Research Status and Trends in Composite Instructional Design Integrated with Technology: A Bibliometric Analysis

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Abstract

With the change in learning styles, especially in a variety of instructional environments supported by technologies and tools, instructional design should be adjusted to support different patterns of teaching and learning. Instructional design with technology support includes instructional design activities supported with artificial intelligence technology and blended instructional design. Therefore, it is necessary to conduct a normative summary of the research process of various types of instructional design to explore the development trends of instructional design in the composite instructional environment. This study aimed to analyze published articles from 2012 to 2024 by Biblioshiny and to explore the research status and development trends of composite instructional design (CID). A total of 877 academic papers in the Web of Science (WoS) database were retrieved, and annual output analysis, the most productive journals, countries, and universities analyses, co-authorship analysis, keyword co-occurring analysis, document co-citation analysis, and topic development trends analysis were conducted. The research status of CID included the following aspects: (1) The annual output of articles increased year by year, but the average citations per year of articles decreased year by year. (2) Complex instructional environments represent the latest progress of CID. (3) Three influential co-citation clusters were formed. The new trends of CID were summarized from the following aspects: (1) There has been a gradual shift from traditional classrooms to complex instructional environments that rely on technology. (2) The research value of classroom interaction supported by technology has become increasingly prominent. (3) Joint development with emerging technologies is the key to CID.

Keywords: Composite instructional design, Instructional environment, Bibliometric analysis, Scientific visualization, Biblioshiny

1 Introduction

Effective instructional plans can act as intermediaries to link instructional strategy with the instructional environment [1] and accelerate the formation of excellent instruction [2]. The concept of instructional design can be traced back to Principles of Instructional Design [3]. Instructional design is a comprehensive interdisciplinary subject that connects instructional theory and practice. It is a specific process of implementing instructional theory in instructional content and instructional activities with a systematic approach [4-5]. Instructional design is also an open process, that applies, evaluates, and deduces instructional practices in a specific instructional environment [6], assists students in using resources in the instructional environment for learning, and helps standardize teachers' teaching and improve students' academic performance [7]. With the development of the integration of technology and education, instructional places are constantly changing, and the content of instructional design is getting richer, so the instructional process is becoming more complex [8]. When adopting new technologies for teaching, it is most important to consider instructional objectives and classroom instruction needs [9]. The researcher of reference [10] believed that instructional design also needed to be continuously integrated with new instructional environments, which can form an effective instructional model. If we take instructional design and the instructional environment as a whole, the instructional process changes according to the changes in the environment.

The development of technology has continuously promoted educational reform, and the connection between instructional design and technology has become increasingly close [11]. When technology was introduced into instructional design, some researchers began to explore the new instructional process, including how to integrate technology into the instructional environment and how to carry out the instructional process [6, 10]. The change in the instructional environment supported by technology promotes the sustainable development of instructional design and forms a variety of instructional modes with different instructional environments. The instructional environments above form the composite instructional environments that support the instructional design. For example, an online instruction environment is supported by online instructional platforms such as MOOCs [12], a blended instructional environment combines online and offline instruction [13], the maker instructional environment is supported by artificial

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intelligence [14-15], and the theory-driven gamification goal, access, feedback, challenge, collaboration design (GAFCC) model is a gamified instructional design model by artificial intelligence educational robot [16]. Teachers' and students' attitudes toward instructional design based on different instructional environments will further affect the process of instructional design, such as online instruction [17-18]. Therefore, the integration of technology provided a new view of CID. Many studies have implied the technologies in designing CID based on fully considering the subject and object of education, instructional environment, instructional content, instructional process, and other factors. However, not too much research has been done comprehensive perspective on the related research status and trends in this field up to now, which limited the development in the future. Thus, this study tends to make a summary of the literature on CID integrated with technology.

Combining the development status of CID in the form of a visual map helps explore the sub-dimensions with high development potential and to predict the development trends of CID, which can assist researchers grasp the problems existing in intelligent instructional design, promote education reform in the new era, and cultivate talents in the new era. A bibliometric analysis of the articles on CID-related topics in the Web of Science (WoS) database was conducted using Biblioshiny in this study. The 2nd International STEM in Education Conference in 2012 emphasized the core position of science and technology in STEM education and applied science and technology to innovate teaching models to improve classroom teaching effects. Therefore, annual output analysis, the most productive journals, countries, and universities analyses, co-authorship analysis, keyword co-occurring analysis, document co-citation analysis, and topic development trends analysis from 2012 to 2024 were displayed in the form of a visual map to explore valuable research fields and predict the future development trends of CID in detail and intuitively. Thus, the following questions were proposed.

RQ1. What is the research status of CID according to the analysis of citation articles, authors, and journals?

RQ2. What are the future research trends of CID?

2 Methodology

Bibliometric analysis was used as the data analysis method in this study. Bibliometric analysis is a quantitative analysis method combined with a systematic literature review to analyze topics and references and to realize data and visual analysis of existing articles [19-20]. With the progress of technology and the development of data visualization, there is a growing number of articles related to CID [21]. Bibliometric analysis has been needed and accepted by a growing number of researchers to explore the research status and development trends of related topics [22-23].

2.1 Analysis Tool

Biblioshiny was the bibliometric tool used in this study. Biblioshiny is a unique RStudio open-source tool developed by the authors of reference [24] that supports recommended workflows for bibliometric analysis. Based on the flexibility, freedom, and integration of Biblioshiny and the ability to quickly upgrade its R package integration features, it is efficient and practical for the scientific mapping of topics such as journals, countries, authors, citations, and so on. Most importantly, Biblioshiny allows visualization of documents, authors, and sources to provide more intuitive data by coupled cluster analysis.

2.2 Data Collection

The WoS database includes SSCI, SCI, A&HCI, ESCI, and other types of literature, with high-quality publications in various professional fields [25-26]. Therefore, this study searched the relevant literature in the WoS database on April 2, 2024. Literature retrieval and screening were conducted as the following steps. First of all, the search was conducted in the WoS according to the keywords "technolog*" And "instructional design" OR "teaching design," and a total of 1,924 articles were obtained. After that, based on excluding non-empirical articles such as reviews and books, the remaining 1038 empirical research articles were collected. Following the specification of "Article" as the designated literature type and the temporal range of "2012 to 2024," a manual review was conducted to eliminate redundant or irrelevant literature. Consequently, a total of 856 articles were ultimately retained. The detailed retrieval and screening methodology is illustrated in Figure 1.

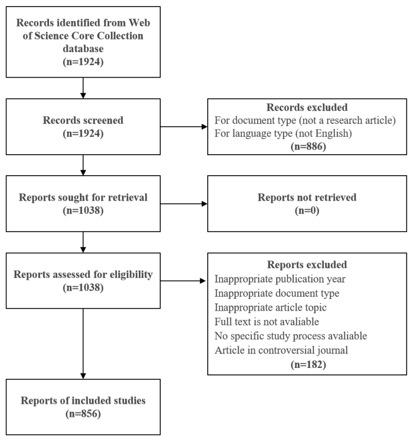

Figure 1. Flowchart of the bibliometric methodology

2.3 Data Processing

Visualization analysis using Biblioshiny can be broken down into the following processes. Firstly, the plain text data exported by WoS was uploaded to Biblioshiny. Secondly, based on the filtering criteria, the type of literature was selected as "articles" in "Filters" and the time range was set as "2012-2024." After that, in "Overview," "Sources," "Authors," "Documents," "Clustering," "Conceptual Structure" and "Intellectual Structure," the literature selected was screened out for visualization analysis. For example, yield analysis of relevant topic articles, analysis of the most productive journals, countries, and universities, co-authorship analysis, keyword co-occurring analysis, document co-citation analysis, and topics trends analysis [27-28]. Document co-citation analysis is any two articles cited together in the same article [29-30] that can better explain the links between the sub-fields and tap the development potential of this field [31]. The emerging fields and valuable research directions of CID can also be judged by the keywords that appear more frequently.

3 Bibliometric Analyses and Results

In this study, the following data analysis was conducted. The visualization research results of CID from 2012 to 2024 are presented in the form of figures and tables.

3.1 Analysis of Research Status

3.1.1 Analysis of the Annual Output of Articles and the Article Output of Journals, Countries, and Universities

The examination of the annual publish provides valuable insights into the overarching trends within the development of this research domain [32]. As shown in Figure 2, the annual output of articles related to CID in the WoS database steadily increased during 2012-2024. During 2018-2019 and 2021-2023, the annual output of articles increased rapidly, indicating that more scholars paid attention to CID and related topics. The development of MOOCs has also constantly spurred the development of online teaching [33], and further pushed the development of blended teaching [34]. The reference [35] suggested using artificial intelligence to develop instructional design tools. It can be seen that a growing number of scholars have realized the importance of using technology to develop instructional design. More recently, with the increasing integration trend of technology in instructional design, scholars have become increasingly concerned about the linkage between technology and teaching content. Related researches tend to promote the thinking process in the design process. Consequently, research on CID has garnered increased attention, indicating a significant trend of development.

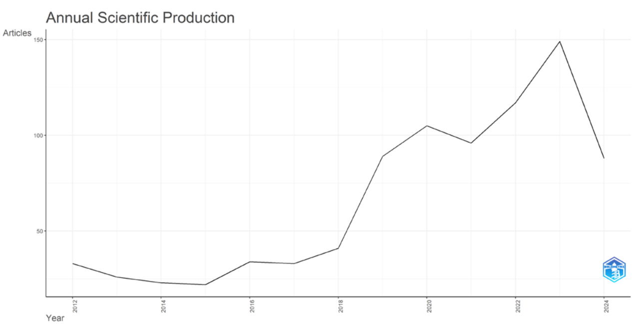

Figure 2. The number of annual productions on CID research in WOS (2012-2024)

Although the annual output of articles in the WoS database was increasing year by year, the average annual citation was decreasing year by year (see Figure 3). The number of cited articles in 2014 was the highest (MeanTCperYear = 6.13), while that in 2024 was the lowest (MeanTCperYear = 0.45).

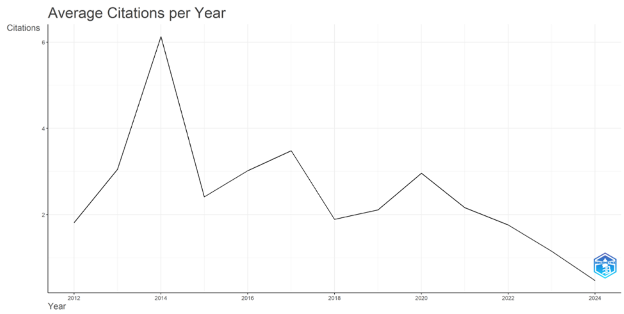

Figure 3. Average citations per year of articles on CID research in WOS (2012-2024)

The examination of the literature serves not only to identify reputable sources of high-quality research within this domain but also to offer essential guidance for scholars seeking to disseminate their findings. Thus, this study showed the output of articles in journals first. Table 1 showed the top 10 journals with the highest articles output in the WoS database. Among them, *ETR&D-Educational Technology Research and Development* published the most articles related to CID, with a total of 57 articles. This was followed by *TechTrends* and *Computers & Education* with 45 and 33 documents respectively. This study also showed the trend of annual production of the top five journals with the highest output (see Figure 4). The average annual output of the five journals showed an overall rising trend. Among them, the journal with the highest average annual output was *ETR&D-Educational Technology Research and Development*. Before 2020, the journal with the second-highest average annual output was the *Computers & Education*. After 2022, the journal with the second-highest average annual output was *TechTrends*. This indicated that after 2022, the journal *TechTrends* paid more attention to CID and added a section on instructional design research.

Secondly, this study analyzed the productivity of countries to reveal patterns in their publication tendencies. Figure 5 visually highlights the distribution of countries researching CID. Table 2 shows the top 10 countries with the highest article production in the WoS database from 2012-2024. Among them, the United States published the most CID-related articles, with a total of 260 articles. China and Australia followed with 174 and 38 articles respectively. At the same time, the country with the highest output of article citations was the United States, with a total citation of 4,096. It was followed by China and Australia, with 1,705 and 815 citations respectively. This study showed trends in annual production in the top five countries with the highest production (see Figure 6). The average annual output of the five countries showed an overall rising trend. Among them, the average annual output of America was far ahead. Figure 7 and Figure 8 showed the cooperation of countries around the world in the form of nodes and a World Map. From 2012 to 2024, China and the United States had the closest cooperative relationship in CID research.

Table 1. The top 10 most productive journals (2012-2024)

The name of the journals	The number of published papers
ETR&D-Educational Technology Research and Development	57
Techtrends	45
Computers & Education	33
International Journal of Emerging Technologies in Learning	33
Education and Information Technologies	31
British Journal of Educational Technology	29
Interactive Learning Environments	18
Journal of Computing in Higher Education	18
International Journal of Engineering Education	17
Journal of Computer Assisted Learning	17

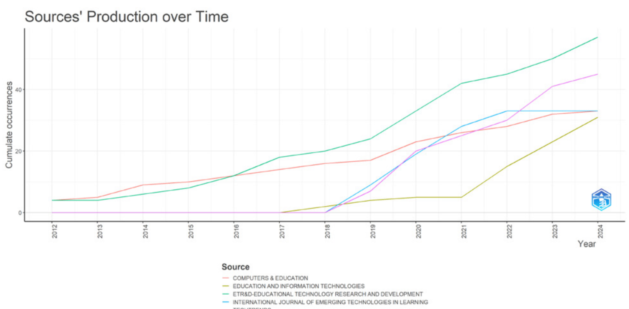

Figure 4. The trends in the annual production of the top five journals (2012-2024)

Table 2. The top 10 countries with the highest production and the highest number of citations (2012-2024)

Country	The number of published papers	Country	Total citations
USA	260	USA	4096
China	174	China	1702
Australia	38	Australia	815
Turkey	35	Turkey	446
Spain	31	Germany	366
UK	24	Netherlands	361
Canada	16	United Kingdom	318
Netherlands	16	Canada	281
Germany	15	Korea	210
Malaysia	15	Israel	206

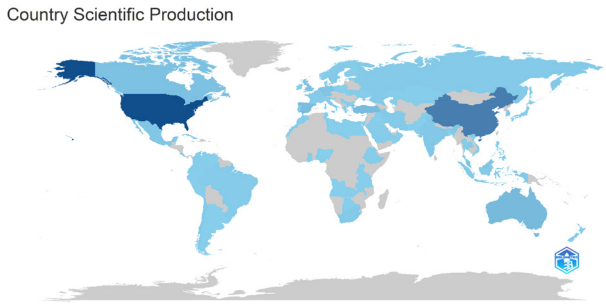

Figure 5. Map of the distribution of countries with higher yields (2012-2024)

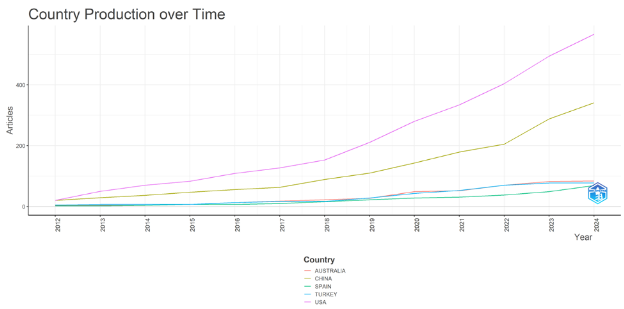

Figure 6. The trends in the annual production of the top five countries (2012-2024)

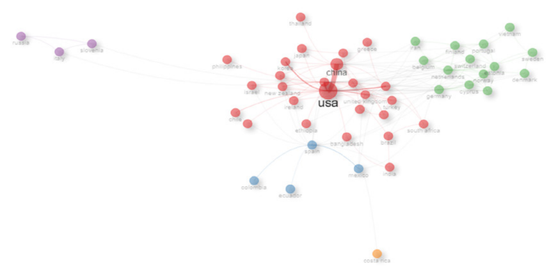

Figure 7. The co-collaboration of countries on CID in WOS (2012-2024)

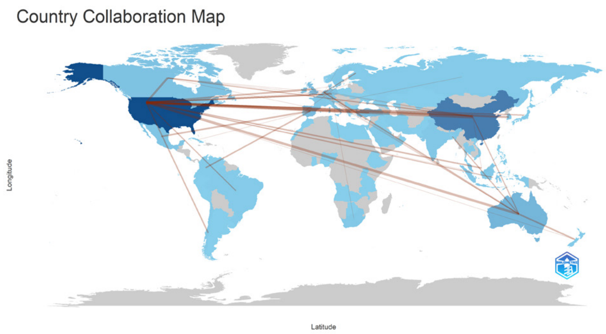

Figure 8. Countries' collaboration world map (2012-2024)

Finally, this study showed the article output of some universities. Table 3 shows the top 10 universities with the highest article output in the WoS database. Among them, the University System of Georgia published the most articles related to CID, with a total of 30 articles. This was followed by the State University System of Florida and Purdue University, with 28 and 21 articles respectively. This study showed the changing trends of the annual output of the top five universities with the highest output among the above universities (see Figure 9). The average annual output of the five universities as a whole presented a rising trend. Among them, the average annual output of the State University System of Florida was the highest. Figure 10 shows the cooperative relationship among universities in the form of nodes. Among them, the University System of Georgia had the closest cooperation relationship.

Table 3. The top 10 universities with the highest production (2012-2024)

Serial number	University	The number of published papers
1	University System of Georgia	30
2	State University System of Florida	28
3	Purdue University	21
4	Purdue University System	21
5	University of Queensland	20
6	Indiana University System	19
7	Brigham Young University	18
8	Indiana University Bloomington	17
9	National Taiwan Normal University	16
10	University of Georgia	16

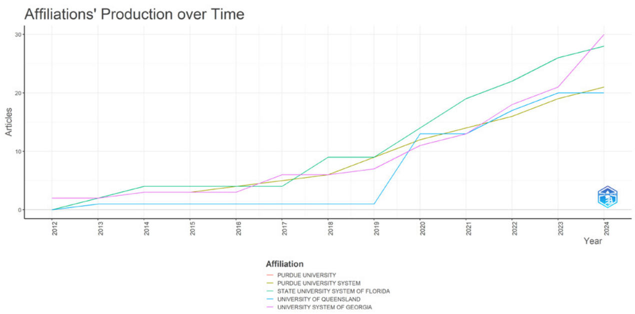

Figure 9. The trends in the annual production of the top five universities (2012-2024)

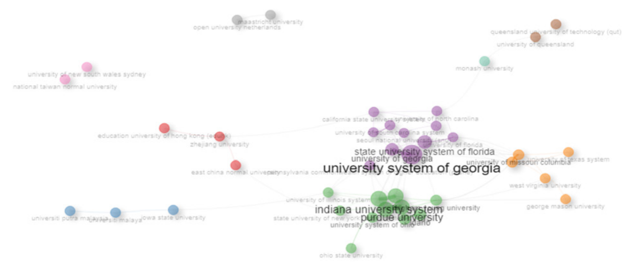

Figure 10. The co-collaboration of universities on CID in WOS (2012-2024)

3.1.2 Co-authorship Analysis

This study explored the researchers who published the most articles in the WoS database between 2012 and 2024. Table 4 shows the top 10 researchers with the highest articles output. Among them, Chen NS, Hwang GJ, West RE, and Wu WCV published 6 articles each related to CID between 2012 and 2024, becoming the researchers with the most publications in the WoS database. Kennedy MJ, Stefaniak J, Thomas CN, and Wang Y followed with 5 published articles respectively. At the same time, this study explored the changing trends of the average annual yield of the articles published by the above authors between 2012 and 2024, which was expressed in the form of nodes (see Figure 11). The larger the node, the more articles output; the darker the color, the more influential the document. Among them, Chen NS, Wu WCV, Kennedy MJ, and Thomas CN published a large number of articles in 2013 to 2015 with greater influence. Between 2018 to 2022, Hwang GJ, West RE, and AL Mamun MA published a large number of articles with greater influence. Table 5 shows the top 10 most cited authors. Among them, West RE was a relatively authoritative researcher who had been cited 24 times. Next came Kim C and Lee CJ cited 20 times. To explore the cooperative relationship between researchers, this study presented the node cluster diagram of researchers. Among them, the larger the node, the greater the influence of the researcher, which can provide a valuable reference for other researchers. Twelve research clusters were formed in Figure 12, indicating that there were 12 research directions in CID research during 2012-2024.

Table 4. Top 10 authors with the highest number of articles in the period of 2012-2024

Rank	Authors	Counts	Articles fractionalized
1	Chen NS	6	2.00
2	Hwang GJ	6	1.39
3	West RE	6	2.78
4	Wu WCV	6	2.08
5	Kennedy MJ	5	1.32
6	Stefaniak J	5	2.33
7	Thomas CN	5	1.32
8	Wang Y	5	2.58
9	AL Mamun MA	4	2.00
10	Arrington TL	4	2.08

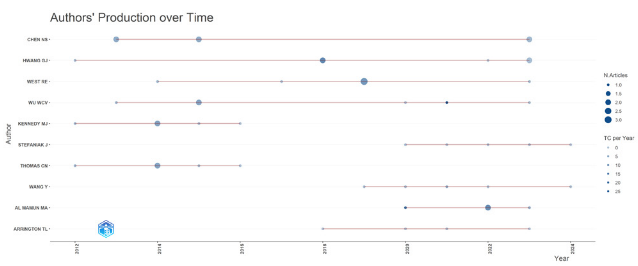

Figure 11. A diagram showing the top 10 researchers' production over time (2012-2024)

Table 5. Top 10 most cited authors in CID research

Rank	Author	Local citations
1	West RE	24
2	Kim C	18
3	Lee CJ	18
4	Bodily R	14
5	AL Mamun MA	13
6	Borup J	13
7	Lawrie G	11
8	Wright T	11
9	Kennedy MJ	9
10	Leary H	9

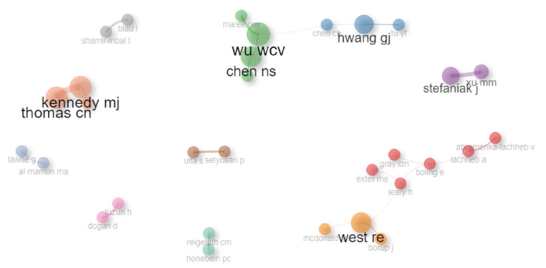

Figure 12. The co-collaboration of researchers on CID research in WOS (2012-2024)

3.1.3 Keyword Co-occurring Analysis

Keywords serve as a valuable tool for researchers, facilitating the efficient identification and retrieval of pertinent literature within a specific academic domain. Additionally, the presence of certain keywords in scholarly works can indicate prevailing trends and focal areas of interest within that field of study [32]. This study used high-frequency co-occurring keywords to elaborate on hot topics in the CID research. Visualization analysis results showed that 28 keywords appeared more than 20 times [36]. The higher the frequency, the higher the importance of this keyword in the field of CID. Table 6 shows the top 10 keywords with the highest frequency, among which "education," "technology," and "students" appeared the most frequently, 114 times, 103 times, and 96 times respectively. To better understand and present the relationship between co-citation keywords, this study used a word cloud map to carry out word cloud visualization analysis on articles in WoS (see Figure 13). The term "keyword co-occurrence" denotes the simultaneous presence of two or more keywords within the main text of a single academic paper. This phenomenon can elucidate the interrelationships and organizational framework of these keywords within a specific research domain, thereby facilitating the identification of emerging developmental trends [32]. The co-citation relationship between keywords was presented using the co-occurence keywords diagram (see Figure 14). Among them, the size of nodes can reflect the proportion of each keyword in this research field. Among them, the keywords closely related included "technology," "students," "instructional-design," "education," "performance," "knowledge," etc. Therefore, the core role of instructional design is to help students learn knowledge and show better academic achievements in education.

Table 6. Top 10 co-occurring keywords on CID research in the period of 2012-2024

Rank	Keywords	Occurrences
1	education	114
2	technology	103
3	students	96
4	instructional-design	70
5	impact	55
6	knowledge	53
7	design	51
8	framework	48
9	performance	47
10	science	44

Figure 13. Word clouds of keywords in CID research from 2012 to 2022 in WoS

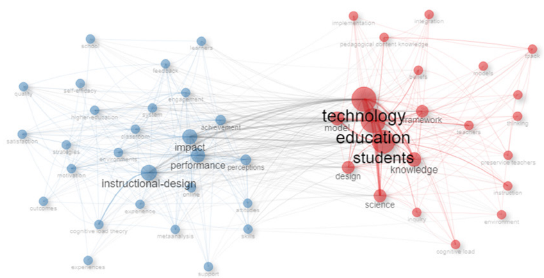

Figure 14. The co-occurence keywords on CID research in WoS (2012-2024)

3.1.4 Document Co-citation Analysis

To explore the most authoritative articles in CID, this study used coupled cluster analysis to obtain a visual document co-citation network for Bibliometry (see Figure 15). Nodes represented cited articles, and the links between nodes reflected the co-citation relationship. Figure 15 shows the three cluster networks, and Table 7 shows the relevant information of the four network clusters, including label keywords, frequency, centrality, and impact. The labels of the four clusters were "impact - conf 57.1% students - conf 57.1% technology - conf 29.4%," "education - conf 35.7% pedagogical content knowledge

- conf 87.5%," "technology - conf 23.5% instructional-design - conf 19.6% education - conf 21.4%," and "instructional-design - conf 51% technology - conf 33.3% cognitive load theory - conf 94.1%", and the centralities were 0.320, 0.454, 0.376, and 0.488. The four cluster networks were not independent of each other, and there was a certain correlation between them.

Table 8 shows the top 10 cited articles in CID worldwide. The article that received the highest number of citations, totaling 298, was authored by Martin in 2013 [37]. In order to examine the impact of mobile learning on student performance and attitudes, the author implemented an experimental study. This study involved the establishment of an experimental group that utilized iPods/iPads, while a control group was assigned to receive computer-based instruction. The findings of this research indicated that mobile technology plays a crucial role in fostering positive attitudes among students. This was followed by the article cognitive load theory and educational technology by Sweller J with 206 citations. The author used cognitive load theory to design instructional procedures largely relevant to complex information with the assistance of educational technology [38].

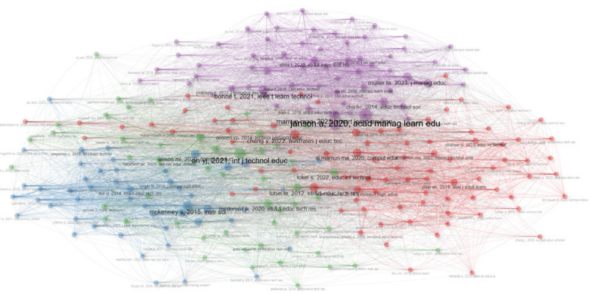

Figure 15. Document co-citation network of 2012–2024

Table 7. Cluster notes on the CID field in 2012-2024

Label	Frequency	Centrality	Impact	Color
impact - conf 57.1% students - conf 57.1% technology - conf 29.4%	87	0.320	1.826	red
education - conf 35.7% pedagogical content knowledge - conf 87.5%	49	0.454	2.363	blue
technology - conf 23.5% instructional-design - conf 19.6% education - conf 21.4%	51	0.376	2.065	green
instructional-design - conf 51% technology - conf 33.3% cognitive load theory - conf 94.1%	63	0.488	1.716	

Table 8. Top 10 most globally cited articles in CID research (2012–2024)

Author, year	Article title	Journal name	Total citations
Martin F, 2013	Here and now mobile learning: An experimental study on the use of mobile technology	Computers & Education	298
Sweller J, 2020	Cognitive load theory and educational technology	ETR&D-Educational Technology Research and Development	206
Küçük S, 2016	Learning anatomy via mobile augmented reality: Effects on achievement and cognitive load	Anatomical Sciences Education	190
Plass JL, 2013	The impact of individual, competitive, and collaborative mathematics game play on learning, performance, and motivation	Journal of Educational Psychology	152
Chu, H, 2014	A cooperative computerized concept-mapping approach to improving students' learning performance in web-based information-seeking activities	Journal of Computers in Education	141
Drysdale JS, 2013	An analysis of research trends in dissertations and theses studying blended learning	The Internet and Higher Education	128
Tondeur J, 2017	Developing a validated instrument to measure preservice teachers' ICT competencies: Meeting the demands of the 21st century	British Journal of Educational Technology	126
Mouza C, 2014	Investigating the impact of an integrated approach to the development of preservice teachers' technological pedagogical content knowledge (TPACK)	Computers & Education	107
Wrigley C, 2017	Design Thinking pedagogy: the Educational Design Ladder	Innovations in Education and Teaching International	104
Marek MW, 2021	Teacher experiences in converting classes to distance learning in the COVID-19 pandemic	International Journal of Distance Education Technologies	101

3.2 Analysis of Future Research Trends

A visual topic graph is an efficient way to explore the development trends of CID research [39], including a time map of keywords and a thematic evolution map.

Figure 16 shows the time map of keywords. The horizontal and vertical coordinates represented the year and the emerging keywords. The size of the node represented the frequency of the keyword occurrence. “education,” “impact,” “performance,” “students,” “knowledge,” and “design” appeared more frequently, indicating that the development trends of CID can be discussed from the above fields.

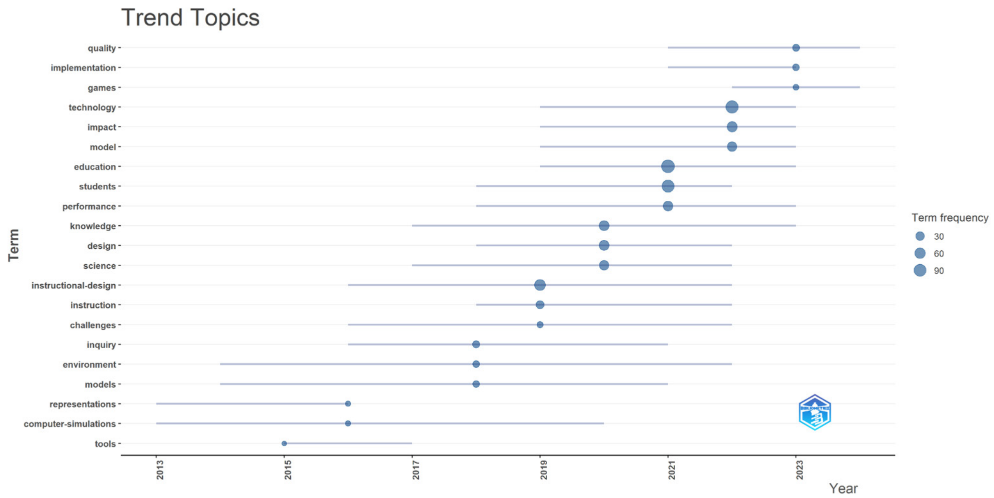

Figure 16. The time map of keywords on CID research in 2012-2024

Figure 17 shows the thematic map of CID in the form of plane coordinates. The horizontal and vertical coordinates represented the relevance degree (centrality) and development degree (density) respectively. The further away from the origin on the horizontal coordinate, the higher the relevance degree (centrality) between topics, and the closer the relationship between CID sub-fields. On the vertical axis, the farther away from the origin, the stronger the development degree (density) between themes, and the higher the exploration and development value of themes. The subjects located in the first quadrant had a strong relevance degree (centrality) and high development degree (density), so it was of high value for in-depth study. For example, there were “affordances, computer-simulations, representations,” “environments, cognitive load, inquiry”, and “design-based research, field.” The subjects in the second quadrant had higher research value, but there is less research now. For example, there were “decade, technology acceptance, process,” and “health, trends.” The subjects in the fourth quadrant were closely related to current research, but the value of future research was not high. The subjects in the third quadrant rarely appeared in the present research and have no great research value for the future. For example, there were “instructional-design, cognitive load theory, acquisition,” “education, framework, science,” and “beliefs, tpack, mathematics.”

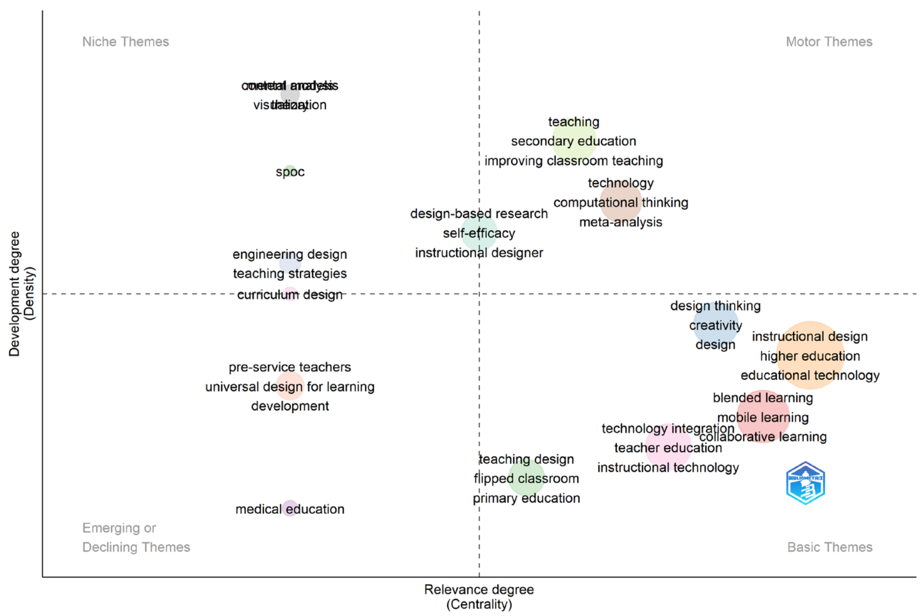

Figure 17. Thematic map of CID research in 2012-2024

Figure 18 shows the thematic evolution map of CID research. The analysis encompasses thematic evolution, evolutionary pathways, and conversion correlations. The thickness of the line indicates the relative significance of these two themes within a given year. Additionally, the use of color facilitates the differentiation of various research topics [32]. The research themes of CID from 2012 to 2021 were "blended learning," "instructional design," "technology integration," "online teaching," "technology," "spoc," and "instructional designers." It laid a good foundation for the development of CID. For the period 2022-2024, the emerging themes extended to "education," "instructional design," "instructional design and technology," "virtual reality," "flipped classroom," "creativity," "mathematics education," "spoc," "program," "teaching design," and "teacher professional development." The development of CID in recent years is more inclined to combine online learning with classroom education, including students, teachers, and instructional environment.

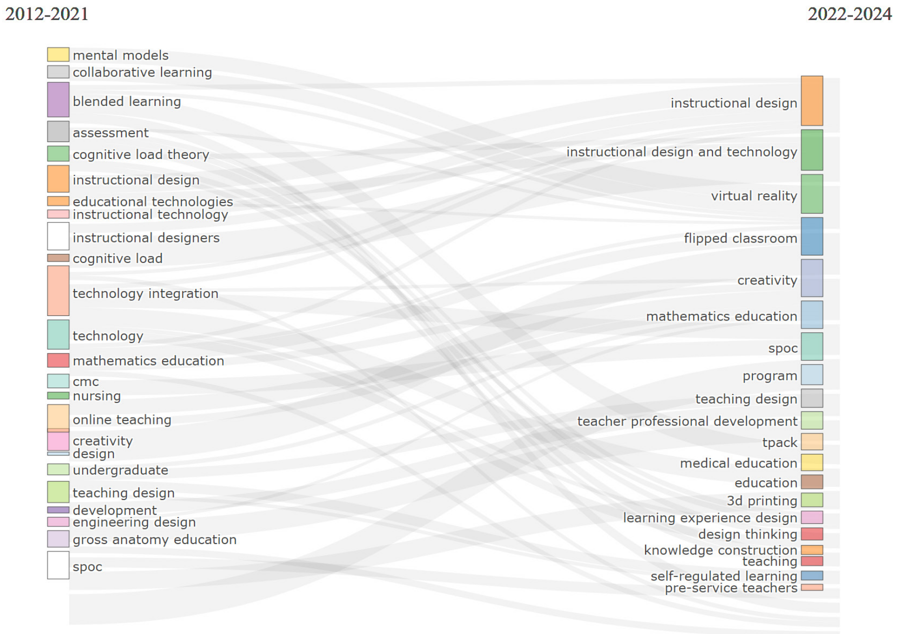

Figure 18. Thematic evolution of CID research in 2012-2024

4 Discussion

With the development of instructional reform, teachers' teaching methods and students' learning methods are constantly changing, and the composite teaching environments supported by technology are becoming more and more abundant; the corresponding research on instructional design is also increasing. Typical composite instructional environments include online instruction, blended instruction, artificial intelligence-supported maker instruction, and gamified instruction. Therefore, this study used Biblioshiny to conduct a bibliometric analysis of the articles in the WoS database, and explored the research status and development trends of CID in the past decade to reasonably standardize the research of all kinds of instructional designs, including the following aspects: annual output analysis of CID-related articles, the most productive journals, countries and universities analyses, co-authorship analysis, keyword co-occurring analysis, document co-citation analysis, and topic development trends analysis. This study found the articles, authors, and journals had a great effect on CID, as well as the emerging keywords of CID and the development direction with great potential, and explored the integration of technology and CID.

4.1 Research Status of Composite Instructional Design

The research status of CID can be described in detail from the following four aspects. The first aspect is the article output. In the WoS database, the annual output of articles related to CID showed an increasing trend from 2012 to 2024. The annual output of articles related to CID was the lowest in 2015, with 22 articles, and the annual output of documents in 2023 was the highest, reaching 158 articles. However, the average citations per year of articles showed a decreasing trend year by year. The reason is that the continuous updating of technology indicates that instructional design should adapt to the requirements of the times in the field of education and accelerate the speed of development, and researchers should constantly update instructional design based on previous studies, so the number of articles of all types will increase, and the number of citations of articles on unrelated topics will decrease. For example, technology reasoning instructional design is used in the instructional process, but there is no unified standard in this process, and previous studies have not given clear guidance [40]. Technology is evolving rapidly and there are still challenges in supporting instructional design in the form of modeling [41]. This leads to a growing number of categories of instructional design, such as online instruction, blended instruction, artificial intelligence instruction, and so on. The second aspect is the document co-citation. The classification of different instructional environments form different document co-citation clusters. The results of this study found three document co-citation clusters. The label of first cluster was “technology-conf 50.9% instructional-design-conf 38.5% impact-conf 67.9%”, which indicated that this group explored the influence of technology on instructional design in classroom teaching. The label of second cluster was “education-conf 40% pedagogical content knowledge-conf 88.9% tpack-conf 100%”, which indicated that the research topic of this group was more inclined to the teaching content and teaching method. The label of third cluster was “instructional-design-conf 51.9% technology-conf 32.1% cognitive load theory-conf 94.1%”, which indicated that the load research of technology in CID was rising gradually. The above three main document co-citation clusters are essentially exploring teacher-student interaction, instructional design principles, basic theories, and so on, so the articles have a high citation rate. The third aspect is authoritative authors and national contributions. The country with the most published articles was the United States, and the country with the most citations was also the United States. However, other countries, especially China, are also increasingly developing the field of CID, and cooperation with the United States is getting closer and closer. Finally, the results of keyword co-occurring analysis showed that “education,” “technology,” and “students” appeared more frequently, indicating that the development of CID always revolves around the subject and object of education or even the relationship between teachers and students. It also indicated that the purpose of developing CID is to maintain students’ academic performance and cultivate talents for society.

4.2 Emerging Trends of Composite Instructional Design Research

To promote reform in the field of education and to promote the optimization of instructional design, two aspects can be considered: learning task and learning material design [42], and instructional design is one of them. After fully analyzing the research status of CID, this study further summarized the latest research theme and agenda of future research on CID.

Firstly, artificial intelligence (AI) instruction is the latest research topic in the field of CID. The frequent occurrence of “online,” “information,” “students,” “user acceptance,” and “higher education” among the keywords proves that it is feasible for technology to drive the development of education. The application of artificial intelligence in education can be divided into three categories: AI as a new subject, AI as a direct mediator, and AI as a supplementary assistant to influence the teacher-student, student-self, and student-student relationships respectively belong to the three aspects of student learning, teacher teaching, and management application respectively, which correspond to three types of instructional design [15]. The practice has proved that AI-driven instructional design is popular among students, and pays attention to cultivating students’ solid technical and theoretical foundation and personalized innovation ability [43].

Secondly, the application of technology to enhance classroom interaction has a strong development potential in the future research of CID. CID is an instructional design supported by a composite instructional environment. The advancement of technology is constantly changing the instructional environment, the teachers’ teaching way, and the students’ learning way. The process and means of classroom interaction and instructional feedback are also being gradually upgraded. Interaction and feedback are key parts of the instructional design process, and it is also a necessary means to ensure the quality of classroom teaching. Good management of the interactive relationship between teachers and students in the classroom can ensure effective classroom efficiency [43]. Especially in online learning, communication and feedback are important means to investigate students’ satisfaction [44]. Learning strategies and peer communication can promote the development of students’ higher-order thinking skills. The development of technology is constantly changing the way of classroom interaction with instructional design. The instructional design based on interaction can better assist teachers in influencing students’ learning through the instructional environment [13]. The change in teaching interaction can be explored from the two aspects of time and space. In terms of space, classroom observation is helpful to promote teacher-student interaction [45]. Participatory instructional design is a strategy that considers students’ perception of instruction. When teachers and students participate together, students can effectively perceive instructional activities [46]. Classroom video transcription can visually analyze teaching videos and think about teaching improvement methods from the details [47]. Compared with traditional courses, blended classrooms provide more opportunities for students to communicate in an interactive learning environment and accelerate the development of group cooperation [48]. In terms of time, dynamic system research methods such as state space grids are used to draw real-time graphs of teacher-student interaction from the time of interaction, which is conducive to continuously increasing the cyclic and stable state of teacher-student interaction [49]. Instructional design used by online education platforms represented by MOOCs can provide formative feedback for teacher-student interaction and student-student interaction [50]. Synchronous components (virtual classroom technologies) can break the constraints of time, assist teachers and students in getting timely feedback, and facilitate interaction between teachers and students in online courses [44]. The enhanced scaffolding designed for online courses increases the quality of the scaffolding session of the learning platform and effectively increases the interactive efficiency of online learning [51]. In blended classrooms, an instant response application uses two instant interaction modes to enhance peer interaction, namely time-ranked mode and like-ranked mode [52].

To sum up, the development of technology constantly promotes the reform of education, and CID is gradually being expanded and updated to meet the requirements of future education. The future development of CID should start from the teaching purpose and teaching process, should pay attention to classroom teaching interaction, and should gradually improve the efficiency of classroom teaching to cultivate students' personalized learning and cultivate practical talents for the future society.

5 Conclusions and Limitations

In terms of the research status, the application scope of technology in instructional design involves four aspects of instructional design, namely annual output, document co-citation, authoritative authors and national contributions, and keyword co-occurring. The bibliometric analysis of CID indicates that several significant aspects remain inadequately explored. Current research has predominantly concentrated on the categories and components of instructional design. However, there has been a lack of widespread promotion of standardized practices within the CID process. Furthermore, the majority of existing studies examining teachers' critical thinking are primarily theoretical rather than empirical. Addressing these issues is essential for future research endeavors. In terms of the development trend, the existing research topics and the topics evolution trend show that the training of students' various abilities is at the center. For example, we should cultivate students' scientific concepts and learning habits from the perspective of technology, which has gradually revealed the essence of technology's participation in teaching - the development of student personalization and ability. This provides some references for the future research direction of the researchers. The bibliometric analysis has some value, but also some limitations. First, the analysis results of this study can only see the changing trends of articles output, but cannot see the reasons behind the trends change. Hence, some more accurate research methods such as meta-analysis or systemic review should be implied in future studies. Furthermore, this research examined pertinent articles within the WoS database, while disregarding documents that are not included in this database. Future studies can make a comprehensive analysis of the articles in more databases.

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