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Instructional Prototypes in Technology Education: A Bibliometric Mapping of Design and Development Studies

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Abstract

This study conducted a bibliometric mapping of design and development studies on instructional prototypes in technology education, specifically to describe emerging research trends, identify productive and influential contributors, and determine the field's knowledge structures, themes, and collaboration patterns. Using bibliometric analysis, data were retrieved from the Web of Science database covering publications from 1966 to 2026. The dataset consisted of 1,372 documents from 914 sources and was analyzed using Bibliometrix in R and VOSviewer. Findings revealed that research on instructional prototypes has developed into a sustained and expanding field, with increasing scholarly attention in recent years. The publication outlets and citation patterns showed a multidisciplinary orientation involving educational technology, technology and design education, engineering education, medical education, applied training, and professional learning. Productive contributions were concentrated in selected countries, journals, and authors, while collaboration patterns indicated international cooperation, with stronger links among specific country pairs and research networks. The co-citation, keyword co-occurrence, and thematic mapping results showed that the field is anchored in educational technology, instructional design, simulation-based learning, e-learning, skills development, curriculum innovation, and professional training. The study concludes that instructional prototype research is an important and growing area in technology education because it supports research-based, technology-mediated, and competency-oriented instruction. The findings imply the need to strengthen teacher education, TVET, and technology education programs by preparing educators to design, develop, implement, and evaluate context-responsive instructional prototypes and by promoting broader cross-institutional and international collaboration.

Key words: *Instructional Prototypes, Technology Education, Bibliometric Analysis, Design and Development Studies*

Introduction

Technology education has increasingly become a strategic field for preparing learners to design, produce, test, and improve technological solutions for real-world problems. Instructional prototypes are important in this field because they translate abstract technical concepts into usable learning artifacts (Design-Based Research Collective, 2003). The said prototypes may take the form of devices, modules, simulators, laboratory trainers, digital tools, and other instructional systems that support hands-on and skills-based learning (McKenney & Reeves, 2021). In design and development studies, these prototypes are not merely teaching aids but research-based outputs that undergo systematic analysis, design, development, implementation, and evaluation to address authentic instructional needs (Goodyear, 2020). The research-based and practice-oriented nature of instructional prototypes makes them highly relevant to technology education, as learning in this environment is often grounded in performance, experimentation, problem-solving, and the practical application of technological knowledge (Abd Majid, Kasavan & Siron, 2024).

Despite the growing importance of instructional technologies in skills-oriented education, research on instructional prototypes remains dispersed across several areas in educational technology, technical-vocational education and training, design and technology education, engineering education, and digital learning. The dispersion of instructional prototype research across these areas makes it difficult to determine how the field has developed, which journals and countries have contributed most to the literature, and which research themes have shaped the design and development of instructional prototypes in technology education. (Donthu, Kumar, Mukherjee, Pandey & Lim, 2021; Zupic & Čater, 2015). Also, existing bibliometric studies have mapped broader domains such as TVET research, digital technologies in classrooms, and education-related investment. However, these studies do not specifically consolidate the knowledge structure of instructional prototype development in technology education (Alam, Stoica, Sharma & Özgöbek, 2025). Consequently, a focused bibliometric review is necessary to clarify the growth, influence, and thematic direction of design and development studies involving instructional prototypes (Aria & Cuccurullo, 2017).

Bibliometric analysis is a relatively appropriate method for examining this research area because it enables quantitative mapping of publication patterns, citation influence, author productivity, and knowledge structures across a defined body of literature (Donthu et al., 2021). Science mapping techniques, such as co-authorship analysis, keyword co-occurrence analysis, citation analysis, and thematic clustering, reveal research volume and illustrate how ideas, contributors, and institutions connect within a field (van Eck & Waltman, 2010). Recent education-related bibliometric studies published in academic journals demonstrate the value of this approach in identifying publication trends, conceptual patterns, and emerging research directions in educational fields (Filiz, 2025). In this sense, a bibliometric review is suitable for generating a structured overview of instructional prototype research and for supporting future studies in technology education design and development (Li, Sahid & Abd Majid, 2025).

The increasing demand for research-based instructional innovations strengthens the justification for this study, particularly because these innovations support practical learning, technical competence, and technology-mediated instruction. In technology education and TVET contexts, educators and researchers use instructional prototypes to address gaps in equipment availability, laboratory access, learner engagement, simulation-based learning, and competency-based training (Abd Majid et al., 2024; Alam et al., 2025). However, without a bibliometric synthesis, the field lacks a clear evidence-based picture of its most active contributors, influential sources, dominant themes, and collaboration networks (Zupic & Čater, 2015). Mapping these elements remains important because design and development studies produce functional instructional products and contribute reusable knowledge for educators, researchers, and technology developers (McKenney & Reeves, 2021).

Moreover, this study aims to conduct a bibliometric mapping of design and development studies on instructional prototypes in technology education. Specifically, it seeks to describe emerging research trends; identify the most productive and influential contributors; and determine knowledge, thematic, and collaboration structures of the field. This study will generate a comprehensive and accessible knowledge map of instructional prototype research and guide technology education scholars in identifying research gaps, methodological directions, and possible areas for international collaboration (van Eck & Waltman, 2010; Filiz, 2025).

Method

Research Design

This study will employ a bibliometric analysis approach to systematically examine the scientific literature on instructional prototypes in technology education, particularly design and development studies. Bibliometric analysis is well-suited for this study because it enables researchers to quantify publication patterns, assess citation influence, and map the intellectual structure of a research field (Zupic & Čater, 2015). In addition, the design is appropriate for identifying publication trends, productive contributors, influential sources, and citation performance, since bibliometric procedures support performance analysis and science mapping across authors, institutions, countries, journals, and documents (Aria & Cuccurullo, 2017; van Eck & Waltman, 2010).

Data Collection

The data collection procedure was designed to establish a systematic and reproducible bibliometric dataset on instructional prototypes in technology education, with emphasis on design and development studies. Web of Science was used as the primary database because it provides broad scholarly coverage and enables the retrieval of metadata from multiple verified scholarly sources and indexed records, making it suitable for large-scale bibliometric mapping. Seven high-quality

indexes in WoS were included in the search: the Science Citation Index-Expanded (SCI-Expanded); the Social Sciences Citation Index (SSCI); the Conference Proceedings Citation Indexes (CPCI-S & CPCI-SSH), Book Citation Indexes (BKCI-S & BKCI-SSH) and the Emerging Sources Citation Index (ESCI). Consistent with established bibliometric procedures, the search strategy began with the identification of conceptually related keywords that represented the three core dimensions of the study: instructional prototype terminology, technology education context, and design-and-development research orientation (Donthu et al., 2021; Aria & Cuccurullo, 2017).

As presented in Figure 1, the search string was applied to the title, abstract, and author keywords fields to ensure that retrieved documents were directly related to the review's central topic. The first keyword cluster included terms such as instructional technology, educational technology, learning technology, instructional device, instructional tool, learning tool, educational tool, teaching tool, teaching device, educational device, learning device, and prototype. The second cluster delimited the disciplinary context through terms such as technology education, technical education, technical vocational education, technical-vocational education and training, TVET, vocational education, industrial technology, skills education, skills training, technical training, competency-based training, and practical learning. The third cluster focused on methodological orientation by using terms such as design, develop, evaluation, validation, and implementation. This keyword-clustering approach is aligned with bibliometric studies that use structured search terms to capture the conceptual, disciplinary, and methodological boundaries of a field (Kılınç, 2024).

No restriction was imposed on the starting year of publication, allowing the study to capture the historical development and publication trajectory of instructional prototype research up to May 2026. This inclusive time coverage is appropriate for bibliometric inquiry because it enables the identification of long-term publication trends, influential contributors, and emerging thematic directions across time (Donthu et al., 2021). Similarly, no language restriction was applied during the initial search to minimize selection bias and to allow wider representation of studies across countries and publication contexts. This decision is consistent with bibliometric practices in education research, where broad retrieval is often preferred before screening, cleaning, and metadata analysis (Gazali, Alficandra, Perdima, Makorohim, Rahmadani & Bangun, 2023; Sukardi, Sopandi, Riandi & Lestari, 2022).

The document types included in the search were journal articles, proceeding papers, review articles, early access, book chapters, meeting abstract, editorial materials, and retracted publications. Including these document types provided a more comprehensive view of scholarly production because instructional prototype and technology education studies may appear not only in journal publications but also in graduate research outputs, conference literature, and applied reports. This decision strengthens the dataset's coverage, particularly because technical-vocational education and design-and-development studies are often practice-oriented and may be disseminated through varied academic formats. Based on the established search criteria, 1372 documents were identified and prepared for bibliometric analysis.

Figure 1. The Research Process
Source: Web of Science (WoS) Database

Data Analysis

After data retrieval, the bibliographic dataset will be analyzed primarily using bibliometric techniques in R (bibliometrix) and VOSviewer as presented in Figure 1. Bibliometrix is appropriate for this study because it provides an integrated R-based environment for conducting comprehensive science mapping, including descriptive bibliometric analysis, citation analysis, keyword analysis, collaboration analysis, and thematic mapping (Aria & Cuccurullo, 2017). The use of bibliometrix also supports methodological transparency by enabling researchers to systematically process bibliographic metadata and generate reproducible outputs on publication trends, source productivity, author performance, country productivity, and conceptual structure (Donthu et al., 2021).

Likewise, the VOSviewer will be used to construct and visualize bibliometric networks, particularly keyword co-occurrence, co-authorship, institutional collaboration, country collaboration, and citation-related maps. This software is suitable for the present study because it was specifically developed to create, visualize, and explore bibliometric maps from network data in scientific publications (van Eck & Waltman, 2010). Through VOSviewer, the study can identify clusters of related keywords, patterns of collaboration among researchers and institutions, and the strength of relationships among countries contributing to instructional prototype research in technology education (Zupic & Čater, 2015).

On the other hand, Microsoft Excel will be used as a supplementary tool to organize, clean, tabulate, and summarize metadata before and after bibliometric processing. This step is necessary because bibliometric analysis requires accurate and consistent data preparation, including checking for duplicate records, correcting inconsistent author names or keywords, and classifying publication year, document type, source title, subject area, and frequency distributions (Donthu et al., 2021).

Findings

Research Trends on Instructional Prototypes in Technology Education

Knowing the trends in a research field is important because it enables scholars to identify the direction of knowledge development, recognize dominant and emerging themes, and situate their studies within the broader intellectual structure of discipline (Donthu et al., 2021; Zupic & Čater, 2015). In this study, Table 1 presents the descriptive general data of the emerging research trends on instructional prototypes particularly design and development in technology education. The covered publication dataset spanned from 1966 to 2026, indicating that the literature included in the bibliometric analysis represented approximately six decades of scholarly production. The descriptive general data from the included studies indicate that the dataset covers publications from 1966 to 2026. A total of 1,372 documents were retrieved from 914 sources, including journals, books, and other publication outlets. The dataset recorded an annual growth rate of 7.83%, an average document age of 7.79 years, and an average of 5.544 citations per document. The included publications also contained 29,722 references, indicating the volume of cited literature represented in the dataset.

In terms of keyword and authorship indicators, the dataset included 997 Keyword Plus terms and 2,942 author keywords. A total of 5,440 authors contributed to the retrieved documents. Among the included publications, 179 were single-author documents, while the average number of coauthors per document was 4.14. The dataset also recorded an international coauthorship rate of 11.3%. These results provide the general bibliometric profile of the included studies on instructional prototypes in technology education design and development.

Table 1. Descriptive General Data of the Included Studies

General Information about Data	***Results***
Time Span	1966:2026

Sources (Journals, Book, etc)	914
Documents	1372
Annual Growth Rate %	7.83
Average Document Age	7.79
Average Number of Citation per Document	5.544
References	29722
Keyword Plus	997
Author's Keywords	2942
Authors	5440
Single Author Document	179
Coauthors per Document	4.14
International Coauthorships %	11.3

Source: Web of Science (WoS) Database

Having established the general bibliometric profile, the analysis proceeds to the annual publication pattern and citation performance of the included studies as presented in Figure 2. According to said figure, the publication output remained limited and irregular during the earlier years of coverage, with visible increases beginning in the 2000s and a sharper upward trend from 2016 onward. The number of articles reached its highest point in 2025, with 194 publications, before declining in 2026, which may be attributed to the incomplete coverage of the current publication year. In contrast, the mean total citations per article reached its highest level in 1997 at 42.50, indicating that some earlier publications exerted stronger citation influence despite the lower number of documents produced during that period.

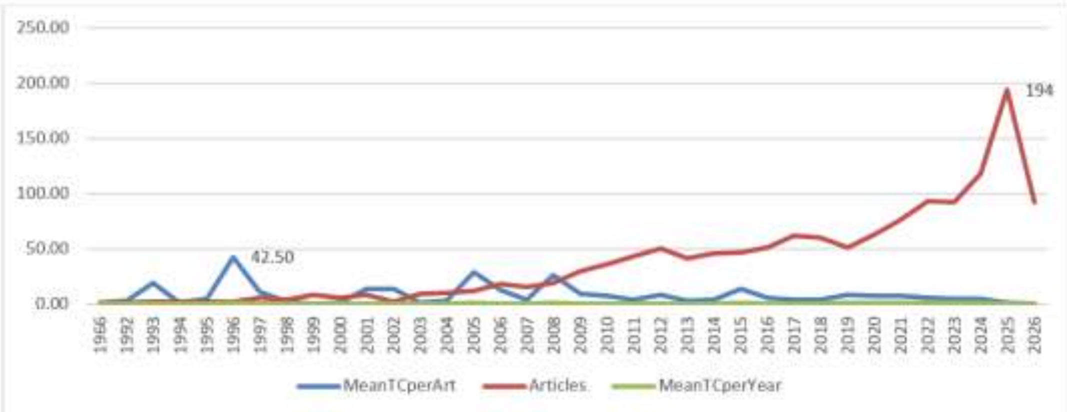

Figure 2. Number of Publications and Average Citation by Year

Source: Web of Science (WoS) Database

Most Productive and Influential Research Contributors

The distribution of publications by the countries of corresponding authors, including classification into single-country publications (SCP) and multiple-country publications (MCP), is presented in Figure 3. The said table shows that the United States recorded the highest number of articles with 170 publications, followed by China with 113, Spain with 58, Germany with 50, and the United Kingdom with 35. These countries were the leading contributors in terms of corresponding author affiliation, indicating that publication output on instructional prototype technology education using design and development researchers was concentrated in highly productive research systems. Other countries with notable contributions included Indonesia (32 articles), Australia (31), Russia (30), Malaysia (27), Canada and Thailand (24 each), India and Turkey (21 each), and the Netherlands (19).

By publication type, most countries reported more single-country than multiple-country publications. The United States produced 153 SCPs and 17 MCPs, while China recorded 104 SCPs and 9 MCPs. Spain had 47 SCPs and 11 MCPs, Germany had 39 SCPs and 11 MCPs, and the United Kingdom had 30 SCPs and 5 MCPs. This pattern indicates that publications from leading countries were largely produced through domestic research collaborations. However, countries such as Spain and Germany showed relatively stronger international collaboration than some others, as reflected in their higher MCP counts. Figure 3 also shows that the United States and China accounted for the highest publication output. In contrast, single-country publications were generally more frequent than multiple-country publications across most contributing countries.

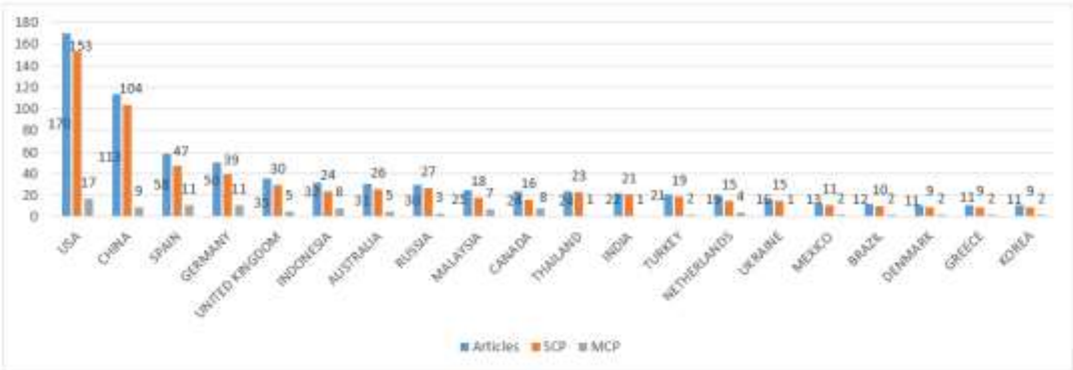

Figure 3. Countries of Influential Research Contributors
Source: Web of Science (WoS) Database

Since instructional prototypes in technology education have been examined across various countries, particularly the United States and China, the retrieved studies were distributed across 914 publication sources. Table 2 presents the 20 leading journals in terms of publication output and citation performance in the field of instructional prototypes in technology education. In terms of publication productivity, Education and Information Technologies and Education Sciences recorded the highest number of publications, with 16 documents each. These were followed by the International Journal of Technology and Design Education (15 publications), BMC Medical Education (14), and the Journal of Applied Behavior

Analysis (12). Other journals and proceedings with notable publication output included the Journal of Technical Education and Training and Surgical Endoscopy and Other Interventional Techniques, each with 10 publications, followed by the International Journal of Engineering Education (9). The results indicate that the publication outlets were distributed across education, technology education, engineering education, medical education, and applied sciences, reflecting the multidisciplinary publication pattern of instructional prototype research.

In terms of citation performance, Computers & Education recorded the highest citation count (336) and h-index (267), followed by Medical Education (228, 180) and Academic Medicine (218, 210). BMC Medical Education also showed strong citation performance, with 213 citations and an h-index of 120, while Medical Teacher obtained 191 citations and an h-index of 156. Although some journals appeared among the most productive sources, only selected journals also ranked highly in citation impact. For instance, Education and Information Technologies ranked among both the most published and most cited journals, with 16 publications and 183 citations. At the same time, Education Sciences and the International Journal of Technology and Design Education also appeared in both categories. Table 2 shows that scholarly production was concentrated in education- and technology-related journals, while journals in educational technology, medical education, and professional training had the highest citation impact.

Table 2. Most Published Journals and Most Cited Journals

MOST PUBLISHED JOURNALS		**MOST CITED JOURNALS**		
Journal Name	***No. of Publications***	***Journal Name***	***Citation Count***	***H-Index***
Education and Information Technologies	16	Computer and Education	336	267
Education Sciences	16	Medical Education	228	180
International Journal of Technology and Design Education	15	Academic Medicine	218	210
BMC Medical Education	14	BMC Medical Education	213	120
Journal of Applied Behavior Analysis	12	Medical Teacher	191	156
Journal of Technical Education and Training	10	Education and Information Technologies	183	121
Surgical Endoscopy and Other Interventional Techniques	10	Sustainability	148	242

International Journal of Engineering Education	9	Patent Education Counseling	130	175
Frontiers in Education	8	British Journal of Educational Technology	124	143
Frontiers in Medicine	8	Journal of Surgical Education	120	84
Journal of Medical Internet Research	8	Computers in Human Behavior	110	302
Frontiers in Psychology	7	Surgical Endoscopy	107	185
Inted2012: International Technology, Education and Development Conference	7	Nurse Education Today	106	123
Medical Education	7	Education Sciences	103	85
9th International Conference on Education and New Learning Technologies (Edulearn17)	6	International Journal of Technology and Design Education	99	67
Computers & Education	6	Interactive Learning Environments	92	93
Edulearn11: 3rd International Conference on Education and New Learning Technologies	6	BMJ - British Medical Journal	91	543
IEEE Transactions on Education	6	Educational Technology Research and Development	91	128
Interactive Learning Environments	6	Frontiers in Psychology	89	241
Nurse Education Today	6	Journal of Medical Internet Research	87	234

Source: Web of Science (WoS) Database

A total of 5,440 authors contributed to the included studies on instructional prototypes in technology education design and development, with an average of 4.14 coauthors per document. Only 179 documents were single-authored, while the 11.3% international coauthorship rate indicates that collaboration was evident but largely concentrated within local or national research contexts. Information on the publication count, h-index, total citations, and first recorded publication year of the 20 most productive authors is given in Table 3.

According to the same table, Banerjee Smita C. recorded the highest number of publications, with 6 documents, followed by Bylund Carma L., with 4 publications. Several authors produced three publications each, including Diefenbach Michael A., Fleisher Linda, Lemos Martin, Lujan-Mora Sergio, and Miller Suzanne M. In terms of h-index, the highest recorded value was 3, observed among Diefenbach Michael A., Fleisher Linda, Lemos Martin, Lujan-Mora Sergio, and Miller Suzanne M. Citation counts varied across authors, with Anderson Donald D. recording the highest total citation count of 73, followed by Diefenbach

Michael A., Fleisher Linda, and Miller Suzanne M. with 66 citations each, and Bylund Carma L. with 63 citations.

Table 3. Impact of Most Prolific Authors

Name of Authors	***No. of Publications***	***h-index***	***Total No. of Citations***	***Year of Publication***
Diefenbach Michael A.	3	3	66	2008
Fleisher Linda	3	3	66	2008
Lemos Martin	3	3	39	2016
Lujan-Mora Sergio	3	3	11	2018
Miller Suzanne M.	3	3	66	2008
Anderson Donald D.	2	2	73	2015
Babich A	2	2	4	2004
Baby Britty	2	2	25	2014
Bailez Maria Marcela	2	2	20	2022
Banerjee Smita C.	6	2	47	2015
Banerjee Subhashis	2	2	25	2014
Belloum Adam	2	2	12	2013
Berger-Estilita Joana	2	2	12	2022
Bernstein David	2	2	12	2013
Bolanos Fernando	2	2	7	2023
Brown Richard	2	2	49	2010
Bylund Carma L.	4	2	63	2010
Corrigan PW	2	2	17	1995
De Laat Cees	2	2	12	2013
De Suvranu	2	2	31	2016

Source: Web of Science (WoS) Database

Figure 4 complements Table 3 by showing the authors' productivity over time, including the temporal distribution of their publications and citation performance. The said figure indicates that author contributions were distributed across different publication periods, with earlier contributions appearing from the late 2000s and more recent outputs extending toward 2025. Authors such as Diefenbach, Michael A., Fleisher, Linda, and Bylund, Carma L. showed earlier publication activity. At the same time, Banerjee Smita C. demonstrated more recent and sustained productivity, consistent with the higher number of publications reported in Table 3. The combined results of Table 3 and Figure 4 show that the field is characterized by a small group of recurrent contributors, with publication productivity and citation impact distributed across both earlier and more recent periods of scholarly output.

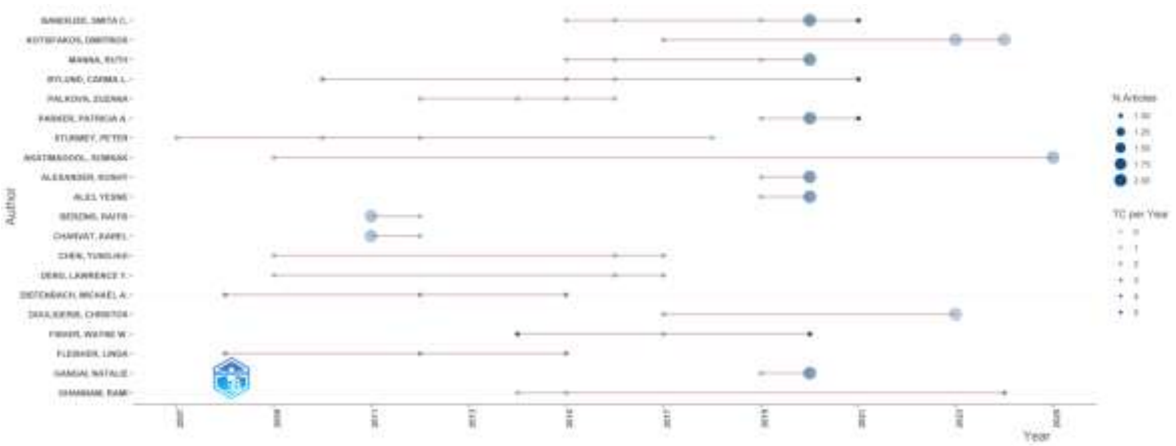

Figure 4. Author's Productivity Over Time
Source: Web of Science (WoS) Database

Furthermore, citation analysis is useful in identifying the influential articles that have shaped the intellectual structure and development of a research field (Kılınç, 2024; Gazali et al., 2023). To determine the most frequently cited studies and their relationships in integrated education research, the 20 most cited articles were analyzed, as presented in Table 4. The results show that Fisher's (2014) article, Preliminary Findings of a Randomized Clinical Trial of a Virtual Training Program for Applied Behavior Analysis Technicians, recorded the highest number of citations, with 58 citations and an annual citation rate of 4.462. The result was followed by Fisher's (2020) article on a virtual training program for teaching applied behavior analysis skills to parents of children with autism spectrum disorder, which received 40 citations and the highest annual citation rate of 5.714 among the listed publications. The article by Banerjee, Bylund, and Parker (2021) on a communication skills training module to reduce lung cancer stigma ranked third, with 33 citations and an annual citation rate of 5.5.

Other highly cited publications included Bylund's (2010) study on a communication skills training module in oncology settings, with 30 citations, and Fleisher and Diefenbach's (2008) study of a web-based provider-patient communication aid, with 29 citations. Several other cited works focused on web-based education programs, multimedia communication modules, communication skills training, vocational education, STEM education, immersive learning, multimedia learning, and laboratory-based learning. The citation counts among the listed studies ranged from 1 to 58, while annual citation rates ranged from 0.167 to 5.714. Table 4 shows that the most cited publications were in virtual training, communication skills training, web-based education, multimedia learning, and technology-supported instructional development.

Table 4. Information on Citation Analysis of Publications on Instructional Prototypes in Technology Education

Name of Author	Title of Published Article	Source	Total No. of Citations	Annual Citation
Fisher, Wayne W. (2014)	Preliminary Findings of a Randomized Clinical Trial of a Virtual Training Program for Applied Behavior Analysis Technicians	Research in Autism Spectrum Disorders, 8(9), 1044-1054.	58	4.462
Fisher, Wayne W. (2020)	A Randomized Clinical Trial of a Virtual-Training Program for Teaching Applied-Behavior- Analysis Skills to Parents of Children with Autism Spectrum Disorder	Journal of Applied Behavior Analysis, 53(4), 1856-1875.	40	5.714
Banerjee, Smita C. Bylund, Carma L. & Parker, Patricia A. (2021)	Responding Empathically to Patients: A Communication Skills Training Module to Reduce Lung Cancer Stigma	Translational Behavioral Medicine, 11(2), 613-618.	33	5.5
Bylund, Carma L. (2010)	Discussing Prognosis in an Oncology Setting: Initial Evaluation of a Communication Skills Training Module	Psycho-Oncology , 19(4), 408-414.	30	1.765
Fleisher, Linda & Diefenbach, Michael A. (2008)	Using Health Communication Best Practices to Develop a Web-Based Provider-Patient Communication Aid:: The Connect™ Study	Patient Education and Counseling , 71(3), 378-387.	29	1.526
Diefenbach, Michael A. Fleisher, Linda (2015)	Development and Preliminary Testing Of Progress: A Web-Based Education Program for Prostate Cancer Survivors Transitioning from Active Treatment	Journal of Cancer Survivorship , 9(3), 541-553.	21	1.75
Fleisher, Linda Diefenbach, Michael A. (2012)	The Development and Preliminary Testing of a Multimedia Patient-Provider Survivorship Communication Module for Breast Cancer Survivors	Patient Education and Counseling , 88(2), 344-349.	16	1.067
Banerjee, Smita C. Manna, Ruth Parker, Patricia A. Alici, Yesne Alexander, Koshy Gangai, Natalie (2020)	Addressing The Quality of Communication with Older Cancer Patients with Cognitive Deficits: Development of a Communication Skills Training Module	Palliative & Supportive Care , 18(4), 419-424.	14	2
Kotsifakos, Dimitrios Douligeris, Christos (2017)	Science, Technology, Engineering and Mathematics (STEM) for Vocational Education In Greece	Proceedings Of 2017 IEEE Global Engineering Education Conference (EDUCON2017, pp. 1831-1836)	5	0.5
Ghannam, Rami (2024)	Immersive Quantum: A Systematic Literature Review Of XR in Quantum Technology Education	Computers & Education: X Reality , 5, 100087.	5	1.667

Chen, Yung-Hui Deng, Lawrence Y. (2017)	Recommendation System Based on Rule-Space Model of Two-Phase Blue-Red Tree and Optimized Learning Path with Multimedia Learning and Cognitive Assessment Evaluation	Multimedia Tools and Applications , 76(18), 18237-18264.	4	0.4
Berzins, Raitis Charvat, Karel (2011)	On How To Build SDI Using Social Networking Principles in the Scope of Spatial Planning and Vocational Education	Computational Science And Its Applications - ICCSA 2011, Pt II, (pp. 78-92).	4	0.25
Ghannam, Rami (2014)	Solar Energy System Design Using Advanced Learning Aids (SOLEDA): An EU Tempus Project	INTED2014: 8th International Technology, Education and Development Conference, pp. 2283-2291	3	0.231
Palkova, Zuzana (2015)	Innovative Learning: From Multimedia to Virtual Worlds	EDULEARN15: 7th International Conference on Education and New Learning Technologies, pp. 1590-1599	2	0.167
Akatimagool, Somsak (2025)	A Blended Laboratory-Based Learning Model for Embedded Systems Education	Journal of Technical Education and Training, , 17(1), 1-13.	1	0.5

Knowledge, Thematic and Collaboration Structures of Instructional Prototypes in Technology Education

This section presents the knowledge, thematic, and social collaboration structures of research on instructional prototypes in technology education, using cocitation analysis, keyword co-occurrence analysis, thematic mapping, author collaboration networks, and country collaboration maps. Cocitation analysis was used to identify the frequently co-cited authors, sources, and documents that shaped the field's intellectual foundation. In contrast, keyword co-occurrence, thematic mapping, and collaboration analyses were used to determine conceptual linkages, thematic orientations, and scholarly cooperation patterns (Aria & Cuccurullo, 2017; Zupic & Čater, 2015). Following the bibliometric approach applied by Kılınç (2024), these analyses provide a comprehensive view of how instructional prototype research in technology education has developed across its knowledge base, conceptual organization, thematic orientation, and collaborative production.

Figure 5 presents the author cocitation network generated through VOSviewer, while Table 5 provides the leading co-cited authors based on citation count and total link strength. The network shows several author clusters, with larger nodes indicating more frequently co-cited authors and lines representing cocitation links among them. Based on Table 5, UNESCO recorded the highest citation count among the listed author entries, with 35 citations and a total link strength of 56, followed by Cook, D. A., with 34 citations and the highest total link strength among the author entries at 94. Other leading co-cited authors included Bandura, A., with 33 citations and 72 total link strength, Venkatesh, V., with 29 citations and 140 total link strength, Braun, V., with 28 citations and 63 total link strength, and Mayer, R. E., with 26 citations and 102 total link strength. Hwang, G. J.; Cohen, J.; Creswell, J. W.; and Vygotsky, L. S. also appeared among the leading author cocitation entries.

In relation to the author cocitation structure, Figure 6 presents the source cocitation network, showing the journals and publication sources that were frequently cited together in the dataset. Table 5 shows that Computers & Education recorded the highest citation count among the co-cited sources, with 336 citations and a total link strength of 4,020. Medical Education followed this with 228 citations and 4,204 total link strength; Academic Medicine with 218 citations and 3,412 total link strength; BMC Medical Education with 213 citations and 4,208 total link strength; and Medical Teacher with 192 citations and 3,778 total link strength. Other highly co-cited sources included Education and Information Technologies, Sustainability, Patient Education and Counseling, British Journal of Educational Technology, and Journal of Surgical Education. The map shows several source clusters, including education- and technology-related sources, medical and health education sources, and surgical or clinical education sources, which appear across different areas of the network.

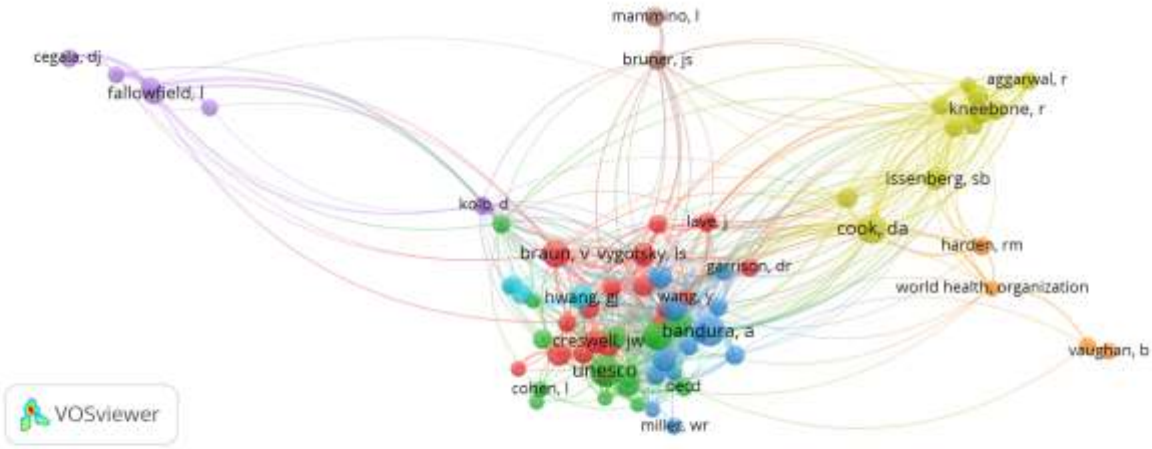

Figure 5. Author Cocitation Network
Source: Web of Science (WoS) Database

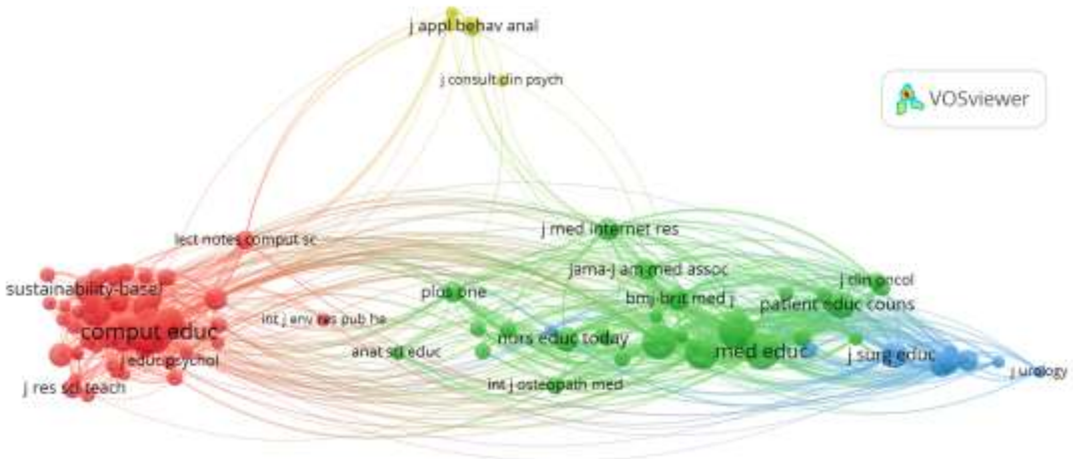

Figure 6. Source Cocitation Network
Source: Web of Science (WoS) Database

Table 5. Leading Co-Cited Authors, Sources, and Documents in Instructional Prototype Research

Cocitation Type	*Cluster*	*Item*	*Citations*	*Total Link Strength*
Author	2	UNESCO	35	56
Author	4	Cook, DA	34	94
Author	3	Bandura, A	33	72
Author	2	Venkatesh, V	29	140
Author	1	Braun, V	28	63
Author	3	Mayer, RE	26	102
Author	6	Hwang, GJ	23	59
Author	2	Cohen, J	22	54
Author	1	Creswell, JW	21	44

Author	1	Vygotsky, LS	21	59
Source	1	Computer and Education	336	4020
Source	2	Medical Education	228	4204
Source	2	Academic Medicine	218	3412
Source	2	BMC Medical Education	213	4208
Source	2	Medical Teacher	192	3778
Source	1	Education and Information Technologies	183	2440
Source	1	Sustainability	148	1701
Source	2	Patent Education Counseling	130	3566
Source	1	British Journal of Educational Technology	124	1866
Source	3	Journal of Surgical Education	120	2766
Document	5	Mishra P, 2006, Teacher College Record	16	33
Document	2	Creswell JW., 2018, Journal Of Investigative Surgery : The Official Journal Of The Academy Of Surgical Research	14	7
Document	1	Seymour NE, 2002, Annals of Surgery	13	39
Document	5	Davis FD, 1989, Management Information Systems Quarterly	12	21
Document	6	Issenberg SB, 2005, Medical Teacher	12	26
Document	1	Martin JA, 1997, British Journal of Educational Technology	12	34
Document	4	Radianti J, 2020, Computer and Education	12	32
Document	7	Venkatesh V, 2003, Management Information Systems Quarterly	12	24
Document	7	Braun V., 2006, Qualitative Research In Psychology	10	6
Document	5	Cohen J., 1988, Statistical Power Analysis For The Behavioral Sciences	10	10

Source: Web of Science (WoS) Database

Extending the source-level cocitation results, Figure 7 presents the document cocitation network of the included studies, while Table 5 identifies the leading co-cited documents. Mishra and Koehler's (2006) publication in Teachers College Record had the highest citation count among the listed documents, with 16 citations and a total link strength of 33. Creswell's (2018) work followed with 14 citations and 7 total link strength, while Seymour et al. (2002) recorded 13 citations and 39 total link strength. Several documents recorded 12 citations, including Davis (1989), Issenberg et al. (2005), Martin et al. (1997), Radianti et al. (2020), and Venkatesh et al. (2003). Braun and Clarke (2006) and Cohen (1988) each recorded 10 citations. The document cocitation map consists of several clusters, with educational technology, qualitative research, medical education, simulation-related studies, and bibliometric or review-related references appearing across the network.

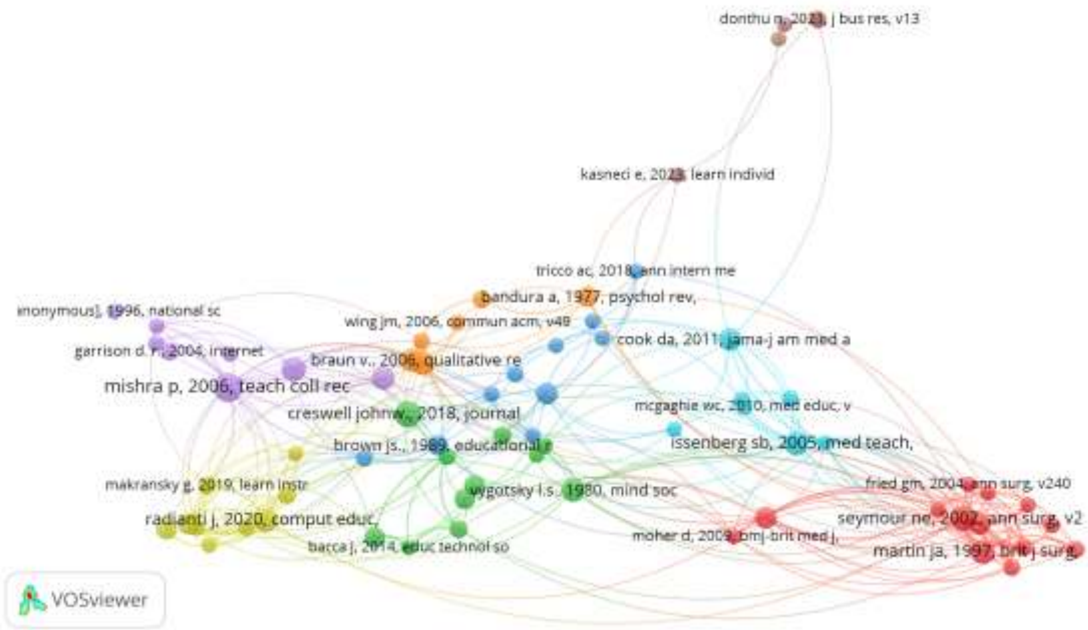

Figure 7. Document Cocitation Network
Source: Web of Science (WoS) Database

Furthermore, the conceptual structure of research on instructional prototypes in technology education was examined through keyword co-occurrence analysis to identify the dominant concepts, thematic linkages, and knowledge patterns within the field. From the 1,372 documents included in the analysis, a total of 2,942 author keywords and 997 Keyword Plus were identified. To generate a more focused and interpretable network, the minimum occurrence threshold was set to 10, yielding 70 keywords that met the inclusion criterion. The co-occurrence network of these frequently used keywords is presented in Figure 8, showing the conceptual associations and clustered themes that characterize the research landscape on instructional prototypes in technology education using design and development approaches.

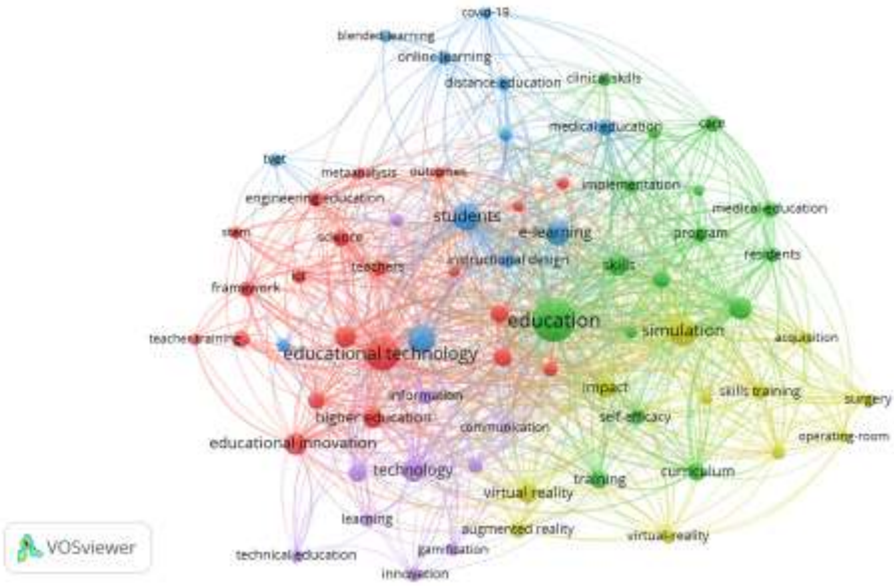

Figure 8. Co-occurrence Network of the Most Frequently Used Keywords
Source: Web of Science (WoS) Database

According to Figure 8, the network consisted of 70 items, five clusters, 877 links, and a total link strength of 1,581. The most visible keywords in the network included education, educational technology, simulation, e-learning, students, technology, training, higher education, instructional design, skills, and curriculum. The size of the nodes indicates the frequency of keyword occurrence, while the lines show co-occurrence relationships among the keywords.

The keyword network shows five color-coded clusters representing groups of terms that frequently appeared together. The red cluster included terms such as educational technology, higher education, educational innovation, framework, STEM, ICT, science, teachers, teacher training, and engineering education. The green cluster included education, simulation, skills, program, implementation, care, medical education, residents, and clinical skills. The blue cluster included students, e-learning, online learning, blended learning, distance education, COVID-19, and TVET. The yellow cluster included training, curriculum, virtual reality, augmented reality, skills training, self-efficacy, operating room, acquisition, and surgery. In contrast, the purple cluster included technology, learning, technical education, innovation, and gamification.

Based on the keyword co-occurrence results, Figure 9 presents a thematic map of instructional prototype research in technology education using keyword centrality and density. The map shows four thematic quadrants: niche themes, motor themes, basic themes, and emerging or declining themes. In the motor themes quadrant, the keyword groups included care, information, and program, as well as simulation, performance, and skills. The basic themes quadrant contained educational technology, students, and vocational education. The niche themes quadrant included teachers, framework, and engineering education, while the emerging or declining themes quadrant included e-learning, instructional design, and clinical skills. The terms education, training, and medical education appeared near the lower central area of the map.

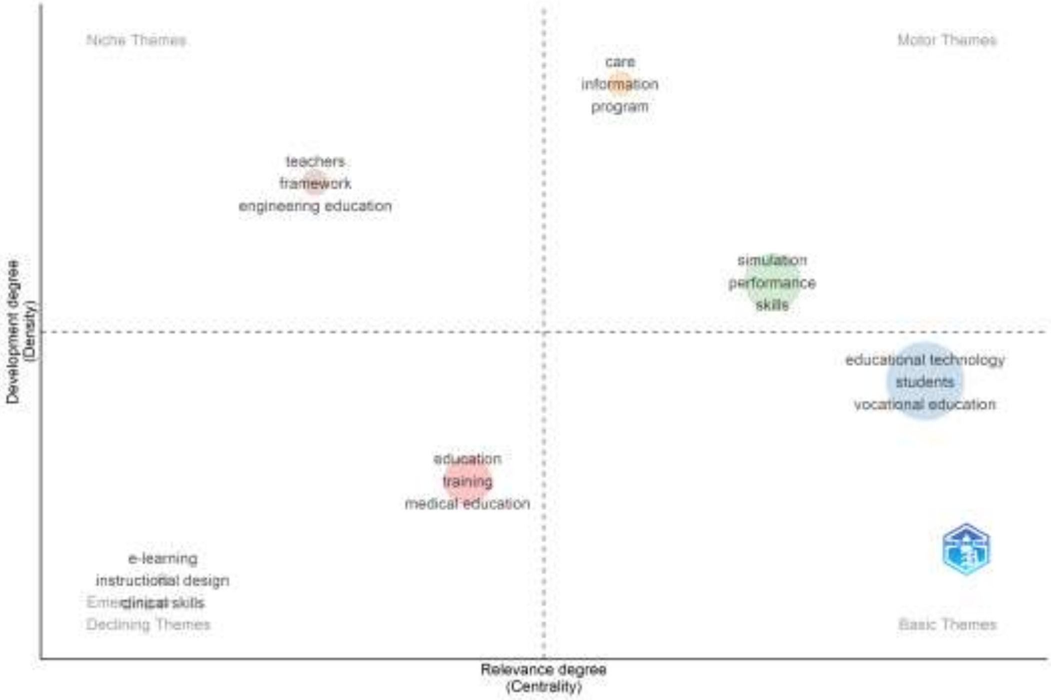

Figure 9. Thematic Map of Keywords
Source: Web of Science (WoS) Database

Moreover, the social structure of research on instructional prototypes in technology education design and development was examined through coauthorship analysis involving authors and countries. Coauthorship analysis was conducted using VOSviewer to map collaboration patterns based on the number of jointly authored publications and the strength of links among contributing authors and countries. For the author-level collaboration network, as presented in Figure 10, the minimum threshold was set to 1 publication per author to identify authors who participated in collaborative research within the dataset. For the country-level collaboration network, as presented in Figure 11, the minimum threshold was set to 1 coauthored publication per country to identify countries involved in the production of coauthored publications. The resulting maps show the structure of scholarly cooperation in the field, where node size represents publication productivity, links indicate collaborative relationships, and total link strength reflects the extent of collaboration among authors and countries.

According to Figure 10, the network consisted of 39 items, 5 clusters, 189 links, and a total link strength of 282. The largest and most visible nodes in the network included Banerjee, Smita C.; Bylund, Carma L.; Manna, Ruth; Parker, Patricia A.; Shen, Megan Johnson; Gangai, Natalie; Alexander, Koshy; Shen, Megan J.; Brown, Richard; and Kissane, David. The author collaboration map showed five color-coded clusters, with the central portion of the network composed mainly of authors such as Banerjee, Smita C.; Bylund, Carma L.; Manna, Ruth; Parker, Patricia A.; Shen, Megan Johnson; and Krueger, Carol A. A separate cluster appeared on the right side of the map, including Kissane, David; Brown, Richard; Bylund, Carma; McLarney, Kara; Matasar, Matt; and Horwitz, Steven. The links among the authors indicate coauthored publications, while the larger node sizes reflect authors with stronger collaborative presence in the network.

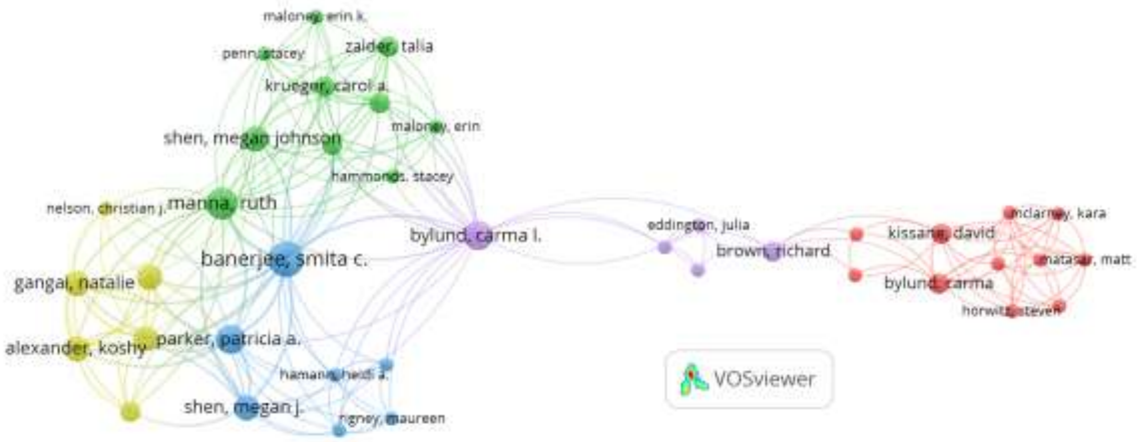

Figure 10. Co-Operation Between Authors
Source: Web of Science (WoS) Database

Consequently, Figure 11 shows the distribution of international coauthorship among countries contributing to research on instructional prototypes in technology education. The United States, China, the United Kingdom, Germany, France, Spain, Italy, Canada, Australia, Japan, South Korea, and India appeared among the more visible contributors in the network. Several European countries formed a dense network of collaboration, while the United States maintained multiple links with countries in North America, Europe, Asia, and Oceania. Based on the collaboration frequency data, the strongest country partnership was between the United States and Canada, with 7 articles, followed by Spain and Ecuador, with 6. Other notable collaboration pairs included China and Malaysia, Germany and Switzerland, the United States and China, and the United States and Germany, each with 5 articles.

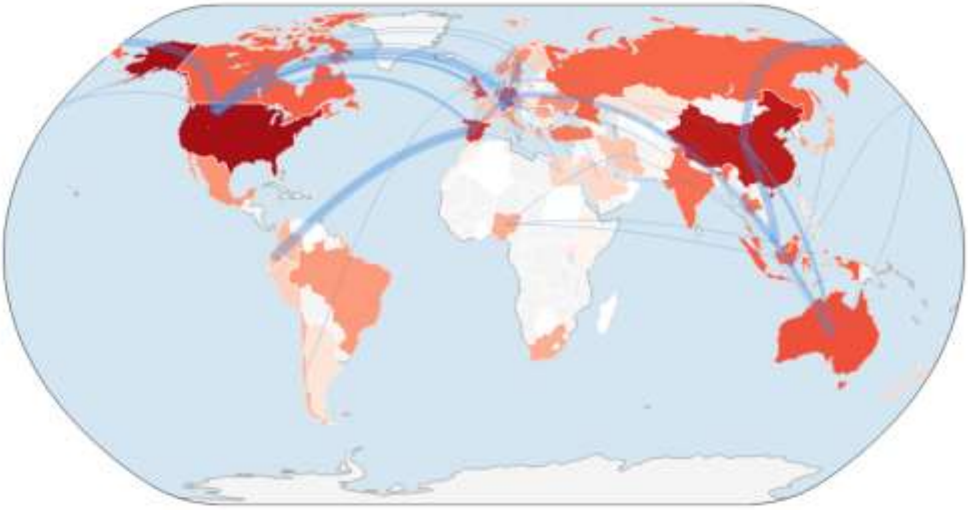

Figure 11. Co-Operation Between Countries
Source: Web of Science (WoS) Database

Discussion

This study aims to conduct a bibliometric mapping of design and development studies on instructional prototypes in technology education using the design and development research process. The bibliometric profile of instructional prototype research in technology education shows a sustained and expanding field, as evidenced by 1,372 documents published across 914 sources from 1966 to 2026. The annual growth rate of 7.83% indicates increasing scholarly attention to instructional prototypes, design-and-development studies, instructional technology, and skills-based learning. Publication growth is commonly used in bibliometric studies to describe the development, visibility, and expansion of a research field over time (Kılınç, 2024; Sukardi et al., 2022). The sharp increase in publications after 2016 suggests that instructional prototype research has become more visible in recent years. However, the decline in 2026 should be interpreted cautiously, as the year may still reflect incomplete indexing.

The results also show that the field is multidisciplinary in terms of publication outlets and citation influence. Productive journals such as Education and Information Technologies, Education Sciences, and the International Journal of Technology and Design Education reflect the field's strong educational and technological orientation. Meanwhile, highly cited sources such as Computers & Education, Medical Education, Academic Medicine, and BMC Medical

Education show that the field also intersects with health professions education, simulation, applied training, and professional learning. Bibliometric studies commonly use source productivity and citation performance to identify disciplinary concentration, research visibility, and publication influence within a field (Gazali et al., 2023; Nurhayati et al., 2024). This result suggests that design-and-development studies on instructional prototypes are distributed across educational technology, medical education, engineering education, technical education, and applied sciences.

At the country level, publication output was concentrated in highly productive research systems, particularly the United States and China, followed by Spain, Germany, the United Kingdom, Indonesia, Australia, Russia, Malaysia, Canada, and Thailand. Country productivity and collaboration indicators are commonly used in bibliometric studies to determine the geographical distribution and social structure of a research field (Kılınç, 2024; Nopiyadi et al., 2025). Although international collaboration was evident, the predominance of single-country publications over multi-country publications suggests that many studies were conducted within national or institutional research contexts. Similar patterns have been observed in bibliometric studies where international collaboration exists but remains uneven across countries, institutions, and regions (Maral & Özdemir, 2022; Rodliyah et al., 2025). In the present study, the strongest country collaboration pairs, including the United States–Canada, Spain–Ecuador, China–Malaysia, Germany–Switzerland, United States–China, and United States–Germany, show that international cooperation was concentrated among selected country pairs.

The authorship results revealed a broad authorship base, with 5,440 authors, an average of 4.14 coauthors per document, and only 179 single-author documents. These findings indicate that instructional prototype research is generally collaborative, particularly because design-and-development studies often require expertise in instructional design, content specialization, technology development, validation, implementation, and evaluation. Coauthorship indicators are often used in bibliometric studies to describe collaboration patterns and the social organization of research production (Kılınç, 2024; Maral & Özdemir, 2022). The results also show that productivity and influence are not always identical, as some authors recorded higher publication counts while others demonstrated stronger citation performance. This distinction is consistent with bibliometric practice, in which publication count reflects productivity, while citations, the h-index, and total link strength reflect different dimensions of scholarly influence (Gazali et al., 2023; Ng & de Guzman, 2017).

Furthermore, the intellectual structure of the field, as shown through cocitation analysis, indicates that instructional prototype research draws from several knowledge bases. Cocitation analysis is useful for identifying the intellectual foundations and relationships among frequently cited authors, sources, and documents in a research field (Zupic & Čater, 2015). The co-cited authors, sources, and documents in this study were associated with educational technology, learning theories, qualitative research, instructional design, medical education, simulation, technology acceptance, and bibliometric methodology. The presence of Bandura, Vygotsky, Mayer, Braun, Creswell, Cook, Venkatesh, and UNESCO in the author cocitation network suggests that the field is anchored in both educational theory and applied research traditions. Similarly, the source cocitation results, which included Computers & Education, Medical Education, BMC Medical Education, Medical Teacher, and Education and Information Technologies, indicate that instructional prototype research is intellectually positioned at the intersection of education, technology, and professional training.

In addition, the conceptual and thematic structures of the field of interest also reveal a broad yet connected research landscape. Keyword co-occurrence and thematic mapping are commonly used in bibliometric research to identify dominant concepts, conceptual linkages, and thematic orientations within a field (Aria & Cuccurullo, 2017; Rodliyah et al., 2025). In the present study, the keyword co-occurrence network included 70 keywords, five clusters, 877 links, and a total link strength of 1,581. The most visible terms, including education, educational technology, simulation, e-learning, students, technology, training, instructional design, skills, and curriculum, indicate that instructional prototype research is strongly associated with technology-supported teaching, skills development, simulation-based learning, and instructional innovation. The thematic map further classified the field into motor, basic, niche, and emerging or declining themes. The appearance of educational technology, students, and vocational education as basic themes, and of simulation, performance, and skills as motor themes, reveals the field's conceptual organization.

Moreover, the social structure, particularly the country collaboration results, indicates that instructional prototype research in technology education is organized around a small number of highly visible research-producing countries. These countries are the United States, China, Canada, Germany, and others with a stronger international publication presence. The strongest collaboration pair, the United States–Canada, followed by Spain–Ecuador, China–Malaysia, Germany–Switzerland, United States–China, and United States–Germany, suggests that both regional and cross-regional coauthorship patterns shape the field. This pattern is consistent with other bibliometric studies that used coauthorship and cocitation analyses to examine the intellectual, conceptual, and social structure of the field (Kılınç, 2024). Similarly, countries such as the USA, UK, China, Australia, Canada, and Brazil were considered prominent contributors in country-cooperation analyses.

Additionally, the concentration of stronger collaboration links among North America, Europe, and selected Asia-Pacific countries suggests that international cooperation in instructional prototype research is present but unevenly distributed across regions. This result aligns with bibliometric studies in education that use collaboration mapping to show how publication output, thematic structures, and cross-country research participation vary across national and institutional contexts (Nopiyadi et. al., 2025). Similarly, Rodliyah et al. (2025) emphasized that bibliometric data can reveal publication patterns, collaboration trends, and emerging research clusters, which supports the interpretation that country cooperation maps are useful for identifying both dominant collaboration routes and less connected areas within a research field.

Lastly, the findings address the study objectives by describing the growth of instructional prototype research, identifying productive and influential contributors, and mapping the knowledge, thematic, and collaboration structures of the field. A major strength of the study is its use of multiple bibliometric techniques, including performance analysis, cocitation analysis, keyword co-occurrence, thematic mapping, author collaboration, and country collaboration. However, the results should be interpreted within the limits of the Web of Science dataset and the search terms used in the study. Bibliometric findings may vary when other databases, such as Scopus, Lens.org, or Google Scholar, are used because each database differs in coverage, indexing practices, and citation data.

Conclusion

The research on instructional prototypes in technology education has developed into a sustained and expanding scholarly field. The publication pattern suggests that instructional prototype studies have gained increasing attention as educational institutions, technical-vocational systems, and professional training environments respond to the demand for research-based, technology-supported, and skills-oriented learning tools. The growth of this literature reflects the continuing relevance of design and development studies in producing instructional devices, digital tools, simulators, modules, and other learning systems that support practical learning, competency development, and technology-mediated instruction. Thus, the field is an important area of inquiry within technology education because it connects instructional innovation with authentic learning needs and performance-based educational contexts.

Also, the current study is shaped by a multidisciplinary and internationally distributed body of contributors. Productive and influential contributions came from journals, authors, and countries representing educational technology, technology and design education, engineering education, medical education, applied training, and professional learning. This indicates that instructional prototype research is not confined to a single discipline but is supported by different academic and professional communities that share an interest in improving instruction through designed, tested, and evaluated learning innovations. However, the collaboration patterns further suggest that while scholarly cooperation is present, much of the research remains concentrated within specific countries, institutions, and selected international partnerships. This highlights the need for stronger cross-country and cross-institutional collaboration, especially among technology education and TVET researchers in emerging research contexts.

Consequently, the knowledge, thematic, and collaboration structures reveal that instructional prototype research is anchored in educational technology, instructional design, simulation-based learning, skills development, e-learning, curriculum innovation, and professional training. The co-citation and keyword patterns show that the field draws from established theories and methods in learning, technology acceptance, qualitative inquiry, medical and technical education, and design-based research. The identified themes suggest that future studies further strengthen the field by focusing on emerging technologies, learner-centered prototype evaluation, competency-based applications, and broader collaboration across education, industry, and international research networks.

Furthermore, this study implies that teacher education programs should strengthen the preparation of pre-service and in-service teachers in designing, developing, implementing, and evaluating context-responsive learning tools, simulations, modules, digital resources, and laboratory-based instructional materials. Since simulation, performance, skills, and training emerged as central themes, teachers should be equipped to apply competency-based, hands-on, and performance-oriented approaches, particularly in technology education and TVET contexts. In classroom teaching, instructional prototypes and emerging technologies such as e-learning, blended learning, virtual reality, augmented reality, and gamification support active, practical, flexible, and learner-centered instruction when guided by sound instructional design principles.

Limitation and Recommendation

The significance of this research lies in its ability to provide a clear, data-driven visualization of the field's evolution, offering a valuable framework for understanding how technology-supported instructional prototypes facilitate modern skills-based learning. However, the scope of the study is limited by its reliance on the Web of Science database and the specific search terms used to retrieve bibliometric records; thus, some relevant studies indexed in other databases, such as Scopus, Lens.org, Google Scholar, ERIC, or institutional repositories, may not have been included. In addition, the bibliometric results may be affected by database coverage, indexing practices, citation delays, variations in author names, inconsistent keywords, and incomplete indexing of recent publications, particularly those published this year. Relatively, future researchers are therefore encouraged to expand database coverage, refine search strategies, compare results across multiple databases, and conduct complementary systematic reviews or meta-analyses to examine the pedagogical effectiveness of instructional prototypes. Further studies may also explore underrepresented countries, emerging technologies, teacher education applications, TVET contexts, and stronger international collaboration to deepen the understanding and practical use of instructional prototypes in technology education.

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