

Intellectual Landscape of Technical and Vocational Education and Training: Knowledge Bases, Fronts, and Global Collaboration

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Abstract: Although knowledge of Technical and Vocational Education and Training (TVET) scholarship has experienced an impressive growth since the inception of the 2030 Sustainable Development Agenda, an intellectual mapping of the area has been lacking to date. This study systematically analysed 3,655 TVET-related publications from 2016 to 2026, based on the Web of Science Core Collection. The co-citation analysis shows five knowledge clusters. The keywords co-occurrence analysis reveals four new fronts of research. The co-authorship analysis displays the networks of collaboration at the country and institutional levels. Moreover, guided by Center-Periphery and Punctuated Equilibrium theories as diagnostic lenses, we find that TVET research agendas, methodological norms, and theories are concentrated in a small number of institutions in high-income countries, and the external policy shocks, especially the COVID-19 pandemic and the development of artificial intelligence, have accelerated existing digital trends, but have not radically changed the fundamental priorities in the research. The research presents a systematic mapping of the intellectual landscape of TVET in the Sustainable Development Goals era, clearly revealing the fragmentation of the current theoretical framework and highlighting the significant implications for researchers, policymakers, and practitioners engaged in the development of this field.

Keywords: Technical and Vocational Education and Training, Bibliometric Analysis, Center-Periphery Theory, Sustainable Development Goals, Research Fronts.

1. Introduction

Over the past decade, Technical and Vocational Education and Training (TVET) has become a critical issue under the 2030 Agenda for Sustainable Development and Sustainable Development Goal 4 (SDG 4). One target of SDG 4 is to increase the number of youth and adults who have relevant skills, including technical and vocational skills, for employment, decent jobs, and entrepreneurship (UNESCO, 2024). And TVET has become increasingly institutionalized in terms of its scholarship. Our bibliometric analysis, based on data from the Web of Science Core Collection, indicates that the annual number of TVET publications grew from 233 in 2016 to 622 in 2025, representing a compound annual growth rate (CAGR) of 11.5%. This trend has accelerated sharply since 2024 (Omar & Abdullahi, 2024). The expansion has spread across 142 developed and developing countries. These technological, demographic, and labor-market shifts (Salari et al., 2025; Zhang, Lai & Gong, 2024) have heightened the demand from scholars and practitioners for an understanding of the intellectual basis and emerging trends in TVET research.

Although specific TVET subfields, including work-integrated learning (Fu et al., 2026; Horne & Majola, 2025; van der Veen & Datzberger, 2022), vocational teacher education (Dionne, Gagnon & Petit, 2024; Xin, Tang & Mou, 2024), apprenticeships (Acharya, 2026; Longley & Clarke, 2022; Thapa & Gaihare, 2024), and skills development systems (McGrath & Yamada, 2023; Ngware et al., 2024; Vasilev, 2024) have been elucidated, the broader academic landscape remains insufficiently mapped in its intellectual structure, theoretical foundations, and shifting research priorities. How the field has responded to post-2016 economic and technological disruption, and how internal structural inequalities have evolved, warrant deeper investigation.

To fill this gap, this study traces the intellectual organization and developmental trends of global TVET research since 2016 by synthesizing the existing scholarship in TVET, and proposes three interdependent questions:

- 1) What are the knowledge bases underlying modern TVET research and how are they organized into distinct intellectual clusters?
- 2) What are the frontiers of the emerging literature that define the current interests and future perspectives of the field?
- 3) What is the mode of production and spreading of TVET knowledge across national and institutional borders and what does this tell us about the global organization of the field?

And they are thoroughly discussed in the bibliometric analyses of co-citation, keyword co-occurrence, and co-authorship. Moreover, the Center-Periphery Theory and Punctuated Equilibrium Theory are adopted as two interpretive lenses for understanding the findings.

This paper makes four contributions. First, it provides a systematic mapping of TVET's intellectual landscape in the post-2015 SDGs era. Second, it reveals the theoretical and methodological foundations and emerging fronts of the field. Third, it indicates that TVET knowledge generation, such as publication and citation, is geopolitically concentrated in Anglophone countries, while the Global South remains comparatively marginalized. Lastly, it traces the catalytic effect of COVID-19 and artificial intelligence (AI) on new research directions, showing the field's capacity to adapt to global shocks.

2. Literature Review and Theoretical Framework

2.1. Previous Bibliometric and Thematic Reviews on TVET

To date, academic studies about mapping the TVET landscape have mainly been in the form of narrative or thematic reviews, with a small but increasing amount of bibliometric research. Some reviews have synthesized knowledge in certain subdomains, such as the study of self-regulated learning in vocational schools by Mejeu and Grieder (2025), and the bibliographic review of active methodologies in vocational training by Fernández Olivero and Simón Medina (2022). Some have shed light on issues about new technologies or circumstances, such as a systematic review of the use of extended reality (XR) in logistics and supply chain training by Zhu et al. (2025b), and the use of VET in the logistics sector in the political-socio-economic conditions of Australia

by Fogarty et al. (2024). Others reviewed in detail the sub-baccalaureate career and technical education degrees of United States community colleges and synthesized evidence on the short-term certificates, diplomas, and associate degrees, as examined by Soliz (2023). These specialized reviews establish conceptual foundations and offer best practices, but they don't provide a comprehensive perspective on how the subfields interact within the wider intellectual architecture and don't cover the latest phase of the discipline (2022–2026). The manual literature selection is ineffective when scaled to corpora spanning decades.

Among the limited number of bibliometric studies, Abd Majid, Kasavan and Siron (2022) provided a baseline bibliometric mapping of global TVET publications (1999–2021); the temporal limit of their dataset creates an opportunity to examine the post-pandemic phase and the explosion of AI-related research (2022–2026). Additionally, whereas the available quantitative studies have provided descriptive statistics (e.g., publication counts, citation rates), the incorporation of interpretive theoretical perspectives, such as Center-Periphery Theory and Punctuated Equilibrium Theory, would be conducive to the comprehension of knowledge production mechanisms.

This study examines the period from 2016 to 2026, thereby expanding on prior works. Furthermore, this paper innovatively provides a theoretical interpretation of thematic knowledge, linking descriptive patterns with structural dynamics in TVET research.

2.2. Center-Periphery Theory and Knowledge Production

The Center-Periphery Theory (CPT) is originally an idea from Wallerstein's (1974) theory of world-systems, which holds that the world is organized around an unequal divide: core countries dominate the economy and culture, while peripheral countries are subsidiaries. This framework was applied later to the sociology of scientific knowledge, illuminating the lasting asymmetries in citation practices, editorial domination, and agenda-setting (Bulut, 2026; Pereira, 2025). These disparities suggest that knowledge production is entrenched in a geopolitical system that favors specific epistemic groups over others.

TVET research is closely tied to national economies and labor-market policies (Salas-Velasco, 2024), and the current academic literature continues to be dominated by the views of a small number of Anglophone nations (Esmond & Wedekind, 2023; Nature Human Behaviour, 2023), even though TVET systems in different countries have different challenges, such as skills deficit in developed economies or unemployment of young populations in developing countries (Bano, 2025; Zhu, Zhu & Baylon, 2025a). Moreover, the observed geographic concentration of publications and citations is consistent with the structural imbalance the center-periphery model describes, which we read as knowledge flows tending to be unidirectional—from core to periphery—rather than bidirectional. The CPT can contribute to understanding the country and institutional collaboration patterns in TVET studies.

2.3. Punctuated Equilibrium Theory and Research Trajectories

Punctuated Equilibrium Theory (PET) emerged in evolutionary biology and was applied to the study of the public policy by Baumgartner and Jones (1993) and Kingdon (1985). PET indicates that the policy systems generally enjoy a long

phase of incremental stability (equilibrium) but occasionally followed by short-lived radical change due to outside shocks. This theory could be applied wherein external occurrences, involving economic crises, pandemics, or technological revolutions, trigger new lines of inquiry and remaking of old scholarly communities in academic study (Li, Yang & Cai, 2025).

PET can serve as a diagnostic lens in the temporal overlay analysis to identify the two external shocks to the field—the COVID-19 pandemic and the emergence of generative artificial intelligence—as either punctuation or path-dependent acceleration.

3. Methodology

Bibliometric analysis and science mapping are strong methodological interventions. Systematic analysis of co-citation, keyword co-occurrence, and co-authorship networks helps researchers determine the knowledge base (foundational works shaping a field's theoretical and methodological orientation) and research fronts (new topics pointing to future directions) (Jing et al., 2024; Kumar, 2025; van Eck & Waltman, 2010). Applied to TVET research, these approaches highlight the unseen strata of the literature and the intellectual boundaries that shape the field, bringing its dynamic development into view.

3.1. Data Source and Search Strategy

To answer the research questions, we conducted a bibliometric search of 3,655 TVET articles published in 2016–2026 in the Web of Science Core Collection (WoSCC) database. The WoSCC is recognised as a comprehensive and authoritative source for social-science bibliometric analysis (Guerrero-Bote et al., 2021) due to its strict indexing and citation information (Rong et al., 2025). Co-citation analysis identified the knowledge bases, keyword co-occurrence analysis mapped the research fronts, and co-authorship analysis explored national and institutional collaboration.

On 18 February 2026, we conducted a topic search within the Web of Science Core Collection databases (Science Citation Index Expanded [SCI-EXPANDED], Social Sciences Citation Index [SSCI], and Arts & Humanities Citation Index [A&HCI]), using the following search terms:

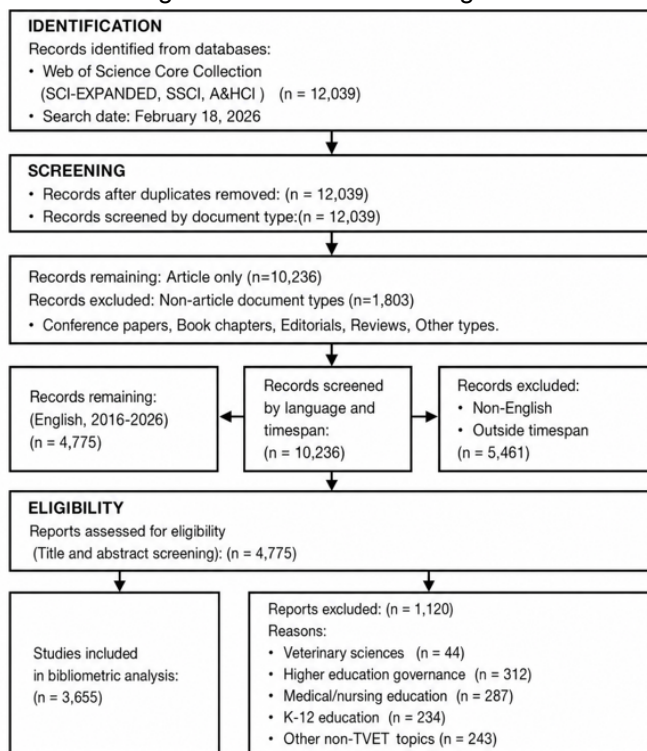
TS = (“technical and vocational education” OR “vocational education and training” OR “VET” OR “TVET” OR “career and technical education” OR “vocational training” OR “professional education”). It is worth noting that TVET research indexed in WoSCC does not adhere to a single label; we conducted the above search query to maximize coverage of the terminological variants used for Technical and Vocational Education and Training in the literature. Although the keyword “professional education” is extremely broad and likely to retrieve many non-TVET studies, a portion of the TVET literature can only be found under the search query of this keyword; therefore, it was retained. Subsequent keyword analysis confirmed that it is the third most frequently used keyword in the TVET field (Section 4.2). The non-TVET professional development and professional school literature retrieved by this keyword was expected and resolved through the following multi-stage Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) screening. The screening functioned as the validation procedure for the broad search string, removing records referencing non-TVET content (high-school governance, fundamental education reform, and clinical/medical

education unrelated to TVET). But residual retrieval bias is an inherent limitation of recall-oriented bibliometric searching. While the screening mitigated this limitation, it did not eliminate it. In addition, because the acronym “VET” stands for both “vocational education and training” and “veterinary”, the search query retrieves many veterinary science records that are not TVETs; to ensure data quality and relevance, these unrelated records are removed at the topic category, source, and content levels.

- Document Type: Restricted to peer-reviewed journal articles (not conference proceedings, book chapters, editorials, or other forms of publications).
- Language: English only.
- Timespan: 2016–2026 (covering the post-2015 SDGs era).
- Subject Categories: Rejected Veterinary Sciences (WC = “Veterinary Sciences”).
- Source Publications: Excluding veterinary specialist journals (J VET MED EDUC, VET REC, BMC VET RES, VET PARASITOL).
- Content screening: Publications where “VET” referred to veterinary medicine rather than vocational education and training were manually excluded, as were those focusing on governance in general higher education, primary education curriculum reform, or clinical/medical education unrelated to TVET.

The initial search retrieved 12,039 records. Following the PRISMA guidelines (Page et al., 2021), we employed a multi-stage screening process (see Figure 1):

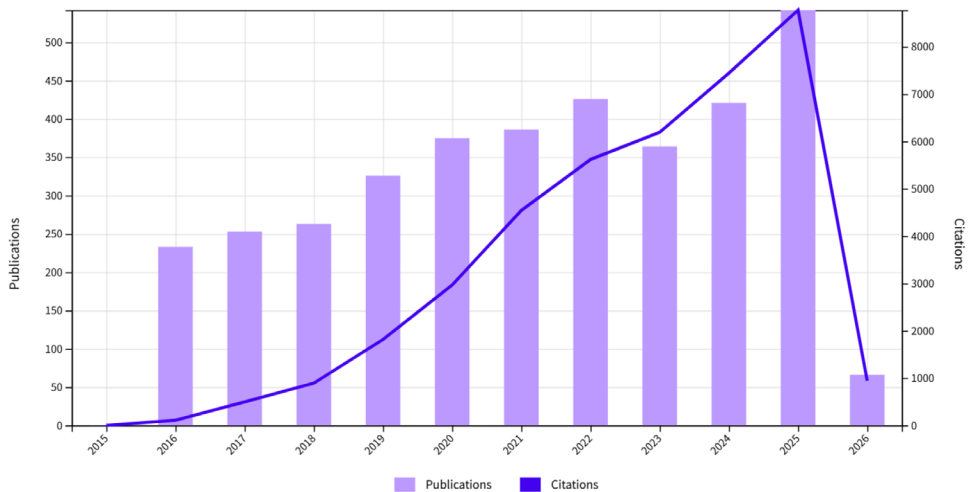
Figure 1: PRISMA Flow Diagram.



First, by filtering document types (peer-reviewed articles only), 1,803 records that did not match the type were removed (remaining 10,236); secondly, by filtering language and publication time (English, 2016–2026), 5,461 records did not match (remaining 4,775); and finally, by filtering title and abstract 1,120 unrelated records were removed,—44 veterinary-science articles and 1,076 articles unrelated to TVET, on higher-education governance, basic-education reform, clinical/medical education, or veterinary medicine. All title and abstract screenings were performed by two authors, with any disagreements resolved through discussion to reach consensus.

The final dataset comprised 3,655 publications, exported in tab-delimited format with full records and references, and then it was imported into VOSviewer 1.6.19. The annual publication trajectory (Figure 2) exhibits a marked upward trend, with pronounced growth since 2024. Since the search was conducted on 18 February 2026, the 91 records dated 2026 represent only a partial statistical snapshot of that year, and of these records, 58 were early-access articles accepted to their official issue assignment, while 33 had already been formally published. These statistics can not be compared to the full-year statistics for 2016–2025. They are included to document the status of available publications as of the search date, rather than to indicate a decline in output.

Figure 2: Annual Publication Trajectory (2016–2026, retrieved 18 February 2026).



3.2. Analytical Procedures

All analyses were conducted in VOSviewer 1.6.19 (van Eck & Waltman, 2010), which employs the VOS (visualization of similarities) mapping technique and the smart local moving (SLM) clustering algorithm (Waltman & van Eck, 2013) to identify clusters of related items based on co-occurrence or co-citation relationships (Waltman, van Eck & Noyons, 2010; Xie & Waltman, 2025).

Four network analyses were performed: (1) document co-citation analysis to identify knowledge bases; (2) keyword co-occurrence analysis to map research fronts; (3) country co-authorship analysis to examine patterns of international collaboration;

(4) institutional co-authorship analysis to examine patterns of organizational collaboration.

The thresholds are meant to balance representativeness against readability. On the one hand, the threshold must retain enough items to capture the intelligence and collaborative structures within the field, ensuring that the resulting networks are of comparable, interpretable scale. On the other hand, the threshold should exclude peripheral items, as their weak connections would disrupt the visualization and dilute the cluster structure. Furthermore, citation counts, keyword occurrences, and document counts follow different distributions. A uniform threshold across networks would be inappropriate; each threshold would be set relative to its own distribution. To meet the above requirements, the co-citation threshold was set at ≥ 19 citations per document, yielding 65 highly-cited references; the keyword threshold was set at ≥ 43 occurrences, retaining 61 high-frequency terms while filtering incidental keywords; the country threshold was set at ≥ 10 documents per country, identifying 58 countries with sustained TVET output; and the higher institutional threshold was set at ≥ 16 documents per institution, identifying 52 organisations with recurrent research activity (49 forming the largest connected component) from the long-tailed distribution of institutional productivity. This calibration logic follows standard VOSviewer practice (van Eck & Waltman, 2010; Waltman et al., 2010), and its adequacy is supported ex post by the quality indicators reported in Table 1: the co-citation and institutional networks exhibit significant community structure ($Q = 0.384$ and 0.522), whereas the keyword and country networks show weaker but interpretable separation ($Q = 0.157$ and 0.272) that reflects the inherent density of these networks (see Section 4.2).

3.3. Quality Assessment

Cluster quality was assessed using four indicators: modularity Q (the strength of cluster division, values > 0.3 indicating significant clustering structure), the silhouette score (within-cluster coherence, values > 0.7 indicating strong homogeneity), network density, and total link strength. Since the modularity coefficient Q and the silhouette coefficient are not displayed in the VOSviewer 1.6.19 interface, we calculated modularity Q and silhouette from the exported VOSviewer network and map files on correlation-strength-normalised networks (van Eck & Waltman, 2010), consistent with VOSviewer's mapping and clustering procedure, where cluster assignments were taken directly from VOSviewer's clustering results. The network visualisation diagrams were generated using the default colour scheme of VOSviewer, in which node size denotes citation or occurrence frequency, and link thickness indicates association strength. To reduce node overlap and improve legibility, the node positions in the four network maps (document co-citation, keyword co-occurrence, country co-authorship, and institutional co-authorship) were re-optimised using the Kamada–Kawai layout algorithm (Kamada & Kawai, 1989) in Pajek 6.02 (Batagelj & Mrvar, 1998). For each map, the network data exported from VOSviewer were saved in Pajek format and re-laid out with the Kamada–Kawai algorithm; this step adjusted only the visual placement of nodes and did not alter the cluster structure, which was determined by VOSviewer's SLM clustering.

Table 1: Bibliometric Network Quality Indicators for the Four TVET Research Networks.

Network	Items (N)	Clusters	Links (L)	Network Density	Modularity Q	Avg. Silhouette	Total Link Strength
Document co-citation	65	5	606	0.291	0.384	0.612	1702
Keyword co-occurrence	61	4	1361	0.744	0.157	0.332	5752
Country co-authorship	58	5	786	0.475	0.272	0.445	2983
Institutional co-authorship	49	6	181	0.154	0.522	0.749	323

Note. Q > 0.3 indicates significant community structure (Fortunato & Barthélemy, 2007); silhouette values of 0.71–1.00, 0.51–0.70, and 0.26–0.50 indicate strong, reasonable, and weak within-cluster coherence, respectively, and values of 0.25 or below mean no substantial structure (Rousseeuw, 1987; Kaufman & Rousseeuw, 1990). Per-cluster silhouette values are reported in the Supplementary Materials.

4. Results

4.1. Knowledge Bases: Document Co-Citation Analysis

The co-citation network comprises 65 highly cited references, and based on the SLM clustering algorithm, they naturally fall into the methodological dimension and substantive/theoretical dimension, forming five distinct knowledge clusters that constitute the foundational knowledge system of contemporary TVET research. The network exhibited significant community structure (modularity Q = 0.384) and reasonable within-cluster coherence (average silhouette score = 0.612; Table 1). This bilateral system is not a product of subjective classification but the natural workings of citation in the discipline: scholars who adopt the same methodology will cite the same methodological canon regardless of their substantive subjects, and scholars who choose the same theoretical tradition will cite the same foundational theories in spite of their methodologies.

The 10 most co-cited references are listed in Table 2, the co-citation network in Figure 3, and the five knowledge clusters in Table 3.

Table 2: The 10 Most Co-cited References.

Rank	Cited Reference	Citations	Total Link Strength	Cluster
1	Braun, V., & Clarke, V. (2006). Using thematic analysis in psychology. <i>Qualitative Research in Psychology</i> , 3(2), 77–101. doi:10.1191/1478088706qp063oa	133	47	1 (Red)
2	Hanushek, E. A., Schwerdt, G., Woessmann, L., & Zhang, L. (2017). General education, vocational education, and labor-market outcomes over the lifecycle. <i>Journal of Human Resources</i> , 52(1), 48–87. doi:10.3368/jhr.52.1.0415-7074r	68	232	3 (Green)
3	Hu, L.T., & Bentler, P. M. (1999). Cutoff criteria for fit indexes in covariance structure analysis: Conventional criteria versus new alternatives. <i>Structural Equation Modeling: A Multidisciplinary Journal</i> , 6(1), 1–55. doi:10.1080/10705519909540118	62	71	2 (Blue)
4	Cohen, J. (2013). <i>Statistical power analysis for the behavioral sciences</i> . routledge. doi:10.4324/9780203771587	60	45	2 (Blue)
5	Bussemeyer, M. R., & Trampusch, C. (Eds.). (2011). <i>The political economy of collective skill formation</i> . Oxford University Press. doi:10.1093/acprof:oso/9780199599431.003.0001	54	90	5 (Purple)

Rank	Cited Reference	Citations	Total Link Strength	Cluster
6	Hall, P. A., & Soskice, D. (Eds.). (2001). Varieties of capitalism: The institutional foundations of comparative advantage. Oxford University Press. doi:10.1093/0199247757.001.0001	41	81	5 (Purple)
7	Spence, M. (1973). Job market signaling. The Quarterly Journal of Economics, 87(3), 355–374. doi:10.2307/1882010	38	128	4 (Yellow)
8	Bandura, A. (1977). Social learning theory. Prentice Hall. doi:10.1891/0889-8391.13.2.158	37	31	2 (Blue)
9	Hair Jr., J. F., Anderson, R. E., Tatham, R. L., & Black, W. C. (1998). Multivariate Data Analysis (5th ed.). Upper Saddle River, NJ: Prentice Hall.	37	55	2 (Blue)
10	Fornell, C., & Larcker, D. F. (1981). Evaluating structural equation models with unobservable variables and measurement error. Journal of Marketing Research, 18(1), 39–50. doi:10.2307/3151312	36	64	2 (Blue)

Figure 3: Co-citation Network of Cited References.

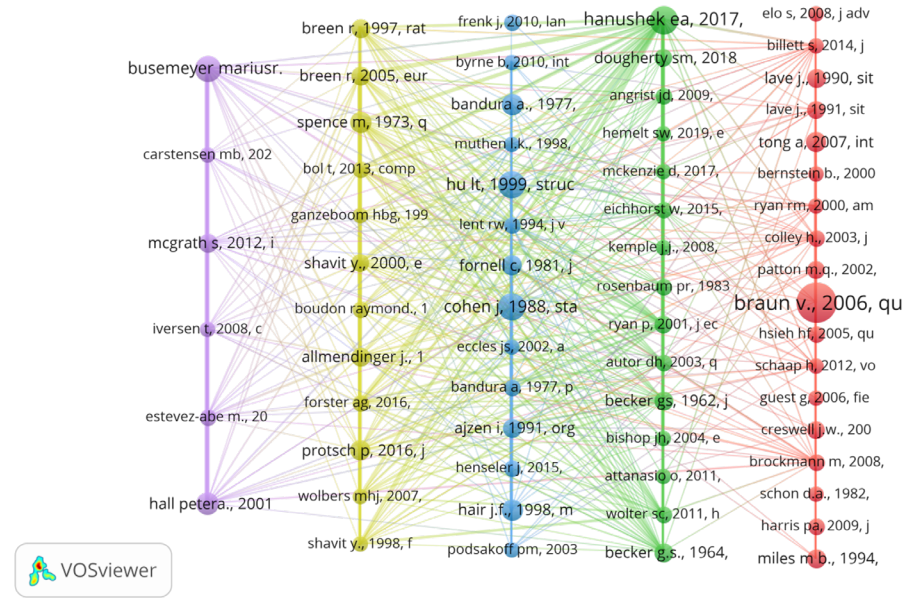


Table 3: Five Knowledge Clusters Exhibited by the 65 Highly Cited References.

Dimension	Cluster	Cluster Label	Size	Representative Publications
Methodological Foundations	1 (Red)	Qualitative Research Methodologies	18 (27.7%)	Braun and Clarke (2006); Tong et al. (2007); Lave and Wenger (1991); Miles (1994)
	2 (Blue)	Quantitative Research Methodologies	14 (21.5%)	Hu and Bentler (1999); Cohen (2013); Hair et al. (1998)
Substantive/Theoretical Foundations	3 (Green)	Human Capital and Skills Development	15 (23.1%)	Becker (1993); Hanushek et al. (2017); Ryan (2001)
	4 (Yellow)	Social Stratification and Inequality	12 (18.5%)	Spence (1973); Breen and Goldthorpe (1997); Protsch and Solga (2016); Breen (2005)
	5 (Purple)	Political Economy and Institutional Analysis	6 (9.2%)	Hall and Soskice (2001); Busemeyer and Trampusch (2011)

4.1.1. Dimension 1: Methodological Foundations

- Cluster 1 (Red): Qualitative Research Methodologies

The largest cluster (N=18, 27.7%) centres on qualitative methods, chiefly thematic analysis and phenomenology. The cluster is anchored by the thematic analysis by Braun and Clarke (2006), followed by interpretative phenomenological analysis (Smith, Flowers & Larkin, 2010), grounded theory (Charmaz, 2014), situated learning (Lave & Wenger, 1991), and the qualitative analysis of data (Miles & Huberman, 1994; Patton, 2014). It also includes key methodological works: a research design framework by Creswell and Creswell (2009), the guide to qualitative content analysis by Hsieh and Shannon (2005), and the Consolidated Criteria for Reporting Qualitative Research (COREQ) checklist by Tong et al. (2007).

This cluster signals the field's orientation toward the lived experience of vocational learners, teachers, and practitioners (Wuttke et al., 2024). Such studies examine the contextual characteristics of vocational learning and the significance of workplace and educational engagement (Alhazmi & Kaufmann, 2022).

- Cluster 2 (Blue): Quantitative Research Methodologies

The second cluster (N=14, 21.5%) focuses on quantitative methods, including structural equation modeling (SEM) and psychometrics. The most relevant ones are the recommendations on fit indices in covariance structure analysis (62 citations) made by Hu and Bentler (1999), the statistical data analysis power (60 citations) examined by Cohen (2013), and the textbook on multivariate data analysis (37 citations) by Hair Jr et al. (1998).

This cluster reflects the field's growing need for rigorous quantitative evaluation of TVET outcomes, program efficacy, and learner characteristics. These psychometric and statistical approaches indicate that vocational education policies and practices must be evidence-based. Seminal works on social cognitive theory (Bandura, 1977a, 1977b), SEM (Fornell & Larcker, 1981; Henseler, Ringle & Sarstedt, 2015) and career development theory (Lent, Brown & Hackett, 1994) are part of this cluster and show considerable methodological consistency.

4.1.2. Dimension 2: Substantive/Theoretical Foundations

- Cluster 3 (Green): Human Capital and Skills Development

The third cluster (N=15, 23.1%) focuses on human capital theory and skill development policy. The fundamental work of Becker (1993) on human capital and his previous theoretical work (Becker, 1962) are the basis of this cluster. The influential study about the outcomes of general and vocational education by Hanushek et al. (2017), works on the economics of vocational training (Ryan, 2001), the return to vocational education (Angrist & Pischke, 2009), and the effectiveness of vocational education (Eichhorst et al., 2015) are also included in the cluster.

This cluster presents the economic perspective on TVET. The human capital theory offers a conceptual model for explaining why education, productivity and income are linked (Auerbach & Green, 2025). The model serves as a guide for formulating policies about returns to vocational skills and the optimal investment in training (Cheng, Cao & Md Rashid, 2025). The cluster's moderate heterogeneity indicates a theoretical focus spanning neoclassical human capital theory and institutional views of skill formation.

- Cluster 4 (Yellow): Social Stratification and Inequality

The fourth cluster (N=12, 18.5%) addresses social stratification, educational inequality, and TVET's effect on social stratification. These foundational works include the signaling theory by Spence (1973) (38 citations), the theory of rational action by Breen and Goldthorpe (1997), and the comparative analysis of educational systems and the labor market by Allmendinger (1989).

This cluster exemplifies critical sociological perspectives on TVET, focusing on how students from different backgrounds are steered toward different career paths (Nazir, 2025), such as the examination of social stratification in the German VET system by Protsch and Solga (2016) and the comparative studies of vocational education and social stratification by Breen (2005). The cluster indicates the field's concern for equity, access, and social justice—trending SDG-era issues.

- Cluster 5 (Purple): Political Economy and Institutional Analysis

The fifth cluster (N=6, 9.2%) addresses the political economy and institutional analysis of skill formation. The intellectual background of the cluster consists of Hall and Soskice's (2001) *Varieties of Capitalism* (41 citations), the works of Busemeyer and Trampusch (2011) on the political economy of collective skill formation, and the works of Estevez-Abe, Iversen and Soskice (2001) on the concept of social protection and skill formation.

This cluster reflects the field's interest in macro-level comparative analysis of TVET systems and institutional effects on skill formation. Contributions on the role of firms in skill formation (Iversen & Soskice, 2001), international development perspectives (McGrath, 2012), and more recent works about institutional change in skill formation systems (Carstensen & Ibsen, 2021; Hosseinioun et al., 2025) are incorporated in this cluster. The cluster's modest size may reflect that the scope of comparative institutional analysis remains somewhat limited in wider TVET research.

Together, the five clusters reveal the knowledge bases of modern TVET research. The qualitative (27.7%) and quantitative (21.5%) clusters account for nearly half (49.2%) of the network, indicating that methodological works form the most densely connected stratum. Their co-existence signals methodological pluralism, yet the sparse citation links between them suggest qualitative and quantitative traditions operate largely in parallel, with limited cross-paradigm engagement.

The three theoretical traditions—human capital theory (Cluster 3, 23.1%), social stratification and inequality (Cluster 4, 18.5%), and comparative political economy (Cluster 5, 9.2%)—trace a shift from the microeconomic logic of individual skill investment, to the meso-level analysis of how educational systems reproduce social hierarchies, to the macro-level comparison of how national institutions shape skill-formation regimes. Their downsizing (23.1% to 9.2%) suggests that economically oriented frameworks are more deeply embedded than macro-institutional or critical-sociological perspectives.

Cross-cluster integration is limited: methodological and theoretical commitments tend to be bundled—within a given theoretical tradition, researchers adopt its corresponding methodological toolkit rather than select it based on the research question.

In summary, TVET's knowledge bases form a dual-dimensional structure—methodologically plural yet substantively fragmented—making for diversification instead of theoretical synthesis and cross-paradigm accumulation.

4.2. Research Fronts: Keyword Co-Occurrence Analysis

The co-occurrence network comprised 61 high-frequency keywords, derived from a pool of 14,982 keywords. The network was highly dense (density = 0.744), while its modular structure was comparatively weak (modularity Q = 0.157; average silhouette = 0.332; Table 1). Therefore, the network was classified into four thematic groupings based on the substantive coherence of keywords rather than on strong topological separation. The co-occurrence analysis of keywords identified four distinct research frontiers, representing current priority directions and emerging trends within the field.

The 10 most frequent keywords are listed in Table 4, led by “education” (450), “vocational education and training” (229), “professional education” (205), “students” (189), and “impact” (188), reflecting the field’s focus on educational processes, professional development, and evidence-based outcomes. The co-occurrence network (Figure 4) yields four thematic clusters (Table 5).

Table 4: The 10 Most Frequent Keywords

Rank	Keyword	Occurrences	Total Link Strength	Cluster
1	Education	450	804	4 (Yellow)
2	Vocational education and training	229	391	4 (Yellow)
3	Professional education	205	248	3 (Blue)
4	Students	189	445	3 (Blue)
5	Impact	188	429	1 (Red)
6	Vocational training	182	327	2 (Green)
7	Work	162	422	2 (Green)
8	Employment	156	390	2 (Green)
9	Health	145	245	1 (Red)
10	Knowledge	144	319	4 (Yellow)

Figure 4: Keyword Co-occurrence Analysis Network.

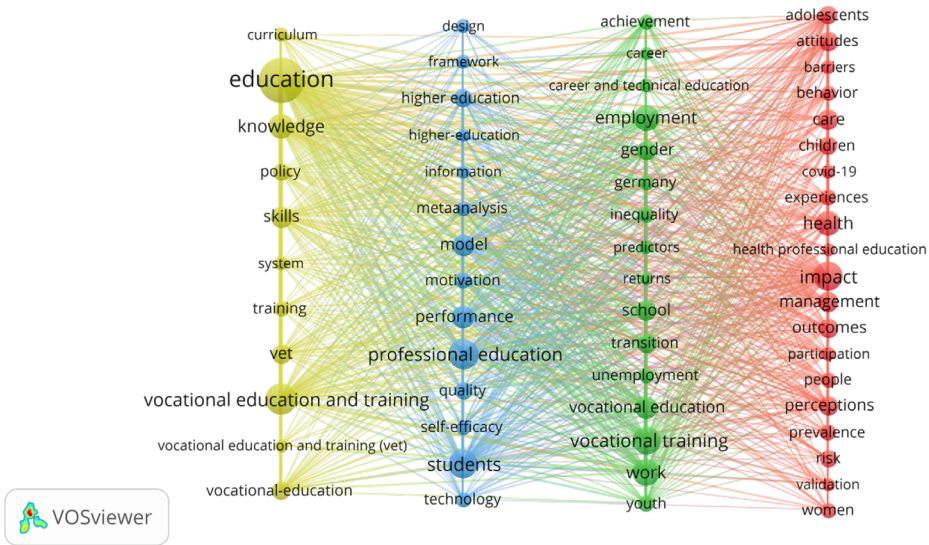


Table 5: Keyword Co-Occurrence Clusters.

Cluster	Research Front	Size	Representative Keywords
1 (Red)	Health Professions and Workplace Learning	20 (32.8%)	"Impact," "health," "management," "care," "COVID-19."
2 (Green)	Labor Market Transitions and Graduate Outcomes	16 (26.2%)	"Vocational training," "work," "employment," "transition."
3 (Blue)	Higher Education-TVET Interface	14 (23.0%)	"Professional education," "students," "performance."
4 (Yellow)	Policy-System-Curriculum Dynamics	11 (18.0%)	"Education," "knowledge," "skills," "policy," "curriculum."

- Cluster 1 (Red): Health Professions and Workplace Learning

The largest domain (N=20, 32.8%) focuses on health professions education and workplace learning. Core keywords within this domain include "impact" (188), "health" (145), "management" (105), "care" (100), "perceptions" (92), "outcomes" (91), "attitudes" (87), "adolescents" (86), and "children" (82). The keyword "health-professions education" in this cluster refers to the training of healthcare professionals (including nursing, allied health, and clinical support occupations). Healthcare professional training falls within the scope of contemporary TVET scholarship: a type of education and training that focuses on providing students with practical skills and knowledge for a specific trade or vocation. And it is consistent with the International Standard Classification of Education (ISCED), which recognizes that vocational education programs in the health and welfare sector encompass nursing, dental services, and medical and social services (UNESCO Institute for Statistics, 2012). Ostrognaj et al. (2024) examined work-integrated placements in virtual health promotion. Mlambo, Silén and McGrath (2021) conducted a metasynthesis of research on nurses' continuing professional development, another strand of workplace learning for the healthcare workforce. This cluster indicates that substantial research focuses on the workplace learning skills of the healthcare workforce. This topic received growing attention, during the COVID-19 pandemic, as healthcare systems worldwide faced the unprecedented challenge of managing the healthcare workforce (Ostrognaj et al., 2024).

High-frequency words, such as "risk" (76 occurrences), "prevalence" (61), "barriers" (51), and "participation" (48), indicate the propensity to learn the health-related behavior, access to care, and the situational determinants of health in the vocational training practice. High-frequency terms, including "COVID-19" (48) and "health professional education" (46) reflect the pandemic's impact on this domain. Nakar and Trevarthen (2024) reported that VET educators overcame unprecedented pedagogical complexity and quickly modified their instruction during and after the crisis, while Mbambo and du Plessis (2025) reported that TVET institutions prioritized digital competence and alternative assessment to ensure continuity during disruptions. These studies explored educators' and students' pandemic adaptations and were situated within the TVET literature rather than academic medical education.

- Cluster 2 (Green): Labor Market Transitions and Graduate Outcomes

The second cluster (N=16, 26.2%) addresses labor market transitions, graduate employment outcomes, and skills matching. Core keywords include "vocational training" (182), "work" (162), "employment" (156), "vocational education" (116), "school" (101), "gender" (91), "transition" (88), "youth" (67), "inequality" (66), and "unemployment" (55).

This cluster reflects policymakers' sustained interest in the economic returns of

vocational qualifications and in how TVET prepares learners for an unstable labour market. “Germany” (60) stands for the attention to the German dual system as a vocational education model, while “achievement” (57), “predictors” (47), “career” (44), and “returns” (43) connect the cluster to labor economics. The temporal analysis shows increasing concern for gender equity (“gender”, 91) and youth unemployment (“unemployment”, 55), consistent with SDGs related to decent work and inequalities (UNESCO, 2021).

- Cluster 3 (Blue): Higher Education-TVET Interface

The third front (N=14, 23.0%) examines the relation, articulation, and credit transfer between higher education and TVET, and academic-vocational stratification. Core terms include “professional education” (205), “students” (189), “performance” (126), “model” (114), “higher education” (84), “quality” (76), “motivation” (63), “meta-analysis” (58), “technology” (58), and “self-efficacy” (55).

The cluster reflects ongoing debates about TVET’s position in the educational framework and the institutional barriers vocational learners face when entering higher education. Terms such as “higher education” (84), “framework” (47), and “design” (48) reflect attention to TVET’s position in higher education and the design of mechanisms for linking TVET to higher education, while “barriers” (51), “transition” (88), and “self-efficacy” (55) embody the institutional barriers vocational learners face when transitioning between vocational and academic pathways.

- Cluster 4 (Yellow): Policy-System-Curriculum Dynamics

The fourth front (N=11, 18.0%) covers policy analysis, system governance, and curriculum development. Words such as “education” (450), “vocational education and training” (229), “knowledge” (144), “skills” (112), “vet” (91), “vocational-education” (82), “policy” (77), “training” (57), “curriculum” (53), “system” (50), and “vocational education and training (vet)” (46) are frequent.

This cluster illustrates how the field responds to changing economic and social needs by addressing the structure, regulation, and reform in the entire TVET system. “Policy” (77), “system” (50), and “curriculum” (53) reflect a focus on the structure of the entire TVET systems, while “vocational education and training” (229) and “vet” (91) signify a systemic governance analysis and attention to regulation. New keywords—digital transformation, green skills, and AI integration—inform the large-scale TVET reform since 2022 (Figure 7) and explain why TVET scholarships are more attuned to global sustainability and technological agendas (OECD, 2023; World Economic Forum, 2023).

The emerging fronts include health professions and workplace learning, labor market transitions and graduate outcomes, the higher education-TVET interface, and policy-system-curriculum dynamics, disclosing a thematically diverse field in which employability remains the constant concern (Clusters 1 and 2) and systemic integration gains attention (Clusters 3 and 4).

To assess the robustness of this thematic structure when including health-professions records and records indexed under the term “professional education” (Section 3.1), we conducted two sensitivity analyses. We reran the keyword co-occurrence analysis of the 3,655-record corpus, while keeping all VOSviewer parameters identical to the baseline settings (minimum occurrence ≥ 43 ; SLM clustering; association-strength normalisation). In the first scenario, we removed 855 records assigned to any health-related Web of Science category aligned with the ISCED “Health and welfare” field (UNESCO Institute for Statistics, 2012), retaining 2,800 articles. The resulting network retained four clusters

(43 keywords), with its modularity Q essentially unchanged (0.148 versus 0.157) and the average silhouette value marginally improved (0.371 versus 0.332). The health-professions theme persisted, with “health,” “care,” “outcomes,” and “perceptions” in the same cluster. Thus, excluding all health-related records not only failed to expose this thematic structure as an artificial construct resulting from contamination by health records, but actually preserved its integrity, consistent with the perspective presented earlier in this section.

In the second scenario, the 205 records in which “professional education” appeared as a discrete keyword (author keywords or Keywords Plus) were removed (3,450 records retained). As a result, the network fragmented into five clusters (56 keywords), and the average silhouette value fell to 0.182—below the 0.25 cutoff point, denoting no substantial structure (Kaufman & Rousseeuw, 1990). The coherence of the health-professions cluster collapsed (per-cluster silhouette value $0.232 \rightarrow 0.090$), with a singleton keyword (“training”) detached. Here, the structure proved markedly less robust. The asymmetry is inspiring: the keyword mapping exhibits resilience when records tagged with “health” are removed, but appears fragile when records indexed under “professional education” are withdrawn, indicating that “professional education” functions as a bridging descriptor connecting the health-professions cluster and the higher education–TVET interface cluster. Its removal severs the cross-cluster links that hold the map together. This finding empirically reinforces the legitimacy of “professional education” as a search descriptor argued in Section 3.1, while transparently exposing the dependence of the keyword structure (an admittedly weakness) on this connecting term, a limitation of co-occurrence mapping in a thematically pluralistic field.

4.3. Knowledge Production Structure: Country Collaboration Analysis

The country co-authorship analysis showed that TVET knowledge production had the characteristics of a centralized network. The network comprised 58 countries (minimum 10 documents each), with moderate density (density = 0.475) and comparatively weak modular separation (modularity Q = 0.272; average silhouette = 0.445; Table 1). Nevertheless, the five clusters share discernible historical, linguistic, and institutional similarities. The 10 most productive countries are listed in Table 6, the network in Figure 5, and the clusters in Table 7. VOSviewer assigns records to England, Scotland, and Wales, based on affiliation address, and they appear as distinct nodes rather than being aggregated under the UK.

Table 6: The Top 10 Most Productive Countries.

Rank	Country	Documents	%	Citations	Total Link Strength	Cluster
1	USA	878	24.02	12747	507	4 (Yellow)
2	Australia	383	10.48	4882	306	4 (Yellow)
3	Germany	382	10.45	4833	395	2 (Green)
4	China	347	9.49	3562	235	4 (Yellow)
5	England	329	9.00	3986	508	1 (Red)
6	Spain	210	5.75	2254	221	2 (Green)
7	Canada	194	5.31	3133	236	1 (Red)
8	Switzerland	185	5.06	2677	236	3 (Blue)
9	Netherlands	143	3.91	1754	245	5 (Purple)
10	Italy	120	3.28	1655	254	3 (Blue)

Figure 5: Country Collaboration Network.

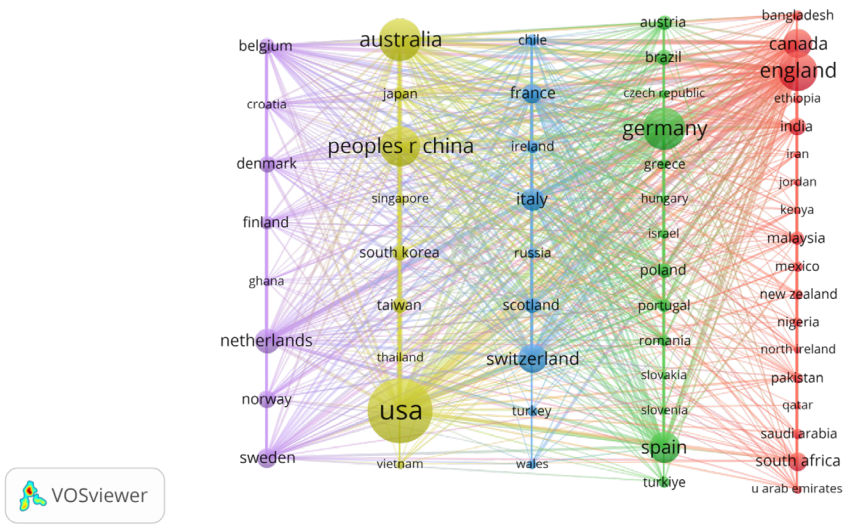


Table 7: Country Collaboration Clusters.

Cluster	Label	Countries	Key Members
1 (Red)	British Commonwealth & Global South	18	England, Canada, South Africa, India
2 (Green)	Germanic & Central European	14	Germany, Spain, Austria, Poland
3 (Blue)	Western European & Mediterranean	9	Switzerland, Italy, France, Ireland
4 (Yellow)	Asia-Pacific	9	USA, Australia, China, South Korea
5 (Purple)	Nordic & Northern European	8	Netherlands, Sweden, Norway, Denmark

- Cluster 1 (Red): British Commonwealth and Global South
The first cluster (N=18) centers on England (329 publications), with ties to Canada (194), South Africa (80), India (73), Malaysia (47), Pakistan (30), Bangladesh (29), Mexico (29), Saudi Arabia (29), New Zealand (28), Nigeria (24), and the United Arab Emirates (19). This structure aligns with colonial-era ties, and English is the dominant language of academic publication.
Studies in this cluster often discuss TVET development in the post-colonial world, particularly issues related to access, equity, and quality assurance in developing economies (Nungse & Sagbara, 2024). The coexistence of the countries in the Global South and classic Commonwealth nations implies that although the citation-impact analysis fails to reflect actual scholarly imbalance, knowledge exchanges continue to exist.
- Cluster 2 (Green): Germanic and Central European
The second cluster (N=14) is anchored by Germany (382 publications), with Austria (51), Spain (210), Brazil (57), Poland (53), Portugal (43), Türkiye (35), Romania (31), Greece (25), Israel (23), Czech Republic (18), Hungary (16), Slovenia (16), and Slovakia (12) as part of the cluster. The thick collaboration networks reflect shared academic traditions in vocational education, especially the dual apprenticeship model.

The cluster focuses on comparative analysis of skill-formation systems and the political economy of vocational education. Germany serves as the model case, its dual system providing a benchmark for policy transfer in European and Latin American contexts (Milmeister, Rastoder & Houssemand, 2022). The entry of Brazil and Türkiye is a sign of collaborative networks beyond the conventional European borders.

- Cluster 3 (Blue): Western European and Mediterranean

The third cluster (N=9) has Switzerland (185), Italy (120), France (95), Scotland (60), Ireland (41), Chile (34), Türkiye (30), Russia (27), and Wales (21). This cluster reveals the diverse vocational cultures of Western European nations, and new Mediterranean and Latin American ties.

Studies in this cluster often adopt EU policy frameworks, such as the European Qualifications Framework and the European Credit System of Vocational Education and Training (ECVET). Chile's inclusion reflects growing European-Latin American cooperation and South-South knowledge exchange on vocational-education reform.

- Cluster 4 (Yellow): Asia-Pacific

The fourth cluster (N=9) revolves around the USA (878 publications), Australia (383), and China (347), with South Korea (56), Taiwan of China (55), Japan (45), Singapore (19), Vietnam (17), and Thailand (15) in its periphery. The fastest growth comes from this cluster, indicating increasing TVET research potential in the Asia-Pacific.

The USA's lead (878 publications, 24.02%) is consistent with its large research community and the concentration of high-impact English-language journals in Anglophone nations. China's 347 publications (9.49%) imply a rapid growth in its TVET research capacity, yet citation analysis shows that China's impact remains limited to regional networks.

- Cluster 5 (Purple): Nordic and Northern European

The fifth cluster (N=8) encompasses the Netherlands (143), Sweden (91), Norway (74), Denmark (67), Belgium (57), Finland (48), Ghana (20), and Croatia (18). This pattern reflects that Nordic and Northern European nations boast strong welfare and well-developed vocational education systems.

The studies associated with this cluster often focus on equity, social inclusion, and lifelong learning, as they are the policy priorities of Nordic welfare states. The inclusion of Ghana indicates that Nordic scholars are working with their African colleagues on development-oriented TVET research, while the low publication rate of African countries in this cluster points out persisting disparities in research capacity.

From the center-periphery lens, the observed concentration reflects not only intellectual superiority but a geopolitical system that tends to favor specific epistemic groups while marginalizing others (Gomez, Herman & Parigi, 2022). Even as semiperiphery countries like China have increased their publication output, the legitimacy accorded to theoretical traditions continues to be associated with core nations (Wu, Yang & Li, 2024). This structural imbalance raises critical questions about whose knowledge counts in TVET scholarship (Connell, 2007) and whose voices remain underrepresented in the academic discourse.

4.4. Institutional Collaboration Networks

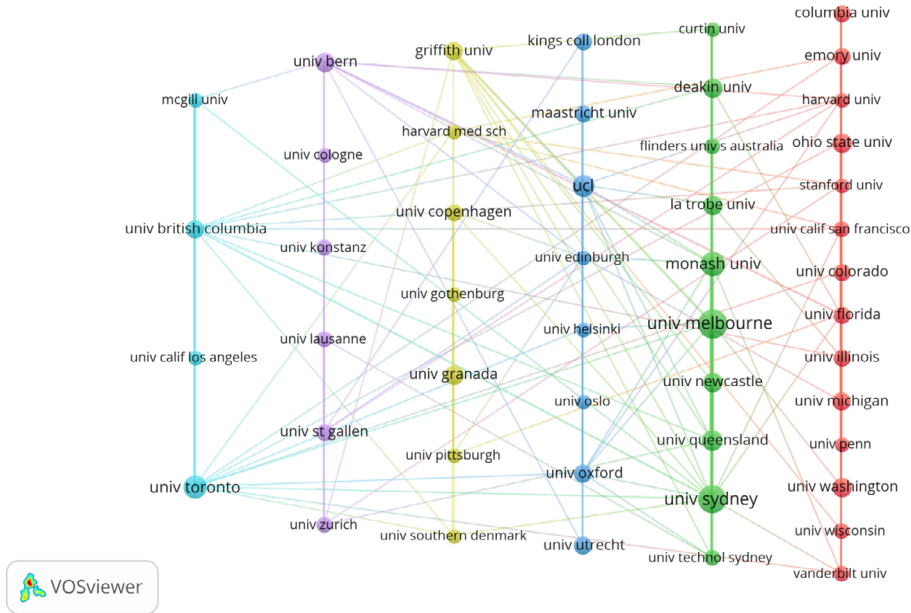
The institutional co-authorship analysis revealed that TVET research capacity is

concentrated in a small number of universities. 52 institutions met the threshold of publishing at least 16 documents per institution; 49 formed the largest connected component (the remaining three had no links above the threshold). The network was sparse (density = 0.154) but well-structured (modularity Q = 0.522; average silhouette value = 0.749; Table 1). The 10 most productive institutions are listed in Table 8 (led by the University of Melbourne with 61 publications, the University of Sydney with 56, and Monash University with 45); the network is shown in Figure 6.

Table 8: The Top 10 Most Productive Institutions.

Rank	Organization	Documents	Citations	Total link strength	Cluster
1	The University of Melbourne	61	600	56	2 (Green)
2	The University of Sydney	56	638	48	2 (Green)
3	Monash University	45	914	38	2 (Green)
4	University of Toronto	40	495	18	6 (Sky Blue)
5	University College London	35	519	12	3 (Navy Blue)
6	The University of Queensland	32	216	34	2 (Green)
7	University of Bern	29	402	12	5 (Purple)
8	University of Washington	29	375	13	1 (Red)
9	Deakin University	28	536	25	2 (Green)
10	The Ohio State University	28	342	18	1 (Red)

Figure 6: Institutional Co-authorship Network.



As shown in Figure 6, Cluster 2 (Green) comprises mainly Australian universities—the top 7 universities (Melbourne, Sydney, Monash, Queensland, Deakin, Newcastle, La Trobe)—reflecting strong vocational-education research infrastructure. Cluster 1 (Red) and Cluster 6 (Sky Blue) are North American networks, concentrated in

American universities (Washington, Ohio State, Michigan, Columbia) and Canadian universities (Toronto, British Columbia), respectively. Cluster 3 (Navy Blue) centres on European collaboration, anchored by universities in England (UCL, Oxford) and the Netherlands (Utrecht).

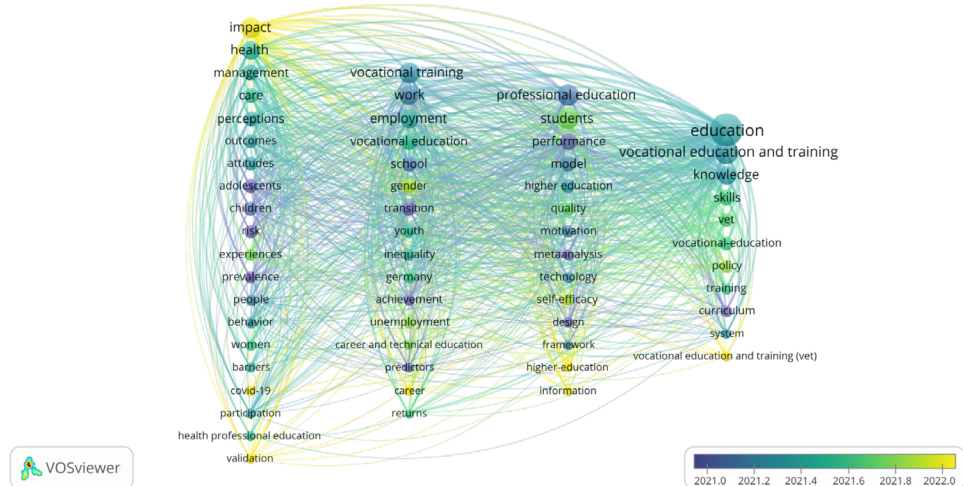
Although the data set included 4,656 institutions, only 52 met the threshold, and 49 formed the connected network. English-speaking countries are overrepresented among the top 10 institutions. This institutional concentration aligns with a core-semiperiphery-periphery structure at the institutional level, in which universities in Anglophone countries occupy a central position in the theoretical and methodological norms of the field. Peripheral institutions tend to draw on the theoretical frameworks and methodological conventions of these central institutions. From the center-periphery lens, this pattern serves as a strategy for gaining visibility and citation impact (Connell, 2007). The voices of the Global South may be marginalized, despite the significant issues these countries face regarding vocational education policy.

In answer to the third research question, the production and dissemination of TVET knowledge across national and institutional borders exhibit a hierarchical concentration. The CPT interprets it as a core-periphery structure, in which knowledge flows are predominantly unidirectional from core to periphery, rather than bidirectional.

4.5. Temporal Evolution: Policy Shocks and Research Trajectories

The temporal overlay visualisation of keyword co-occurrence patterns indicates a marked shift in research priorities after the external policy shocks, suggesting the field's capacity to adapt to external shocks. Based on Figure 7, the nodes colored by the average publication year in the keyword co-occurrence network can be used to identify emerging and stable research themes.

Figure 7: Temporal Overlay Visualisation by Average Publication Year.



4.5.1. COVID-19 as a Research Catalyst

The COVID-19 pandemic (2020–2022) was a paradigm policy shock that stimulated

swift rebalancing of TVET research priorities. Although the COVID-19 pandemic started in late 2019, the keyword “COVID-19” appeared 48 times in our data, indicating a rapid scholarly response. There was a sharp increase in the use of keywords such as online learning, digital pedagogy, remote assessment, and work-integrated learning adaptations in 2020–2022. But keywords denoting digitalization and technology-enhanced learning had already been trending upward before 2020. Although the pandemic condensed years of slow institutional adaptation into months of sudden adaptation (Aristovnik et al., 2023; Mondragon-Estrada et al., 2023), it did not radically change the field’s intellectual structure but cemented previous developments and elevated digital pedagogy to an enduring research focus.

4.5.2. Artificial Intelligence as a Research Catalyst

With the advent of generative artificial intelligence in 2022 (and beyond), the future of work re-entered scholarly discussion in vocational education. The frequency of keywords, including “technology” (58 occurrences), “artificial intelligence” (41 occurrences), “automation” (31 occurrences), “future skills” (7 occurrences), and “reskilling” (11 occurrences), has increased in recent publications.

This theme aligns with broader issues of technological displacement, skill obsolescence, and the changing human-machine relationship. TVET researchers are beginning to address how vocational curricula meet the needs of AI-enhanced workplaces, how teaching practices foster digital literacy, and how institutions support workers’ lifelong learning amid repeated career transitions (Deschênes, Dionne & Parent, 2024; Hong, 2025). The citation distribution of these keywords in post-2022 publications indicates that TVET scholarship is becoming more proactive in foreseeing technological changes (Hew & Xie, 2026).

Both the COVID-19 pandemic and AI acted as external catalysts that accelerated existing tendencies—digitalization and future-oriented skills—without altering the field’s epistemic commitments or introducing new theoretical paradigms. According to PET, neither shock constituted a punctuation event; the field experienced a process of acceleration-without-transformation, revealing that the path dependency was strong enough to absorb even large-scale external shocks without paradigmatic reorientation.

5. Discussion

The results described above outline the knowledge bases, research fronts, collaboration networks, and temporal trajectory in TVET research. The following sections will interpret these results, based on the CPT and PET, to identify the originality of the field (Section 5.1), the theoretical implications of its center-periphery structure and acceleration-without-transformation dynamic (Section 5.2), and the structural gap between theory and practice that the co-citation and keyword analyses have jointly exposed (Section 5.3).

5.1. The Originality of the Study

The 2016–2026 TVET literature reveals several distinctive characteristics that differ from pre-2016 scholarship. First, health professions have emerged as a major research front (Cluster 1 in the keyword co-occurrence network), reflecting the

intersection between vocational education and healthcare workforce development. It is a theme largely absent from the pre-2016 literature that focused on industrial and manufacturing trades. Second, a notable shift toward methodological pluralism is evident: qualitative (Cluster 1, 27.7%) and quantitative (Cluster 2, 21.5%) methodological clusters coexist, a departure from the pre-2016 era of overwhelmingly qualitative, descriptive research. Third, growing attention to the higher education–TVET interface (Cluster 3) signals a shift from studying TVET in isolation to examining its articulation with broader educational systems, whereas pre-2016 research treated vocational and academic tracks as separate. Fourth, while high-income Anglophone countries remain structurally dominant, the number of contributing countries has expanded to 142, and the Global South nations—notably China (9.49%), India, and Brazil—have substantially increased output, an incremental though not yet structural improvement over pre-2016 patterns. These shifts indicate that TVET’s knowledge bases and fronts have evolved beyond their pre-2016 configurations, even as the underlying center-periphery structure of knowledge production remains resistant to fundamental change.

5.2. Theoretical Implications

Our study not only provides paradigms for how CPT and PET interpret the structure and dynamics of TVET research, but also discloses certain limitations of these theories when applied to the knowledge production domain.

As an interpretive lens, CPT helps frame why the publication distribution is highly centralized: the country-level concentration reflects not only disparities in research capacity but also structural asymmetries in knowledge generation, with a small segment of the world accounting for a disproportionate share of the research agenda (Jia, 2026). However, this concentration is not reducible to publication quantity: although China has become a major contributor in terms of paper output (9.49% of the entire production), Anglophone countries remain overrepresented in high-impact journals, which often set theoretical priorities. The co-citation network is consistent with the view that the foundational theories of the field draw predominantly on Western academic traditions (Dayé, 2024). Through the center-periphery lens, this can be read as the field following an intellectual agenda oriented by these countries.

The temporal analysis illustrates how PET functions as a diagnostic lens for knowledge production dynamics. Our findings identify a boundary condition of PET. In TVET research systems, epistemic path dependency is strong enough to resist the fundamental impacts imposed by external shocks, forming a pattern we term “acceleration-without-transformation,” that is, accelerating existing trends rather than producing paradigm shifts.

This pattern of acceleration-without-transformation has important implications. The field’s theoretical and methodological traditions established during equilibrium periods function as self-reinforcing mechanisms that channel the field’s response to shocks along familiar trajectories rather than permitting paradigmatic innovation. TVET scholarship would benefit from developing proactive research agendas that anticipate future disruptions (Bano, 2025; Sanchez-Pastor et al., 2025).

5.3. The Missing Bridge between Theory and Practice

A finding from the co-citation analysis is the structural disconnection between the

methodological and substantive clusters. As shown in the keyword analysis, curriculum development, workplace learning, and assessment have been attended by researchers, but these topics are underrepresented in the substantive/theoretical knowledge bases in the co-citation analysis. The limited integration between methodological (1, 2) and substantive (3, 4, 5) clusters indicates that practitioner perspectives, though abundant in qualitative research, are not fully bridged with the field's theoretical and policy-level discourse (Kart & Şimşek, 2024). This inconsistency signifies a gap between theory articulated in the literature and practices experienced by practitioners.

This gap may explain why TVET research is often criticized for insufficient relevance to practitioners (Peters, 2021). Bridging this gap will require deliberate actions—participatory research methods, practitioner-researcher partnerships, or intermediate knowledge products that translate academic findings into practical outcomes (Bohannon, Farrell & Cook, 2025).

5.4. Limitations

The primary methodological limitation lies in the reliance on a single database. The analysis draws exclusively on the WoSCC. Although WoSCC is a standard source for bibliometric analysis, TVET research is also indexed in Scopus, ERIC, and Dimensions. WoSCC coverage is weighted toward English-language, high-impact journals. Vocational-education practitioner outlets, non-English scholarship, and grey literature are consequently underrepresented, biasing the findings toward Anglophone and institutionally formalized TVET. This coverage bias partly constitutes—rather than merely reflects—the center-periphery concentration documented in Sections 4.3 and 4.4, and future research should cross-validate the present map against Scopus, ERIC, or Dimensions to test the stability of the identified clusters and collaboration structures.

Despite these limitations, the study is designed to support reproduction. The complete search strategy, PRISMA flow data, exclusion criteria with stage-by-stage counts, VOSviewer parameter settings, network quality indicators, and sensitivity analyses are documented in the manuscript and the Supplementary Materials (Appendices A–H). The cleaned dataset and the analysis scripts used to compute the quality indicators and the sensitivity analyses are described in the Data Availability Statement. The single element that resists full reproduction is the interpretive judgement entailed in title and abstract screening, which is inherent to any human-coded bibliometric review.

6. Conclusion

This study provides a methodological bibliometric mapping of TVET research in the post-2015 SDGs era, filling a major gap in the current literature. By analyzing 3,655 articles published in 2016–2026, we summarize that TVET research in the post-2015 SDGs era is marked by five knowledge clusters (qualitative research methodologies, quantitative research methodologies, human capital and skills development, social stratification and inequality, and political economy and institutional analysis); identify four developing research fronts (health professions and workplace learning, labor market transitions and graduate outcomes, higher education-TVET interface, and policy-system-curriculum dynamics); and explore national cooperation patterns (British Commonwealth and Global South, Germanic and Central European, Western European and Mediterranean, Asia-Pacific, Nordic and Northern European) and institutional

cooperation patterns (English-speaking countries overrepresented among the top 10 institutions). These findings reveal a field marked by methodological pluralism alongside theoretical fragmentation, with knowledge production highly centralized in high-income countries.

These findings have implications for researchers, policymakers, and practitioners. For researchers, the knowledge-cluster maps offer a mapping model and potential cross-cluster interaction. For policymakers, the research fronts inform priority-setting and resource allocation. As practitioners, they can gain an overview of current TVET research and take a more proactive stance to bridge research and practice.

Three priorities emerge. First, the field should emphasize theoretical integration, moving beyond the parallel coexistence of knowledge clusters toward cross-fertilization. Second, researchers should attend to national and institutional diversity, strengthening North-South knowledge interchanges. This also calls for structural intervention to counteract the epistemic concentration of current publishing ecosystems. Concrete measures include diversifying the editorial boards of leading TVET journals by recruiting Global South scholars, establishing mentoring and co-authorship programs to pair established researchers with early-career scholars in peripheral institutions, and developing multilingual publication platforms that reduce the Anglophone barrier. Third, digitalization and AI, the two recent research fronts identified in our analysis, need further discussion. Because some promising emerging views did not have enough citations to appear in the citation networks. We suggest complementing the analysis with qualitative content analysis. Continued mapping of the TVET research landscape will demonstrate the discipline's growing reflexivity and capacity to address complex vocational-education issues in the 21st century.

6.1. Funding Statement

The authors did not receive support from any organization for the submitted work.

6.2. Data Availability Statement

The data and materials supporting this study are available as follows. The complete search strategy, PRISMA flow diagram data, full listings of co-cited references, keywords, countries, and institutions, the VOSviewer parameter settings, and the per-cluster quality indicators are provided in the Supplementary Materials (Appendices A–H). The Python scripts used to compute the network quality indicators (modularity Q and silhouette) and to conduct the sensitivity analyses are available from the corresponding author upon reasonable request. The cleaned Web of Science record set (3,655 records) is similarly available from the corresponding author upon reasonable request, subject to the Web of Science terms of use governing the redistribution of downloaded records.

6.3. Conflicts of Interest

The authors declare that they have no competing interest.

6.4. Acknowledgement

Not applicable.

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Supplementary Materials

Intellectual Landscape of Technical and Vocational Education and Training: Knowledge Bases, Fronts, and Global Collaboration

Contents

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Appendix A: Complete Search Strategy

Database

Web of Science Core Collection (WoSCC): Science Citation Index Expanded (SCI-EXPANDED), Social Sciences Citation Index (SSCI), Arts & Humanities Citation Index (A&HCI)

Search Date

February 18, 2026

Search Query

TS=(“technical and vocational education” OR “vocational education and training” OR “VET” OR “TVET” OR “career and technical education” OR “vocational training” OR “professional education”)

Exclusion Criteria

NOT WC=(“Veterinary Sciences”)
NOT SO=(“J VET MED EDUC” OR “VET REC” OR “BMC VET RES” OR “VET PARASITOL”)
NOT TS=(“equine” OR “livestock disease” OR “veterinary” OR “equine influenza” OR “animal health” OR “clinical vet” OR “nurse” OR “nursing” OR “medical”)

Filters Applied

Document Type: Article
Language: English
Timespan: 2016-2026

Results

Initial search: 12,039 records

After document type filter (Article only): 10,236 records

After language and timespan filters: 4,775 records

After manual screening and data cleaning: 3,655 records (final dataset)

Appendix B: PRISMA Flow Diagram Data

Identification Phase

Records identified from Web of Science: 12,039

Records after removing duplicates: 12,039

Screening Phase

Records screened (title/abstract): 4,775

Records excluded: 1,120

- Veterinary sciences: 44
- Higher education governance: 312
- Medical/nursing education: 287
- K-12 education: 234
- Other non-TVET topics: 243

Included Phase

Articles included in bibliometric analysis: 3,655

Appendix C: Complete List of Co-Cited References

The co-citation analysis was conducted with the following parameters:

- Minimum number of citations per cited reference: 19
- Total cited references in dataset: 158,851
- References meeting threshold: 65
- Final network after clustering: 65 documents

Cluster 1 (Red): Qualitative Research Methodologies (18 documents)

Braun & Clarke (2006) - Thematic analysis - 133 citations
Tong et al. (2007) - COREQ checklist - 35 citations
Lave & Wenger (1990) - Situated learning - 32 citations
Miles & Huberman (1994) - Qualitative data analysis - 32 citations
Creswell (2009) - Research design - 26 citations
Patton (2002) - Qualitative evaluation - 26 citations
Hsieh & Shannon (2005) - Content analysis - 23 citations
Colley et al. (2003) - Vocational habitus - 24 citations
Harris et al. (2009) - REDCap - 23 citations
Brockmann et al. (2008) - European qualifications - 22 citations
Schaap et al. (2012) - Vocations and learning - 21 citations
Schon (1982) - Reflective practitioner - 20 citations
Bernstein (2000) - Pedagogy and identity - 19 citations
Billett (2014) - Vocational education standing - 19 citations
Guest et al. (2006) - Data saturation - 19 citations
Ryan & Deci (2000) - Self-determination theory - 19 citations

Cluster 2 (Blue): Quantitative Research Methodologies (14 documents)

Hu & Bentler (1999) - Fit indices - 62 citations
Cohen (1988) - Statistical power analysis - 60 citations
Bandura (1977) - Social learning theory - 37 citations
Hair et al. (1998) - Multivariate data analysis - 37 citations
Fornell & Larcker (1981) - SEM evaluation - 36 citations
Ajzen (1991) - Theory of planned behavior - 31 citations
Bandura (1977) - Self-efficacy - 25 citations
Frenk et al. (2010) - Health professionals - 24 citations
Henseler et al. (2015) - Discriminant validity - 24 citations
Lent et al. (1994) - Social cognitive career theory - 24 citations
Byrne (2010) - SEM with AMOS - 20 citations
Muthen & Muthen (1998) - Mplus user's guide - 20 citations
Podsakoff et al. (2003) - Common method biases - 20 citations
Eccles & Wigfield (2002) - Motivational beliefs - 19 citations

Cluster 3 (Green): Human Capital Theory (15 documents)

Hanushek et al. (2017) - General vs. vocational education - 68 citations
Becker (1964) - Human capital - 31 citations

Becker (1962) - Investment in human capital - 29 citations
 Dougherty (2018) - Career academies - 28 citations
 Ryan (2001) - School-to-work transition - 27 citations
 Angrist & Pischke (2009) - Mostly harmless econometrics - 25 citations
 Rosenbaum & Rubin (1983) - Propensity score - 25 citations
 Eichhorst et al. (2015) - VET in industrialized countries - 24 citations
 Autor et al. (2003) - Skill-biased technical change - 23 citations
 Wolter & Ryan (2011) - VET in international context - 23 citations
 Kemple & Willner (2008) - Career academies long-term - 20 citations
 McKenzie (2017) - Active labor market policies - 20 citations
 Attanasio et al. (2011) - Vocational training Colombia - 19 citations
 Bishop & Mane (2004) - Career-technical education - 19 citations
 Hemelt (2019) - Career and technical education - 19 citations

Cluster 4 (Yellow): Social Stratification (12 documents)

Spence (1973) - Job market signaling - 38 citations
 Protsch & Solga (2016) - German VET stratification - 33 citations
 Allmendinger (1989) - Educational systems - 31 citations
 Breen & Goldthorpe (1997) - Rational action theory - 31 citations
 Breen (2005) - Youth unemployment - 29 citations
 Shavit & Muller (1998) - From school to work - 19 citations
 Shavit & Muller (2000) - Vocational secondary education - 28 citations
 Bol & van de Werfhorst (2013) - Educational systems - 25 citations
 Boudon (1974) - Education and inequality - 25 citations
 Forster & Bol (2016) - Occupational specificity - 22 citations
 Wolbers (2007) - Labour market entry - 21 citations
 Ganzeboom et al. (1992) - Intergenerational stratification - 19 citations

Cluster 5 (Purple): Political Economy (6 documents)

Bussemeyer & Trampusch (2012) - Political economy of skill formation - 54 citations
 Hall & Soskice (2001) - Varieties of capitalism - 41 citations
 McGrath (2012) - VET for development - 29 citations
 Estevez-Abe et al. (2001) - Social protection and skills - 23 citations
 Iversen & Soskice (2008) - Asset theory - 21 citations
 Carstensen (2021) - Institutional change - 20 citations

Appendix D: Complete List of Keywords

The keyword co-occurrence analysis was conducted with the following parameters:

- Minimum number of keyword occurrences: 43
- Total keywords in dataset: 14,982
- Keywords meeting threshold: 61
- Final network after clustering: 61 keywords

Cluster 1 (Red): Health Professions & Workplace Learning (20 keywords)

Impact (188), health (145), management (105), care (100), perceptions (92), outcomes (91), attitudes (87), adolescents (86), children (82), risk (76), experiences (68), women (55), prevalence (61), people (57), behavior (56), barriers (51), COVID-19 (48), participation (48), health professional education (46), validation (46)

Cluster 2 (Green): Labor Market Transitions (16 keywords)

Vocational training (182), work (162), employment (156), vocational education (116), school (101), gender (91), transition (88), youth (67), inequality (66), Germany (60), achievement (57), unemployment (55), career and technical education (47), predictors (47), career (44), returns (43)

Cluster 3 (Blue): Higher Education-TVET Interface (14 keywords)

Professional education (205), students (189), performance (126), model (114), higher education (84), quality (76), motivation (63), meta-analysis (58), technology (58), self-efficacy (55), design (48), framework (47), higher-education (44), information (43)

Cluster 4 (Yellow): Policy-System-Curriculum Dynamics (11 keywords)

Education (450), vocational education and training (229), knowledge (144), skills (112), VET (91), vocational-education (82), policy (77), training (57), curriculum (53), system (50), vocational education and training (VET) (46)

Appendix E: Country-Level Collaboration Data

The country co-authorship analysis was conducted with the following parameters:

- Minimum number of documents per country: 10
- Total countries in dataset: 142
- Countries meeting threshold: 58
- Final network after clustering: 58 countries

Top 20 Countries by Publication Output

1. USA - 878 documents, 12,747 citations
2. Australia - 383 documents, 4,882 citations
3. Germany - 382 documents, 4,833 citations
4. China - 347 documents, 3,562 citations
5. England - 329 documents, 3,986 citations
6. Spain - 210 documents, 2,254 citations
7. Canada - 194 documents, 3,133 citations
8. Switzerland - 185 documents, 2,677 citations
9. Netherlands - 143 documents, 1,754 citations
10. Italy - 120 documents, 1,655 citations
11. France - 95 documents, 1,124 citations
12. Sweden - 91 documents, 960 citations
13. South Africa - 80 documents, 743 citations
14. Norway - 74 documents, 774 citations
15. India - 73 documents, 846 citations
16. Denmark - 67 documents, 822 citations
17. Scotland - 60 documents, 950 citations
18. Belgium - 57 documents, 924 citations
19. Brazil - 57 documents, 542 citations
20. South Korea - 56 documents, 379 citations

Appendix F: Institutional Collaboration Data

The institutional co-authorship analysis was conducted with the following parameters:

- Minimum number of documents per institution: 16
- Total institutions in dataset: 4,656
- Institutions meeting threshold: 52
- Final network after clustering: 49 institutions (largest connected component of the 52 institutions meeting the threshold)

Top 20 Institutions by Publication Output

1. University of Melbourne - 61 documents, 600 citations
2. University of Sydney - 56 documents, 638 citations
3. Monash University - 45 documents, 914 citations
4. University of Toronto - 40 documents, 495 citations
5. University College London - 35 documents, 519 citations
6. University of Queensland - 32 documents, 216 citations
7. University of Bern - 29 documents, 402 citations
8. University of Washington - 29 documents, 375 citations
9. Deakin University - 28 documents, 536 citations
10. Ohio State University - 28 documents, 342 citations
11. University of Granada - 28 documents, 199 citations
12. University of Newcastle - 28 documents, 224 citations
13. La Trobe University - 27 documents, 321 citations
14. University of British Columbia - 25 documents, 414 citations
15. Griffith University - 24 documents, 246 citations
16. University of Michigan - 24 documents, 228 citations
17. University of Oxford - 24 documents, 460 citations
18. Utrecht University - 24 documents, 355 citations
19. Columbia University - 23 documents, 914 citations
20. University of Copenhagen - 23 documents, 229 citations

Appendix G: VOSviewer Parameter Settings

Software Version

VOSviewer version 1.6.19

Co-citation Analysis Parameters

- Type of analysis: Co-citation
- Unit of analysis: Cited references
- Counting method: Full counting
- Minimum number of citations: 19
- Clustering algorithm: smart local moving (SLM) algorithm
- Resolution parameter: 1.0
- Minimum cluster size: 1

Co-occurrence Analysis Parameters

- Type of analysis: Co-occurrence
- Unit of analysis: Author keywords and Keywords Plus
- Counting method: Full counting
- Minimum number of occurrences: 43
- Clustering algorithm: smart local moving (SLM) algorithm
- Resolution parameter: 1.0
- Minimum cluster size: 1

Co-authorship Analysis Parameters

- Type of analysis: Co-authorship
- Unit of analysis: Authors, Organizations, Countries
- Counting method: Full counting
- Minimum number of documents (Authors): 4
- Minimum number of documents (Organizations): 16
- Minimum number of documents (Countries): 10
- Clustering algorithm: smart local moving (SLM) algorithm
- Resolution parameter: 1.0

Visualization Settings

- Scaling: LinLog/modularity
- Attraction: 2
- Repulsion: -1
- Minimum link strength: 0
- Node size: Proportional to citations/occurrences
- Link thickness: Proportional to link strength
- Color scheme: VOSviewer default

Appendix H: Per-Cluster Silhouette Values

Table 9 reports the silhouette value for each cluster within the four bibliometric networks, complementing the network-level indicators reported in Table 1 of the main text. Silhouette values were computed on association-strength-normalised similarity matrices (van Eck & Waltman, 2010) using the cluster assignments produced by VOSviewer's clustering algorithm. Following Fortunato and Barthélemy (2007), modularity $Q > 0.3$ indicates a significant community structure, though modularity optimization is subject to a known resolution limit; following Rousseeuw (1987) and Kaufman and Rousseeuw (1990), silhouette values of 0.71–1.00, 0.51–0.70, and 0.26–0.50 indicate strong, reasonable, and weak within-cluster coherence, respectively, and values of 0.25 or below indicate no substantial structure.

Table 9: Per-Cluster Silhouette Values for the Four TVET Bibliometric Networks.

Network	Cluster	Cluster label	Size (n)	Silhouette
4.1 Document co-citation	1	Qualitative Research Methodologies	18	0.567
4.1 Document co-citation	2	Quantitative Research Methodologies	14	0.722
4.1 Document co-citation	3	Human Capital and Skills Development	15	0.387
4.1 Document co-citation	4	Social Stratification and Inequality	12	0.715
4.1 Document co-citation	5	Political Economy and Institutional Analysis	6	0.847
4.2 Keyword co-occurrence	1	Health Professions and Workplace Learning	20	0.232
4.2 Keyword co-occurrence	2	Labor Market Transitions and Graduate Outcomes	16	0.443
4.2 Keyword co-occurrence	3	Higher Education-TVET Interface	14	0.354
4.2 Keyword co-occurrence	4	Policy-System-Curriculum Dynamics	11	0.326
4.3 Country co-authorship	1	British Commonwealth and Global South	18	0.497
4.3 Country co-authorship	2	Germanic and Central European	14	0.406
4.3 Country co-authorship	3	Western European and Mediterranean	9	0.371
4.3 Country co-authorship	4	Asia-Pacific	9	0.409
4.3 Country co-authorship	5	Nordic and Northern European	8	0.518
4.4 Institutional co-authorship	1	North American (USA-focused)	14	0.748
4.4 Institutional co-authorship	2	Australian	10	0.876
4.4 Institutional co-authorship	3	European	8	0.704
4.4 Institutional co-authorship	4	Health Professions Education	7	0.461
4.4 Institutional co-authorship	5	Swiss and German	6	0.817
4.4 Institutional co-authorship	6	North American (Canada-focused)	4	0.925

Note. Cluster labels follow the main text. For the institutional network, Clusters 4 and 5 are not described in the main text; their labels are assigned based on the composition of the member institutions. The keyword and country networks exhibit weaker overall cluster separation (see Table 1); individual clusters with silhouette values below 0.5 should be interpreted as thematic groupings with limited topological separation.