Bibliometric Analysis of Curriculum Innovation and Competency-Based Approaches in Geography Education

Albertus Erico Jerry Krisna Nugroho [a)], Sugiyanto [b)], and Singgih Prihadi [c)]

Department of Geography Education, Faculty of Teacher Training and Education, Universitas Sebelas Maret, Surakarta, Indonesia

[a)]Corresponding author: albertusericojerry@student.uns.ac.id
[b)]sugiyanto60@staff.uns.ac.id
[c)]singgihprihadi@staff.uns.ac.id

Abstract. This study aims to map the scientific landscape of curriculum innovation and competency-based approaches in geography education through a bibliometric analysis of 1,073 Scopus-indexed documents published between 2019 and 2024, along with other established inclusion criteria. Using a quantitative bibliometric approach supported by VOSviewer, this study explores publication trends, intellectual structures, and emerging conceptual themes. Three research questions guide this investigation: (1) What are the trends in scientific publications based on year, country, and institution? (2) Which documents are most frequently co-cited and form the intellectual foundation of this field? (3) What are the dominant and emerging conceptual and thematic structures in curriculum innovation and competency-based geography education? The results of this study indicate significant growth in academic output, particularly in 2023 and 2024, led by institutions in the United States, the United Kingdom, and Spain. Co-citation and bibliographic coupling analyses identified influential core works focusing on education for sustainable development (ESD), project-based learning, and transformative pedagogy. Keyword co-occurrence analysis reveals a shift in thematic focus toward sustainability, spatial thinking, digital learning, and the development of 21st-century competencies. These findings suggest that curriculum innovation in geography education is becoming increasingly interdisciplinary, practice-oriented, and aligned with global education priorities. This study provides a comprehensive foundation for future research and policy efforts aimed at driving reform of geography curricula.

Keywords: bibliometric analysis; competency-based education; curriculum innovation; geography education

INTRODUCTION

The global transformation of education in the 21st century has brought about fundamental changes in the design and approach to educational curriculum structures in various countries. The shift from a content-based approach to a competency-based approach reflects the fundamental need to equip students with relevant skills to address global challenges (Syafi'i et al., 2024). According to Taliak et al. (2022), competency-based curricula are a strategic step and solution to improve the quality of secondary education. Through competency-based curricula, it is hoped that students will be able to face the era of globalization, which demands adaptive skills from students in the future. Meanwhile, Harianto (2024) states that the development of a competency-based curriculum requires guidance to strengthen students' capacities to prepare for and respond to global challenges through the integration of 21st-century skills. This

view is reinforced by Tahirsylaj & Sundberg (2025), who, through their systematic review, identified five conceptual models of competency-based curricula that have been adapted globally. This suggests that such an approach has evolved into a transnational policy that has been adopted across various national contexts. The adaptation of this approach also reflects the education system's efforts to align itself with dynamic social and economic developments. Additionally, Tarmo & Kimaro (2021) emphasize that higher education institutions need to adapt their education programs to incorporate competency-based curricula, such as those focused on learning outcomes, active learning approaches, and real-world relevance, in order to produce educators capable of adopting such approaches. In a global context, strengthening cross-cultural competencies and social awareness are integral components of competency-based curriculum approaches. Majewska's (2023) study highlights that the development of global competencies, such as cross-cultural critical thinking, understanding of international issues, and empathetic social attitudes, is a key indicator in the design of higher education curricula. Meanwhile, the integration of global competencies in teacher education can be achieved through curriculum collaboration and continuous professional development (Nopas & Kerdsomboon, 2024).

Geography education plays a strategic role in achieving competency-based curriculum objectives. Through a cross-curricular approach in geography education, connections between disciplines can be established, and students' spatial analysis skills strengthened (Mwangangi et al., 2024). The integration of Education 4.0 elements in geography education, such as the use of digital technology and personalized learning, contributes to the development of 21st-century skills (González-pérez & Ramírez-montoya, 2022). According to Risiro (2022), learning activities through competency-based assessments can connect classroom learning processes with the contextual needs of the workplace. Relevant research through Nugroho et al. (2025), bibliometric study found that the implementation of geography curricula and teaching methods in the future will focus on collaborative approaches, project-based learning, and the use of geospatial technology in geography education. The importance of strengthening spatial thinking skills through GIS-based geography education and spatial data visualization can support geography competencies (Hickman, 2023). Various implementations of learning strategies in geography education continue to be explored to determine how applied learning strategies can support the skills students possess. The results of Putra et al. (2023)'s studies indicate that the use of STEM-based mobile textbooks in geography learning can strengthen students' spatial acuity while increasing their active participation in learning. A deep understanding of geographical concepts is crucial in building awareness of spatial dynamics, places, and human interactions with their environment (Fouberg, 2023). The importance of a geographical approach in primary education as a foundation for fostering spatial literacy and environmental responsibility from an early age (Dolan, 2020).

Curriculum innovation in geography education also serves as a response to technological developments, community needs, and various global challenges faced by humanity. According to Gregersen-Hermans (2021), future curricula must integrate the concepts of Education for Sustainable Development (ESD) and internationalization to equip students with global awareness and a commitment to sustainability. This is supported by the findings of Agbedahin (2019), who states that Education for Sustainable Development (ESD) is an educational approach that can strengthen environmental awareness, social justice, and sustainable economic development. Meanwhile, Glavič (2020), asserts that the success of Education for Sustainable Development (ESD) lies in its ability to identify key issues and integrate them concretely into the educational curriculum. In line with this, a values-based and global citizenship curriculum approach has also become a focus in social studies, including geography education. The perspective of global citizenship values has begun to be adopted in history education, for example, through an intercultural perspective as part of global citizenship education that can be adapted in geography education (Hajisoteriou et al., 2024). According to Nadilla et al. (2025), a comparative study of character education in Japan and Indonesia highlights the importance of a curriculum that instills humanistic values, empathy, and social responsibility. Thus, students are not only equipped with cognitive competencies but also grounded in social and community-oriented values.

However, despite the abundance of studies and experiments on innovative curricula and learning strategies to support competency-based approaches in geography education, there has been no bibliometric study specifically mapping global scientific contributions in the field of curriculum innovation and competency-based approaches in geography education. Most of the research presented consists of case studies or descriptive contextual studies that do not reflect the developments, relationships, and literature that contribute holistically. As a result, many studies examine variables that are not connected and integrated to determine future curriculum innovation and competency-based

approaches in geography education. Additionally, there is no existing scientific knowledge mapping study that can serve as a basic reference for conducting evaluations, formulating policies, and developing further curricula globally in an integrated manner. Based on this background, this research focuses on answering the following research questions:

RQ1: What are the trends in scientific publications based on publication year and regional distribution related to studies on curriculum innovation and competency-based approaches in geography education?

RQ2: How are documents/sources frequently cited together to indicate the intellectual foundation of the field in scientific literature on curriculum innovation and competency-based education in geography?

RQ3: What is the structure and direction of scientific publication discourse related to curriculum innovation and competency-based approaches in geography education?

This study uses a bibliometric approach, aiming to specifically map the structure of development, the distribution of affiliated regions, and the direction of discourse related to curriculum innovation and competency-based approaches in geography education. The findings of this study are expected to serve as an important reference for researchers, educators, and education policymakers in designing a geography education system that is responsive to the demands of the 21st century, in light of the developments of the times.

In linking bibliometric findings with the established curriculum framework, this study also refers to classical curriculum theory. Tyler's Goal Model emphasizes the importance of formulating measurable learning outcomes, in line with competency-based education (Du, 2024). Taba's Grassroots Model highlights the importance of teacher initiative in curriculum development in the local context (Robinson & Aronica, 2016). Stenhouse's Process Model positions the curriculum as a reflective and evolving process through project-based learning and problem-solving practices (Elliott & Norris, 2012). Meanwhile, the constructivist perspective emphasizes that meaningful learning emerges through direct experience and interaction (Idawati et al., 2025), in line with the trends of sustainability-based and digitalized learning identified through the results of bibliometric analysis.

In connecting bibliometric trends with established curriculum frameworks, this study also draws upon classical curriculum theories. Tyler's objective model highlights the importance of clearly defined learning outcomes, which aligns with the growing emphasis on competency-based education. Taba's grassroots model emphasizes curriculum development initiated by teachers, aligning with recent literature that stresses teacher agency in adapting geography curricula to local contexts. Stenhouse's process model, on the other hand, views curriculum as an evolving and inquiry-oriented process, which is evident in the increasing integration of project-based and problem-based learning identified in this study. Furthermore, constructivist perspectives on curriculum suggest that meaningful learning emerges through interaction and experience, which is consistent with the trends toward experiential, sustainability-oriented, and digitally enhanced geography education revealed by the bibliometric findings.

METHODS

This research is a bibliometric study employing a quantitative-descriptive approach, aiming to map trends in scientific publications, identify dominant keywords, and analyze the structure of scientific publication discourse on the topics of curriculum innovation and competency-based approaches in geography education. The bibliometric approach was chosen because it can provide an understanding through an objective and systematic mapping of the scientific literature collected (Donthu et al., 2021). The scientific literature was obtained for processing through the bibliometric approach using the Scopus database. The Scopus database was selected because it is considered one of the most comprehensive scientific databases with a high level of international credibility for analysis using a bibliometric approach (Mongeon & Paul-Hus, 2016). Table 1 presents the keywords used to search for scientific literature in the Scopus database, along with their purpose. The term "OR" in the query string was used to capture synonyms or variations of similar terms, while the term "AND" was used to combine the main components to ensure the search results were relevant to the scope of the research topic. This strategy was designed to maximize the literature to be analyzed in the study, thereby providing relevant, contextual, and comprehensive literature coverage (Aria & Cuccurullo, 2017).

The data collection process was carried out in several stages by entering search queries into Scopus using strings compiled based on Table 1. After entering the search queries, the next step was to set the inclusion and exclusion criteria. The establishment of these scientific literature boundaries aims to ensure that only relevant, up-to-date, and

research-focused documents are analyzed in this bibliometric study (Haddaway et al., 2022). Figure 1 illustrates the process of selecting scientific articles, which was conducted using the established inclusion and exclusion criteria. Before the selection process, inclusion criteria were first established to produce the documents analyzed in this study. Table 2 presents the inclusion and exclusion criteria established in this study. This establishment aims to filter relevant literature on the research topic, enabling it to address the objectives of this study (Donthu et al., 2021).

TABLE 1. Query string structure and purpose

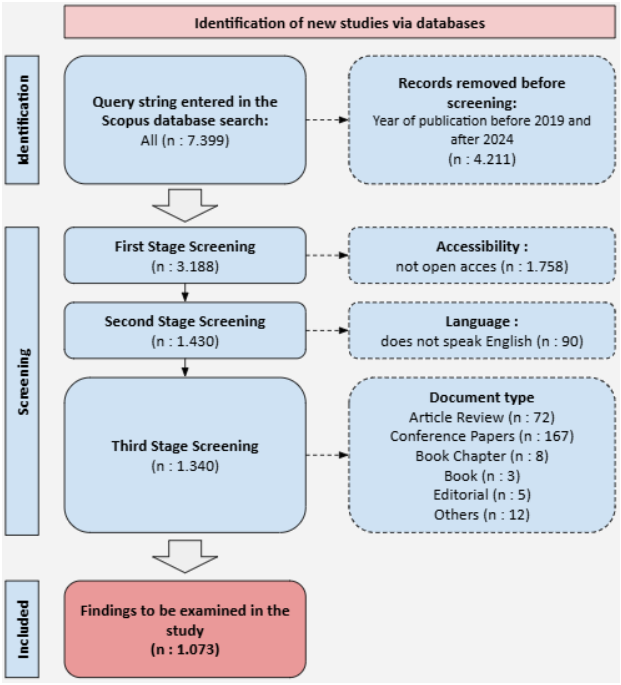
String Query Components	Purpose of Keywords Selection
"curriculum" OR "syllabus" OR "program" OR "course" AND	Covering various terms that refer to learning structures or designs, both at the national curriculum level and course design at educational institutions.
"innovation" OR "development" OR "improvement" OR "change" AND	Representing the process of transformation or renewal in the education system, particularly in relation to curriculum design and implementation.
"competency" OR "skill" OR "ability" OR "proficiency" AND	Focus on competency-based approaches and the development of students' skills as the main orientation of 21st-century learning.
"geography" OR "geospatial" OR "spatial" OR "environmental" AND	Identify studies within the scope of geography education that encompass relevant spatial and environmental topics.
"education" OR "learning" OR "teaching" OR "instruction"	Filter the results to keep them within the context of education and learning processes, including both formal and informal settings.

Source: (Donthu et al., 2021), with modification

TABLE 2. Inclusion and exclusion criteria

Section	Criteria	Inclusion	Exclusion
Identification	Publication Time	From 2019 to 2024	before 2019 and after 2024
	Availability	All Open Access	restricted access
	The language used	English language	Not English language
Screening	Document type	Article empiric	review articles, conference papers, books, book review, book chapter, editorial, note, etc

Source: (Haddaway et al., 2022), with modification



Source: (Haddaway et al., 2022), with modification

FIGURE 1. Selection stages

After going through the selection process of inclusion and exclusion criteria, the next step was to export the collected bibliographic data consisting of 1,080 documents and download it in .csv format, which included metadata, citation data, keywords, affiliations, and references. The data downloaded in .csv format was further filtered to ensure that it had been downloaded completely. This method aligns with common practices in bibliometric studies, which emphasize the quality and relevance of data for analysis (Bukar et al., 2023). Data analysis in this study used VOSviewer 1.6.20 and Microsoft Office Excel software. According to Bukar et al. (2023), VOSviewer helps present research findings through various types of analysis and analysis units that help researchers identify, analyze, and visualize findings. Data analysis in this study was conducted using quantitative descriptive methods, utilizing metadata to examine annual trends, country of origin, and journal sources to analyze publication trends. Co-occurrence analysis was employed to identify dominant keywords and emerging research themes, as well as to predict future research directions (Ellegaard, 2018). Bibliographic coupling was used to examine contemporary relationships between documents based on common sources or frequently cited references, to indicate the intellectual foundations of the field (Perianes-Rodriguez et al., 2016). The selection of analytical techniques for this study was considered to achieve the research objectives, making descriptive publication trend analysis, Bibliographic Coupling, and Co-occurrence appropriate for use in this study (Marchiori et al., 2021). The results of this study utilize visualizations, including network visualization and density visualization, to provide comprehensive visual outcomes. Interpretation is conducted by examining dominant clusters, the strength of relationships, and the spatial distribution between nodes, interpreted in accordance with the findings and visual outcomes. The validity of this study is ensured through the use of the Scopus database, an internationally recognized scientific database acknowledged as a high-quality source of scientific references. Additionally, the analysis procedure employs a bibliometric approach to ensure the reliability of interpretations, with visualization results triangulated across co-author, co-occurrence, and bibliographic coupling analyses (Bukar et al., 2023).

RESULTS AND DISCUSSION

This study uses a bibliometric approach. From the Scopus database, 1,073 documents were identified as relevant to this study. Based on the literature reviewed, this study identified and analyzed trends in scientific publications, including the distribution of publications by country and affiliation, the development of intellectual structures and relationships emerging through bibliographic linking, and the conceptual and thematic structure of curriculum innovation in geography education. These findings address the research objectives by specifically mapping and identifying the developmental structure, trends, and scientific affiliations contributing to the discourse on curriculum innovation and competency-based approaches in geography education.

Publication Trends and Research Dissemination

Figure 2 shows the development of trends in the number of scientific publications related to curriculum innovation and competency-based approaches in geography education from 2019 to 2024, which has continued to grow based on articles from the Scopus database. There has been a significant increase in the number of publications over the past five years, indicating that this topic is increasingly attracting the attention of the global academic community. In 2019, 108 documents were found, increasing to 151 documents by 2020, a 43-document rise. The trend in 2021 increased by 22 documents from the previous year. Thus, in 2021, the number of documents examining this theme increased to 173. In 2022, there were 206 documents, representing a 33% increase from 2021. The situation was different in 2023, which tended to decline compared to previous years, which had seen relatively increased growth. In 2023, the number of documents decreased by 4 to 202. Although the decrease was not significant, it certainly raises questions for the public about why the trend declined, whether it was due to the dynamics of post-COVID-19 pandemic developments becoming problematic in this area. In 2023, there was a decrease; however, in 2024, the number of publications increased by 31 documents, resulting in a total of 233 documents. Based on the data obtained, a sharp increase occurred after 2019, consistent with the study by Piotrowska et al. (2019), which identified that since the late 2010s, there has been a shift in the focus of research in geography education from local context issues toward contemporary issues such as the integration of spatial literacy, global environmental issues, and more reflective pedagogical approaches.

This increasing trend reflects the need for curriculum renewal that not only covers geographical content but also aspects of critical thinking skills, problem-solving, and global citizenship awareness.

Furthermore, Xuan et al. (2019), emphasize that the geography curriculum has great potential in shaping scientific literacy for students, especially in understanding complex phenomena involving human-environment relationships. Therefore, the increase in publications after 2019 can be interpreted as a scientific response to the need for a more integrative, holistic, and interdisciplinary geography curriculum. According to Chang & Kidman (2019), the fundamental questions that need to be answered in geography education reform are "for whom" and "for what purpose" the curriculum is designed. These questions have sparked various studies that question the relevance of content, pedagogical strategies, competencies, and evaluation systems in current geography education, ultimately contributing to an increase in publications in this field. Thus, the trend of increasing publications over the past five years is not merely a statistical phenomenon but reflects the growing global academic awareness of the need to revitalize the role of geography education as a means of building 21st-century competencies. This also highlights the critical and reflective dynamics within the scientific community regarding the direction and orientation of geography education in the future.

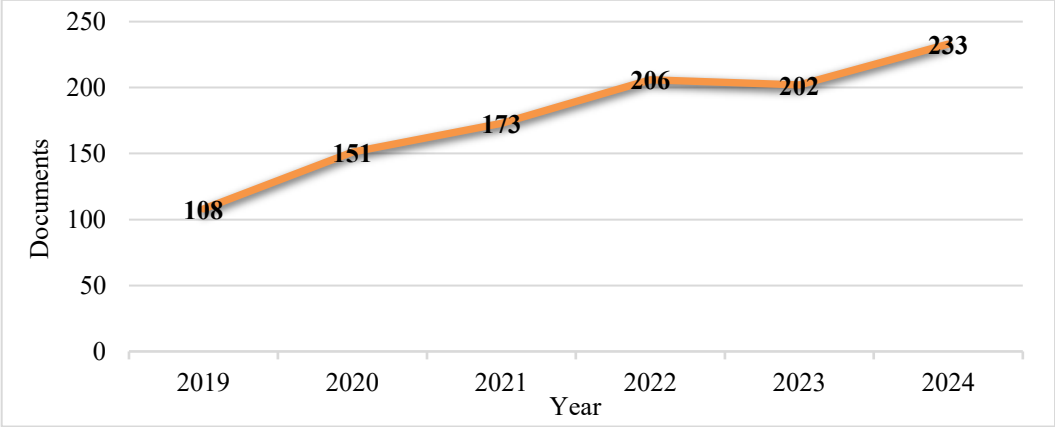


FIGURE 2. Publication documents by year

Based on Figure 3, the distribution of documents is visualized according to the country of origin of the author's institution. Countries such as the United States, the United Kingdom, Spain, Australia, China, Canada, Germany, and Indonesia are among the leading contributors to publications in this field. This dominance reflects the high research capacity, strong academic infrastructure, and high educational awareness in these countries regarding the importance of updating geography curricula. In the United States, the high number of publications is closely related to the push to reflect on and reformulate the historical and pedagogical aspects of geography education. Kinkaid & Fritzsche (2022), emphasize that the geography curriculum at the higher education level in the United States still contains exclusionary narratives that need to be reviewed to make them relevant to contemporary global challenges. This has led to the emergence of critical and innovative studies in curriculum development. Additionally Miao et al. (2022), show that geography curricula in the United States are evolving and beginning to be directed toward supporting education for sustainable development (ESD), which could serve as a catalyst for increased publications in this field. Significant contributions from other regions, such as the United Kingdom, also show similar dynamics. Rawling (2020) argue that the national curriculum framework in the UK still falls short of capturing the essence of geography in a more profound and transformative way. This ultimately stimulates the emergence of new research aimed at reformulating a more contextual approach to geography learning. The same point is made by Butt (2020), who states that geography education in the UK is currently undergoing a reflective phase, re-evaluating past research orientations while building prospects for more innovative and relevant future research. According to Roberts (2023), there is a need for "powerful" pedagogy to foster spatial understanding, environmental ethics, and social awareness through the geography curriculum.

In Europe, Spain, as one of the main contributors, has also shown an increase in research contributing globally. García-Álvarez & Arias-García (2022), revealed that geography education in Spain is used as a means to shape European citizens with a high level of historical and spatial awareness. A similar view by Castellanos et al. (2021), shows that there is a strong orientation in the Spanish geography curriculum toward education for sustainable development, which contributes to the increase in research in this field. Shifting to the Asian region, China also makes a significant contribution to this theme. Miao et al. (2022), emphasize that although the educational approach in China tends to be structured and centralized, the geography curriculum has evolved to accommodate the principles of sustainability and environmental literacy. In Southeast Asia, countries like Indonesia make significant contributions globally, although not as substantial as those of the United States and the United Kingdom. According to Hawa et al. (2021), geography education in Indonesia is beginning to be directed toward supporting the Sustainable Development Goals (SDGs), though it still faces complex implementation challenges. Meanwhile, Ratnasari et al. (2019), through their comparative study, show that the geography curricula of Indonesia and Malaysia still need to strengthen 21st-century competencies, particularly in spatial skills, global citizenship, and digital literacy. Overall, the distribution of publications by country not only reflects research capacity and educational infrastructure but also reflects each country's concern for the urgency of transforming geography curricula into adaptive, contextual, and sustainability-oriented ones. The gap in contributions between developed and developing countries also indicates room for expanding international collaboration in more inclusive and transformative geography education research.

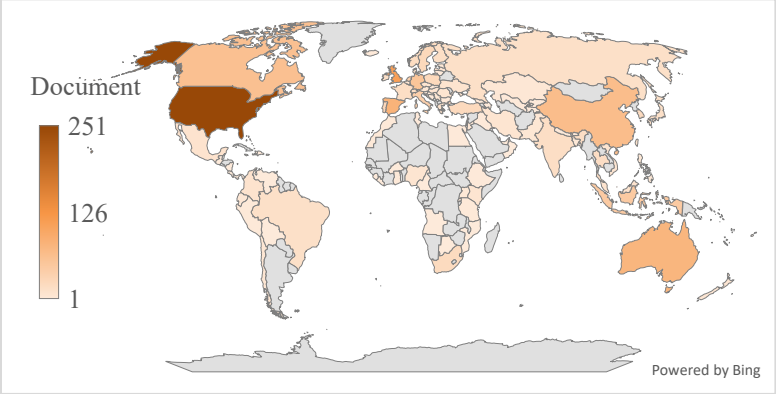


FIGURE 3. Documents by country

Intellectual Structure and Emerging Connections via Bibliographic Coupling

Figure 4 illustrates a visualization of a bibliographic coupling overlay, which highlights the intellectual relationships between documents in the study of curriculum innovation and competency-based approaches in geography education. This visualization is identified using a color scheme based on the year of publication, with blue to turquoise representing documents from 2019 to 2020. The color range from turquoise to green represents documents from 2020 to 2021, and the color range from green to yellow indicates newer documents from 2021 to 2022. This color distribution holds significant meaning, as it reveals the trend of document development and the interconnectedness of authors. Documents colored blue to turquoise were generally published between 2019 and 2020 and are concentrated in the core of the network. This indicates that these early publications served as the conceptual foundation often referenced by subsequent publications. In other words, research conducted during those years contained theories or approaches that underpin the discourse on curriculum and pedagogical renewal in geography education. Meanwhile, documents colored turquoise to green, published between 2020 and 2021, appear to form new clusters or connect with existing clusters. This indicates the emergence of new themes or the diversification of research focus. This phenomenon reflects the ongoing development of academic dynamics. Recent articles often explore topics aligned with future research recommendations. Meanwhile, green to yellow documents were published between 2021 and 2022. This cluster appears to form a new cluster or connect with existing clusters. It even connects with clusters from 2019 to 2022, indicating that these latest articles aim to address research gaps and examine future research

suggestions by referencing previous articles. Therefore, the colors in this overlay not only mark the publication date but also indicate the temporal transformation of the knowledge structure in this field. The evolution from blue to yellow signifies that the initial ideas about curriculum reform have been further developed and enriched by new research. This supports the understanding that bibliographic coupling not only connects documents structurally but also provides a historical and chronological overview of the main ideas shaping the landscape of geography education curricula and competencies in the contemporary era (Aria & Cuccurullo, 2017).

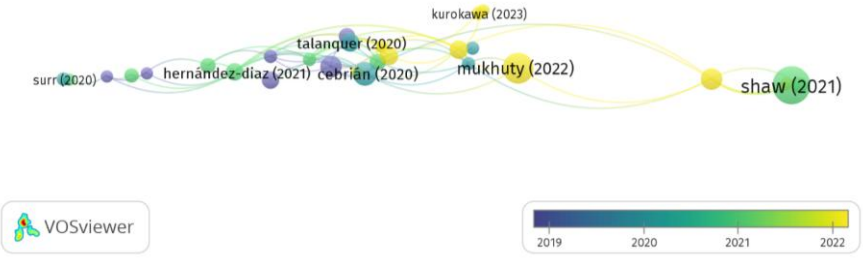


FIGURE 4. Bibliographic coupling overlay documents

Table 3 detailing the 15 authors most closely related bibliographically, as measured by the number of documents, citations, and total link strength. Authors such as Cebrian (2020) and Fuertes-Camacho (2019) rank highest, with 95 and 87 citations, respectively, and a total link strength of 19. This indicates that their works are frequently referenced together by studies in curriculum innovation and competency-based approaches in geography education. Additionally, these findings highlight their role as central figures in the intellectual structure of geography education curricula. Furthermore, authors such as Wang (2022) and Alvarez-Nieto (2022) also demonstrate high connection strength. This also indicates that their work is part of the rapidly evolving collective discourse on curriculum innovation and competency-based approaches in geography education. The total link strength in this bibliographic coupling reflects the authors' strategic position in the scientific network, not only due to their productivity but also because of their contributions to developing interconnected theoretical and conceptual foundations (Biscaro & Giupponi, 2014). In this finding, Shaw (2021) reports a high citation count of 227, but its total link strength is 7, which is relatively low compared to other documents. This indicates that the high influence of their publications in shaping academic discussions and current research directions is shifting the research trend from focusing solely on the quantity of publications toward the quality and relevance of contributions within the context of curriculum and geography pedagogy changes.

TABLE 3. Top 15 authors connected bibliographically based on documents

Documents	Citation	Total Link Strength
Cebrian (2020)	95	19
Fuertes-camacho (2019)	87	19
Wang (2022)	31	17
Alvarez-nieto (2022)	81	14
Price (2021)	38	14
Hernandez-diaz (2021)	56	13
Mckinnon (2022)	34	11
Owojori (2022)	64	11
Talanquer (2020)	66	9
Yuan (20210	52	7
Shaw (2021)	227	7
Duarte (2020)	36	7
Di Lieto (2020)	30	7
Greenland (2022)	62	6
Howard (2020)	37	6

Figure 5 provides a visual illustration of the interconnectedness of certain documents that share common references. These relationships form an interconnected network, enabling the identification of study groups with relevant theoretical and methodological foundations. This visualization demonstrates that literature in the field of curriculum innovation and geography education does not develop in isolation but rather reinforces each other through the consistent use of reference sources. Through this visualization, it can be understood that bibliographic coupling helps in identifying the intellectual centers underlying the development of contemporary geography education research (Bukar et al., 2023). The network formed from the interconnectedness of these examples not only shows citation patterns but also indicates trends in the flow of ideas, theories, and pedagogical approaches that are transnational and multidisciplinary, evolving from 2019 to 2022. This aligns with the foundational theory of bibliographic coupling, where the strength of the relationship between documents is based on the extent of overlap in the references they use, directly reflecting thematic and intellectual proximity (Donthu et al., 2021).

In the context of this study, this interconnectedness is particularly evident in documents addressing the themes of higher education, sustainable development, and 21st-century competency development, indicating that these literatures form thematically interconnected clusters that reinforce each other conceptually. The study by Duarte et al. (2020), proposes the European Project Semester model in engineering education as an approach to enhance sustainability awareness and cross-national collaborative work. This model emphasizes interdisciplinary project-based learning and serves as an initial foundation, inspiring subsequent studies on sustainability competency development through direct practical experience. This is relevant to the previous study by Sady et al. (2019), which highlights the role of educational institutions in shaping sustainability competencies among students. Both articles are interconnected, as they emphasize the importance of a contextual and experience-based curriculum in producing graduates who are ready to face global challenges. In 2020, the study by Cebrian et al. (2020), introduced the use of smart classrooms to develop ESD (Education for Sustainable Development) methodologies, combining digital technology with participatory pedagogical approaches. This article strengthens the methodological foundation of sustainable learning and connects with previous work through its focus on learning innovation and competency development. Building on this, in 2021, research by Price et al. (2021), explored how universities can serve as catalysts for individual and social transformation through sustainable education. This article links the development of sustainability competencies with the role of institutions in creating collective change. Its connection is closely aligned with Cebrian et al. (2020) and Sady et al. (2019) as it emphasizes the importance of systemic change in higher education institutions. This aligns with Hernández-Diaz et al. (2021), who support the idea by presenting evidence of holistic sustainability integration in universities in Colombia. Both establish a connection with previous studies through shared citations on the whole-institution approach and transformative change theory in higher education.

As themes and ideas related to research in the context of sustainable education and curriculum innovation continue to evolve, they are not limited to Geography Education but are expanding into other fields. For example, Álvarez-Nieto et al. (2022), examined nursing students' attitudes toward climate change and sustainability in a multisite, cross-national context. This study is bibliographically connected to works such as Owojori et al. (2022), as both highlight the KAP (Knowledge, Attitude, Practice) dimensions of students toward environmental issues. Furthermore, Wang et al. (2022), examined pedagogy and student competencies in sustainable education at higher education institutions. Additionally, Mukhuty et al. (2022) linked sustainability principles with corporate social responsibility practices in the Industry 4.0 era, which, although focused on an industrial context, still has a bibliographic connection to ESD literature through the concepts of social competence, collective responsibility, and sustainable innovation in the workplace.

From 2019 to 2022, the literature connected in Figure 5 demonstrates structural and intellectual development in the discourse on education for sustainability in higher education. Early articles (2019–2020) laid the conceptual and methodological foundations, while recent works (2021–2022) build upon and expand this understanding through a broader and more geographically and thematically diverse empirical context. This visualization effectively represents the evolution of ideas and the connectivity of references between studies, as well as mapping the mutually supportive and reinforcing research directions in shaping the current framework of sustainability education.

FIGURE 5. Example of bibliographic linking through documents

Conceptual and Thematic Structure of Curriculum Innovation in Geography Education

The co-occurrence overlay visualization in Figure 6 illustrates the evolution of thematic keywords based on publication year. Documents published from 2021 to 2022 are displayed in blue to green, indicating the emergence of topics or those that are increasingly dominant in the discourse on geography curriculum innovation. Keywords such as virtual reality, sustainable development goals, STEM, spatial ability, environment, active learning, and pedagogy appear in the bright yellow area. This indicates that from 2022 to the present, there has been a shift in focus from structural aspects of the curriculum toward contextual learning and practical competencies. This is in line with post-pandemic global needs and climate crisis pressures, which require a curriculum that is more oriented towards strengthening spatial reasoning, problem-solving skills, and sustainability responsibility (Day et al., 2021).

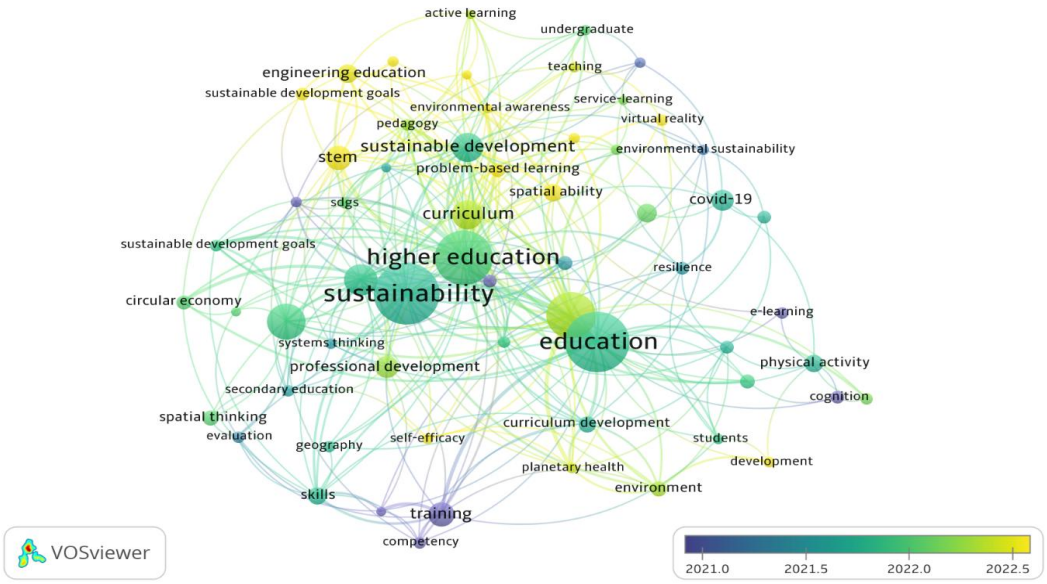


FIGURE 6. Co-occurrence overlay visualization authors keywords

Table 4 shows the most frequently occurring keywords with high total link strength, particularly in publications from 2021 to 2022. The keywords “sustainability” (68 occurrences), ‘education’ (65), and “higher education” (58) remain the main concepts, but since 2021, there has been a strengthening of the terms “climate change” (48), “problem-based learning” (11), and “training” (22). This indicates that current research is not only focused on what is taught (curriculum content) but also on how it is taught (pedagogy) and the competencies being developed. For example,

when applied to the context of Indonesia, the emergence of the keywords "problem-based learning" and "skills" reflects a shift toward active, participatory, and real-world context-based learning, which is an important part of the 21st-century learning approach in the Merdeka Belajar Curriculum (Sobirin et al., 2024).

TABLE 4. Top 15 Related Keywords

Keyword	Occurrences	Total Link Strength
Education	65	82
Sustainability	68	82
Higher education	58	73
Climate change	48	69
Curriculum	27	46
Sustainable development	26	34
Education for sustainable development	29	33
Environmental education	35	28
Curriculum development	13	23
Pedadogy	9	23
Training	22	23
Stem	22	22
Environment	12	21
Skills	14	19
Problem-based learning	11	19

Figure **7** clarifies the results presented in Figure 6 by providing examples of keyword networks derived from documents. In 2021–2022, it is evident that keywords such as “environmental education,” “STEM,” “education for sustainable development,” and “skills” are closely tied to more traditional terms, including curriculum and pedagogy. The bright colors on these nodes indicate that these studies are still new but are beginning to form the core of the conceptual structure of this field. This demonstrates the strengthening of connectivity between sustainability issues, curriculum, and teaching methods at the higher education level. In other words, recent research has moved from foundational concepts toward direct interventions in geography education practices. In line with the findings of Wang et al. (2022), this discusses how pedagogy in higher education is directed toward strengthening students' sustainability competencies. This is also relevant to the findings of Price et al. (2021), which advocate for universities as centers of social transformation through the integration of sustainability into the entire education system, including curriculum design.

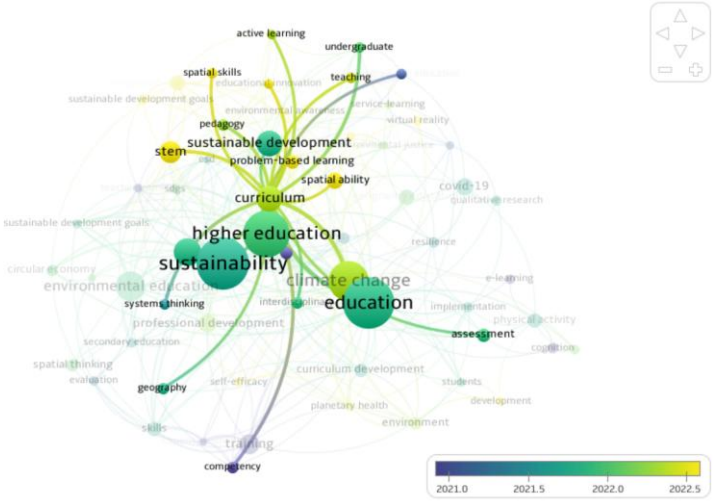


FIGURE 7. Example of co-occurrence overlay visualization of authors' keywords

Table 5 provides an indication of low-frequency but important keywords, particularly as some of them appear in publications from 2021 to 2022 and may serve as indicators of future research directions. For example, “spatial

thinking" (12 occurrences) and "virtual reality" (9 occurrences) reflect the emergence of digital technology and spatial thinking approaches in geography education, which had not been widely discussed previously. Keywords such as e-learning, qualitative research, and teaching also indicate the exploration of more flexible and adaptive teaching methods and media, especially in the context of the pandemic. Thus, despite their low quantitative ranking, the keywords in this table hold strategic value in expanding the scope of curriculum innovation toward technology, spatial-digital, and experience-based learning.

TABLE 5. Bottom 15 related keywords

Keyword	Occurrences	Total Link Strength
e-learning	9	3
Spatial thinking	12	4
Geography education	15	4
Cognition	10	4
Spatial skills	8	5
Qualitative research	10	5
Geography	9	5
development	8	5
Virtual reality	9	6
Undergraduate education	8	6
Green skills	7	6
children	9	6
Service-learning	7	7
Physical activity	14	7
Teaching	7	7

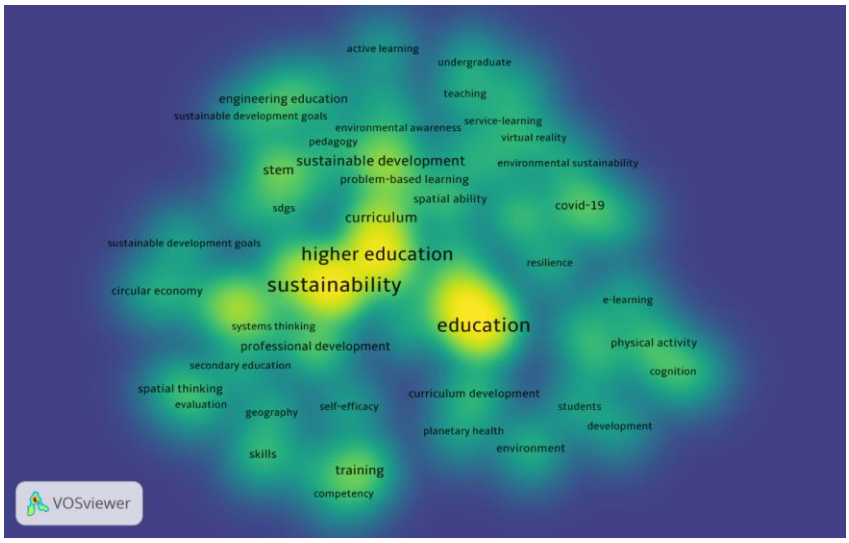


FIGURE 9. Co-occurrence density visualization authors keywords

Based on Figure 9, which illustrates the density of keywords that appear together based on link strength. The bright yellow area, which dominates the center of the network, indicates the highest concentration of keywords, including sustainability, education, climate change, and higher education, all of which are prevalent in publications from 2021–2022. This visualization explicitly confirms that, over the past two years, this field has shifted toward conceptual consolidation in the areas of sustainability and competency development in higher education. The darker colors on the periphery of the network, representing keywords such as spatial thinking, green skills, and e-learning, mark growing areas of research that could be important directions for further research. This aligns with the core concept of Duarte et al. (2020), which promotes project-based learning approaches in engineering education as a means of developing sustainability competencies and fostering cross-cultural teamwork. This view is supported by al. (2022), who explain

how social responsibility practices and Industry 4.0 technologies can be integrated into sustainable higher education systems. Previous studies have provided evaluations, such as criticizing the national curriculum framework for failing to support visionary and innovative geography education, which is relevant for the 2021–2022 curriculum update (Rawling, 2020). This then forms the basis for how pedagogy in geography education is directed to strengthen sustainability competencies in the face of global climate change issues (Wang et al., 2022). These findings directly address the research question regarding how conceptual and thematic developments occur in curriculum innovation research in geography education, particularly in responding to global dynamics, 21st-century competency demands, and the need for sustainable and transformative education.

CONCLUSION

This bibliometric study provides a comprehensive overview of the development, intellectual structure, and thematic evolution of research on curriculum innovation and competency-based approaches in geography education from 2019 to 2024. Based on data analysis from Scopus and visualizations generated using VOSviewer, three major findings were identified.

First, publication trends demonstrate a continuous increase since 2019, reaching their highest level in 2023–2024. The dominance of publications from developed countries such as the United States, the United Kingdom, China, and Spain reflects the growing global recognition of geography education as an interdisciplinary and transformative field. Second, the intellectual structure of this domain is characterized by strong bibliographic linkages among influential works, particularly those by Fuertes-Camacho, Cebrián, and Shaw, which emphasize sustainability-oriented curriculum design, project-based learning, and transformative pedagogy within the framework of Education for Sustainable Development (ESD). Third, the conceptual and thematic structures reveal a significant shift toward integrating digital technology and developing 21st-century competencies. Emerging research topics, such as problem-based learning, virtual reality, green skills, and spatial thinking, indicate a shift toward a more experiential, digitally enhanced, and sustainability-driven geography curriculum.

Despite these contributions, several methodological limitations should be acknowledged. This study relies exclusively on Scopus-indexed and English-language publications, which, although comprehensive, may exclude relevant works published in other databases or local languages. Such limitations could result in an underrepresentation of research from non-English-speaking and developing regions. Moreover, the bibliometric approach, being quantitative in nature, does not allow an in-depth examination of the substantive content and pedagogical nuances of each study. Future research is therefore encouraged to adopt a more inclusive and mixed-method strategy that combines bibliometric mapping with qualitative content analysis, thereby offering deeper insights into theoretical integration and pedagogical practice.

The findings of this study hold several implications for curriculum stakeholders in geography education. For curriculum developers, the increasing prominence of sustainability, spatial reasoning, and digital literacy highlights the importance of integrating competencies such as GIS literacy, environmental responsibility, and global citizenship into the curriculum. For teachers, the trends underscore the importance of adopting inquiry-based, project-oriented, and technology-supported learning models that cultivate students' critical and spatial thinking skills. For teacher education institutions, these findings underscore the need to enhance professional training programs that prepare future educators to effectively apply competency-based and technology-integrated pedagogies. By connecting theoretical frameworks, such as Tyler's Objective Model, Taba's Grassroots Model, and Stenhouse's Process Model, with contemporary global educational trends, this study contributes to bridging the theoretical discourse and classroom practice.

In summary, curriculum innovation in geography education is evolving toward a more contextual, action-oriented, and sustainability-focused paradigm. This transformation not only aligns with global educational priorities but also calls for the development of locally adaptive strategies that enable geography education to serve as a catalyst for building global competence, environmental awareness, and lifelong learning in the 21st century.

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