative thinking and collaboration skills are not represented in the network.

Within the scope of experimental research, a range of pedagogical strategies have been implemented to enhance 4Cs skills in TVET. Technological innovations, including Metaverse-based learning, virtual reality simulations, and communication tools such as WhatsApp and Moodle, create interactive environments that foster collaboration and problem-solving. Collaborative and interprofessional learning approaches increasingly emphasize the importance of teamwork, a critical skill for addressing real-world challenges across diverse disciplines. Furthermore, gamification and game-based learning engage students by stimulating critical thinking and creativity through dynamic, interactive scenarios, while project-based learning and flipped classroom models offer opportunities for the practical application of knowledge, enhancing both analytical and creative abilities. Simulation-based learning activities, which replicate real-world environments, further contribute to the development of practical skills and teamwork. Collectively, these diverse approaches underscore the importance of holistic strategies in equipping students with the necessary 4Cs to succeed in an increasingly complex professional landscape. Based on this analysis, future research in TVET should focus on leveraging artificial intelligence and big data for personalized learning, as well as further exploring experience-based learning opportunities, such as virtual internships. Additionally, integrating values and ethics into TVET curricula is essential for fostering not only technical proficiency but also the professional character required in today's workforce.

Based on the distribution of 4Cs skills as the primary focus of research in Technical and Vocational Education and Training (TVET) (see Table 1), a significant imbalance is evident, with researchers predominantly concentrating on the development of communication skills over other competencies. Nevertheless, by fostering the development of critical thinking, communication, creativity, and collaboration, it is evident that the future workforce will be equipped with the essential skills required to thrive in an increasingly complex and dynamic business landscape (Bhat & Gupta, 2024; Schweinsberg & Garivaldis, 2020). These four competencies are not only interdependent but also of equal importance in meeting the demands of the labor market. Consequently, it is imperative that future research encompasses a broader scope, addressing a comprehensive range of skills and not solely focusing on communication skills.

5. CONCLUSION AND LIMITATIONS

The research on the integration of 4Cs (communication, collaboration, critical thinking, and creativity) in Technical and Vocational Education and Training (TVET) from 2014 to 2024 demonstrates significant growth, highlighting the importance of these competencies in preparing students for the complexities of modern industries. Despite fluctuations in publication trends, including setbacks due to

global crises, the field has made substantial progress, with communication skills being a key focus. However, the involvement of Least Developed Countries (LDCs) in this research remains limited, exacerbating global disparities in educational innovation. This underscores the need for enhanced international collaboration and investment in TVET reforms, particularly in LDCs. Additionally, while communication skills have dominated research, there is a clear call for future studies to explore other essential competencies such as critical thinking, creativity, and collaboration, ensuring a more balanced approach to skill development in the vocational sector. Ultimately, addressing these gaps will contribute to more inclusive and sustainable economic growth through comprehensive and forward-thinking TVET systems.

Although this paper effectively maps the research trends and identifies future research directions regarding 4Cs skills in Technical and Vocational Education and Training (TVET), it is important to acknowledge several limitations. This study relies on bibliometric methods and a Systematic Literature Review (SLR) using data sourced from the Scopus database. While comprehensive, this approach may not fully capture the entire range of global research on 4Cs skills in TVET. Furthermore, the exclusion of non-English publications, as well as certain types of research documents such as book chapters and conference papers, may restrict the inclusion of pertinent studies. While the SLR method successfully maps existing efforts to enhance 4Cs skills, this paper does not incorporate a meta-analysis, which could offer a more holistic and nuanced perspective on the treatments explored. Nevertheless, a meta-analysis could provide a more robust foundation for evidence-based decision-making across various domains, including public policy, medical practice, education, engineering, and other areas related to TVET, by synthesizing the overall findings from relevant research.

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DECLARATION OF INTEREST

There is no conflict of interest in this study.

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This article is a literature review article and therefore does not require ethical approval.

AI USE STATEMENT

ChatGPT is used to help authors develop ideas. The accuracy of all content in this article has been verified.

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