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Culturally Responsive STEM Teaching in Higher Education: A Decade of Bibliometric Analysis

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Abstract

This study conducts a bibliometric analysis about culturally responsive teaching within the Science, Technology, Engineering, and Mathematics (STEM) in higher education from 2015 to 2025. With the utilization of VOSviewer software, the co-citation and co-word analysis were performed. This study involves 1,076 literature which explores the emerging literature of the field from the Scopus database. The findings revealed a 45 times increase in publication output, which displays a shift from an emerging inquiry to a global academic trend. While the United States remains the primary producer and surging contributions from the developing nations. The intellectual basis is pioneered by journals on culturally relevant ways of teaching but the data show an important shift toward culturally sustaining pedagogies. One of the findings is the start of a digital frontier, which utilizes artificial intelligence and computer-based instruction for cultural applications. Furthermore, the overlay visualization revealed a trend from theory-based practices to emphasis on instructional pedagogies and teachers' development. This study concludes that the future of STEM education in a culturally bounded context depends on a complex combination of pedagogy and technology. These results promote a roadmap for educators and policymakers for the creation of inclusive learning that would sustain students' needs.

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Introduction

In the 21st century, the overview of higher education is consisting of paradox of rapid technological advancement and existing inequity in the educational system. Science, Technology, Engineering, and Mathematics (STEM) subjects serves as forefront of the global innovation by supporting economic growth and providing solutions to societal difficulties that range from climate change to public health crises (Akçay, 2024). But, even with the importance of these topics, STEM is described to have a lack of inclusivity that excludes significant numbers of the global population (Lynch et al., 2018). For decades, the marginalized groups that include students of color, gender, and those from lower socioeconomic backgrounds have struggled due to structural barriers that prohibit their access within STEM higher education (Pierszalowski et al., 2021). The exclusion of some populations is not only a matter of social justice, but it is a threat to the scientific realm itself due to the overlooked diverse perspectives that are essential for creative problem-solving and ethical oversight needed in modern research.

Moreover, as a way to relieve these inequalities, the academic trends have shifted from a deficit-based model, which pinpoints students for their lack of success, into a pedagogical model that fosters inquiries within the classroom environment and institutions (Teessar, 2024; Ammar et al., 2024). The intellectual foundation of this culturally relevant pedagogy is anchored by the research work of Ladson-Billings (1995), whose theory of Culturally Relevant Pedagogy (CRP) challenged the discriminatory approach to instruction. Ladson-Billings argued that students' academic success, cultural competence, and sociopolitical consciousness must be enhanced for the effective teaching process. This framework was further expanded by Gay (2010), who defined Culturally Responsive Teaching (CRT) as the use of the cultural intelligence, background experiences, and performance styles of different students to make the learning encounters more relevant to and effective for them.

As the field matured between 2015 and 2025, a significant shift occurred toward what Django Paris (2012) termed Culturally Sustaining Pedagogy (CSP). Differing from the earlier models that aim to bridge the difficulties between home and school as a means to an end, CSP seeks to improve linguistic, literacy, and cultural pluralism as a democratic project. In the context of STEM, this involves the students' recognition of the skills and knowledge sets developed within their communities to serve not as obstacles to scientific learning but as essential assets that can promote innovation and inquiry (Tavdgiridze et al., 2024).

One of the common criticisms of equity-based pedagogies was the perceived benefits and disadvantages between cultural relevance and academic rigor. However, the data from recent years shows a strong effort to integrate these two domains. The National Research Council's (2012) Framework for K-12 Science Education and the Next Generation Science Standards (NGSS, 2013) have become central foundations in this integration. These frameworks solidify science as a social process and that science involves engaging in practices that are relevant to communication, collaboration, and community-based problem-solving. By the alignment of CRP with these high standards, higher education institutions are commencing the novel view of equity as a hallmark of effective teaching rather than a supporting social initiative.

Recent bibliometric and science mapping studies have begun to document the broader development of culturally

responsive teaching. Karagöl (2025) analyzed culturally responsive teaching scholarship using Web of Science data from 1995 to 2025 and reported increasing scholarly attention to the field, with themes such as identity, culture, race, practices, and pre-service teacher education. Similarly, Tien et al. (2024) conducted a science mapping review of culturally responsive teaching in early childhood education using Scopus data, PRISMA procedures, and VOSviewer. While these studies provide important bibliometric foundations, they do not specifically examine the intersection of culturally responsive teaching, STEM disciplines, higher education, equity, faculty development, and emerging technologies. This gap justifies the present study's focus on culturally responsive STEM teaching in higher education from 2015 to 2025.

Moreover, the most recent and most disruptive shift in STEM education is the fast integration of Artificial Intelligence (AI) and computer-aided instruction in teaching practices (Moravec & Martínez-Bravo, 2023; Hutson et al., 2022). AI provides many opportunities for customized learning, rapid feedback, and setting of high-quality instruction (Kaswan et al., 2024; Admane et al., 2024). On the other hand, it also causes significant risks. If AI systems are trained on biased database or designed within a monocultural system, there is an increased risk of automating the inequities that CRP seeks to resolve (Mergen et al., 2025).

This brings the field to a critical juncture of the digital frontier of culturally responsive STEM teaching. There are now explorations on ways AI can be utilized to aid diverse learners, enhance a sense of belonging, and provide inclusive learning environments (Lin et al., 2024; Salas-Pilco et al., 2022). This involves moving away from viewing AI as a neutral agent and treating it as a culturally mediated tool that requires human agency and ethical oversight to remain equitable.

The rapid growth of the publication output in this domain poses an urgent need for a systematic mapping of the literature. Bibliometric analysis provides a comprehensive way through which to understand the intellectual structure of culturally responsive teaching (Fitri et al., 2024). With the use of co-citation analys, the study would identify the foundation of the discipline and co-word analysis to trace the changes in thematic trends. Therefore, researchers can aid the individual studies with a more general view on how knowledge is constructed and disseminated. This study utilizes VOSviewer software to analyze a decade of research to provide a guide for educators and policymakers to comprehend the intersection of pedagogy and equity in higher education.

Despite the existing literature, a gap remains in the practical implementation of these frameworks within the STEM domains of higher education. Many STEM faculty members are experts in their technical fields but have inadequate pedagogical training to create inclusive environments or lack the navigation to the ethical complexities of AI-mediated instruction (Leon et al., 2025). Furthermore, the geographic concentration of the studies in the United States highlights a need for a more globalized perspective that deals with the different cultural contexts of students worldwide. Without a clear understanding of how the field has changed and where the current trends lie, educational efforts toward diversity and inclusion would remain ineffective and fragmented.

In addition, the future of STEM higher education relies on our ability to synthesize the scientific inquiry with the transformative power of culturally sustaining pedagogy. As we move further into the era of AI and automated

instruction, the findings from the past decade of research become more vital. By embedding our technological innovations in the social constructivist theories and the justice-based frameworks, there is an assurance that the STEM classrooms of the future are spaces where all students, regardless of their cultural background, can thrive, innovate, and lead. This study serves as an important reflection on how far this field has come and a strategic guide for the future generation of learners.

Review of Related Literature

The intellectual nature of culturally responsive STEM teaching in higher education has a sophisticated combination of pedagogical theory, sociopolitical frameworks, learning sciences, and disciplinary standards. At the core of the field lies the seminal work of Ladson-Billings in 1995, which established the theory of culturally relevant pedagogy. This framework implies that effective teaching must satisfy the three criteria, which are academic success, cultural competence, and sociopolitical consciousness. With this theory, Gay's (2010) definition of culturally responsive teaching stresses the usage of the cultural characteristics and experiences of ethnically diverse students for more effective teaching.

There are studies that focus on teacher agency and beliefs. The inclusion of Bandura's (1997) self-efficacy theory and Zeng et al. (2025) work on stereotype threat that signifies a teacher's stance is not neutral because their expectations and ability to create an identity-affirming environment could directly impact student performance in STEM contexts. Recently, this praxis has included the role of the educator as a mediator of technology, where AI is viewed as an extension of the teacher's pedagogical view rather than a replacement for it (Porayska-Pomsta, 2016).

Nowadays, a shift has occurred from relevance to sustainability and systemic critique. This is anchored by Paris (2012) and Alim & Paris (2017), who proposed culturally sustaining pedagogy (CSP). CSP changes the focus from simple acknowledgement of student culture to actively enhancing linguistic and cultural inclusion. This domain integrates Critical Pedagogy (Freire, 1970) to interrogate the power dynamics inherent in STEM education. Moreover, Morales-Doyle (2017) and Bullock (2017) argue that STEM education should be a site for social justice. This view is now being utilized to AI, investigating the way algorithms may reproduce racial or gender biases and aiming for equity literacy among both students and faculty to navigate these automated systems.

The theoretical background of the field is provided by the learning sciences, specifically social constructivism and situated learning. The works of Vygotsky (1978) provide the mechanism for understanding how learning occurs through social interaction and participation in communities of practice. In the realm of higher education STEM, there is a notion that knowledge is not a constant group of facts but a co-constructed process. The application of universal design for learning (UDL) propels advocacies toward inclusivity. These theories provide the framework for AI-mediated environments, suggesting that digital tools are most effective when they facilitate collaboration and experiential learning rather than rote memorization.

This domain is characterized by the NRC Framework (2012) and the NGSS (2013), which emphasize inquiry-

based practices and crosscutting concepts. The integration of funds of knowledge (Gonzalez, Moll, & Amanti, 2005) is vital here, advocating for the use of students' household and community assets as valid scientific sources. There are studies describe how culturally responsive techniques are embedded in STEM academe and policy. In the current era, context of learning has changed, where AI applications are utilized to solve the gap between abstract scientific concepts and the real-world experiences of different learner populations.

Recent bibliometric and science mapping studies imply a basis for understanding the broader development of culturally responsive teaching. Karagöl (2025) conducted a bibliometric investigation about culturally responsive teaching using the Web of Science database from 1995 to 2025. The study analyzed 551 English-language articles, review articles, and book chapters and reported a steady annual growth rate that indicates an increasing scholarly emphasis to CRT. The thematic analysis identified key areas that includes identity, culture, race, practices, and pre-service teacher education, that offers a broad map of CRT as an expanding research field. Similarly, Tien et al. (2024) conducted a mapping review of culturally responsive teaching in early childhood education using Scopus-indexed journal articles, PRISMA procedures, and VOSviewer. Their analysis of 562 journal articles confirmed the growing interest in CRT, in relation to family culture and the role of teachers. These studies are relevant to the present study due to the demonstration of bibliometric and science mapping approaches that can reveal publication trends, intellectual structures, and thematic developments in the CRT domain.

However, their scope is not the same as the present study, which specifically focuses on culturally responsive STEM teaching in higher education from 2015 to 2025. Thus, the current study addresses a more specialized gap by examining how CRT is connected to STEM disciplines, higher education contexts, faculty development, social justice, and emerging technologies such as artificial intelligence and computer-aided instruction. The literature displays an important gap in the long-term evaluation of AI-integrated culturally responsive teaching. Most studies target short-term interventions or theoretical frameworks. Furthermore, the publications from the U.S. are abundant, but there is a clear need for research that examines how the different domains intersect in diverse global contexts to ensure that the digital frontier of STEM education remains inclusive.

Research Objectives and Hypothesis Formulation

The purpose of this study is to provide a comprehensive bibliometric analysis of culturally responsive STEM teaching in higher education from 2015 to 2025. Specifically, this study targets to:

1. Provide quantity the growth and geographic distribution of the research to identify main centers of research production.
2. Create a map about the intellectual composition of the culturally responsive pedagogy with co-citation analysis to identify the most influential authors and theoretical clusters.
3. Identify emerging thematic trends through co-word analysis, with a focus on the combination of AI and equity.
4. Analyze the temporal evolution of the discourse to understand how the field has moved from theoretical advocacy to practical, technology-driven implementation.

Method

Research Design

This study applied a bibliometric analysis to examine, in an organized and systematic way, the intellectual, conceptual, and thematic trends of research on culturally responsive STEM teaching in higher education from 2015-2025. The analysis is a replicable research approach to summarize high volumes of academic literature by identifying publication patterns, citation impact, co-citation composition, and keyword co-occurrence (Donthu et al., 2021; Zupic & Čater, 2015). The study applied performance analysis, which measured productivity and impact indicators such as publication growth, country distribution, and citation metrics, with science mapping, which explored the intellectual foundation and conceptual overview through co-citation and co-word network analyses.

Data Source and Retrieval

The literature was garnered using the Scopus database, which was chosen due to the wide indexing of high-quality journals, conference proceedings, and book chapters in different fields of education, engineering, and technology-related fields. The Scopus database is applied in bibliometric analysis due to its reputable citation indexing, standardized metadata, and compatibility with bibliometric analysis tools such as VOSviewer. The final word search string applied in Scopus was:

("culturally responsive teaching" OR "culturally relevant pedagogy") AND ("STEM education" OR "STEM teaching" OR "science, technology, engineering, and mathematics") AND ("tertiary education" OR "higher education" OR "college") AND ("students" OR "learners") AND ("diversity" OR "cultural diversity" OR
"inclusive education")

Table 1. Search String in Scopus Database

No.	Keywords / Operators	Justification
1	"culturally responsive teaching" OR "culturally relevant pedagogy"	These keywords imply the main pedagogical approach explored in the study. The OR operator was utilized to include related terms that may be used interchangeably in the literature.
2	"STEM education" OR "STEM teaching" OR "science, technology, engineering, and mathematics"	These words describe the disciplinary meaning of the topic. The use of the OR operator makes the search more general to utilize articles with the acronym STEM or the complete term for STEM.
3	"tertiary education" OR "higher education" OR "college"	These words narrows the bibliometric search to the aimed level of the study, which is postsecondary education or higher education.
4	"students" OR "learners"	These keywords narrow the target population of the study. The use of the OR operator provides the inclusion of studies with participants referred to as students or learners.
5	"diversity" OR "cultural diversity" OR "inclusive education"	These words aim to apply the diversity and inclusion dimension of the topic. Using the OR operator aids in retrieving studies that describe diversity from different but related perspectives.

This structured search strategy enables the identification of literature at the commonalities of culturally responsive teaching and STEM in higher education that forms a conceptually coherent dataset for the bibliometric analysis.

Inclusion and Exclusion Criteria

To ensure the quality and relevance of the dataset, the strict implementation of inclusion and exclusion criteria was used. The selected publications were included if they were from reviewed journal articles or conference proceedings published in English between 2015 and 2025, explicitly focused on culturally responsive STEM teaching in higher education. The empirical studies and conceptual or review articles were also included. The duplicate records and those with incomplete metadata were also removed.

Data Cleaning and Preparation

The data were downloaded from Scopus in CSV format, which were processed with the aid of VOSviewer software (van Eck & Waltman, 2010). The cleaning process has several procedures for the assurance of data integrity. The removal of duplicates was based on DOI and title matching, and author disambiguation was done using Scopus Author IDs, with manual validation of highly cited authors. The affiliations and country names were screened (e.g., "USA" and "United States"), and author keywords were applied by combining synonyms, setting spelling variations, and eliminating irrelevant words. The vague records were manually screened based on titles and abstracts, and publication years to make sure that all entries fell within the correct timeframe. The final cleaned dataset served as the basis for all subsequent analyses.

Analytical Techniques

Three complementary bibliometric techniques were applied, which are the performance analysis, co-citation analysis, and co-word analysis. The performance analysis calculated the publication output, citation counts, and h-index values that create insights into research productivity and academic impact (Donthu et al., 2021). In addition, the co-citation analysis described the intellectual basis of the field by screening references that are frequently cited together. And the co-word analysis mapped the thematic insights reflected in the co-occurrence of author keywords (Chen & Lien, 2011; Klarin, 2024).

To make sure of analytical aspect of the study, thresholds were utilized based on sensitivity testing and topic standards. A minimum of 20 citations was utilized for the co-citation network aspect. This was the parameter used to capture approximately the top 1% of most cited references in the dataset by analyzing the most influential works and maintaining network coherence. Similarly, a minimum of 13 keyword occurrences was applied in the co-word analysis, and a threshold was set through repetitive assessment to have a reliable interpretation of data. The lower thresholds would make overly dense networks with limited conceptual resolution, but the higher thresholds exclude connected emerging terms. The criteria provide an optimal result with precision. For the co-word analysis, author keywords were analyzed using fractional counting with a co-occurrence threshold of at least 13, yielding 3,437 keywords.

Results

Descriptive Characteristics

Figure 1 illustrates the annual growth of publications on culturally responsive STEM teaching in higher education from 2015-2025.

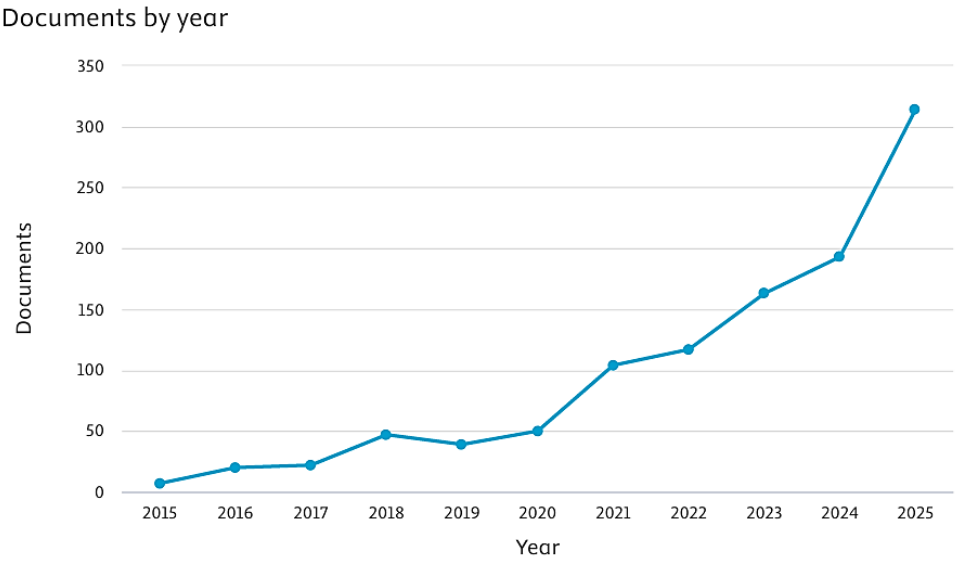


Figure 1. Annual Growth of Publications on Culturally Responsive STEM Teaching in Higher Education from 2015-2025

Figure 1 displays the direction of trend of publication in every year of academic papers featuring culturally responsive STEM teaching at the higher education level. This upward direction exhibits a continuous increase in the literature outputs over the publication period. The number of publications have soared from seven documents in 2015 to 314 studies in 2025. This depicts an increase of approximately 45 times in terms of produced publications. This sequence portrays that culturally responsive teaching has become a rapidly expanding topic within higher education and the STEM domain.

Moreover, when the trend was examined, it was revealed that there are two phases of development. From 2015 to 2020, the publication growth was in increments, ranging from 7 to 50 publications, with a low decrease in 2019. On the other hand, from 2021 to 2025, there is an increase in research output, with 104 publications in 2021 and rising to 314 publications in 2025. In addition, the steeper stance after 2022 depicts a developed research interest in culturally responsive strategies applied to STEM teaching at the tertiary level.

This ascending disposition displays a more level global awareness and appreciation of equity, inclusion, and culturally relevant teaching practices in the education realm. The perceived trend of trajectory reveals that STEM instructors are recognizing the significance of giving solutions to the puzzling difficulties brought by diversity students within STEM learning setups. Utilizing a bibliometric view, the continuous uplift in publication number implies the increased relevance of this research on culturally relevant teaching strategies.

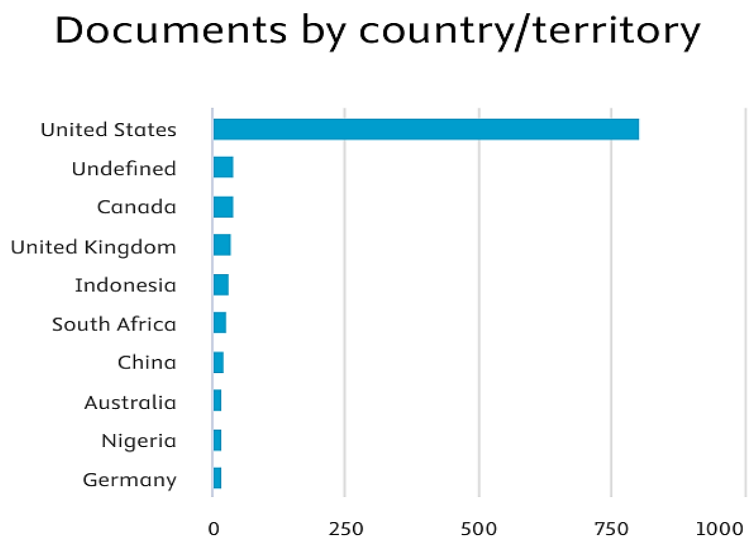


Figure 2. Top 10 Most Productive Countries and Territories in Research on Culturally Responsive STEM Teaching in Higher Education from 2015-2025

Figure 2 reveals the most productive countries in research on culturally responsive STEM instruction, focusing on the tertiary level from 2015 to 2025. The distribution is dense that highlights the United States as the primary contributor to the peak number of literature compared with other countries presented. This surge of publications implies that the scholarly spotlight on culturally responsive STEM teaching in higher education has been shaped mainly by research produced within the U.S. settings.

The major literary works from the United States were caused by the country's strong academic practices which include equity, diversity, and inclusion, particularly in relation to STEM participation. Due to culturally responsive teaching with theoretical and practical roots in the U.S. educational landscape, the country serves as the principal knowledge producer in the field. Aside the United States, the other countries that include Canada, the United Kingdom, Indonesia, South Africa, China, Australia, Nigeria, and Germany display limited but still meaningful contributions. The presence of the works from these countries indicates that research on culturally responsive STEM teaching is gradually gaining international attention, but still has uneven distribution across global regions. The traced pattern emphasizes the leading literature from Western-oriented research, while contributions from many parts of Asia, Africa, Latin America, and other marginalized regions remain few.

Figure 2 includes an undefined category, which refers to Scopus-indexed records with incomplete, unavailable, or non-standardized affiliation-country metadata. In the present dataset, this category accounted for 38 documents; therefore, it was retained in the figure for transparency but was not treated as a separate country or territory in the interpretation of geographic productivity. Its presence indicates a minor metadata limitation that may slightly affect the precision of the country-level distribution, especially among countries with smaller publication counts. However, because the number of undefined records is relatively small compared with the output of the United States, it does not substantially change the main finding that research on culturally responsive STEM teaching in higher education remains largely U.S.-centered while gradually expanding across other national contexts.

Overall, Figure 2 highlights a geographical imbalance in the writing of literature on culturally responsive STEM teaching within the higher education context. While the field is beginning to extend across multiple national contexts, its intellectual strength remains anchored in the United States. This finding calls for the need for more geographically diverse outputs to broaden the theoretical, cultural, and academic perspectives represented in the literature. The expansion of contributions from non-Western and other contexts would strengthen the stance of the field and support a more inclusive understanding of culturally responsive STEM teaching in higher education level.

Citation Analysis

Table 2 presents the top 10 most cited documents in the dataset about the culturally responsive teaching of STEM in tertiary level.

Table 2. Top 10 Most Cited Documents

Rank	Author(s)	Year	Title	Journal Title	Citations
1	Ong	2018	Counterspaces for women of color in STEM higher education: Marginal and central spaces for persistence and success	Journal of Research in Science Teaching	487
2	Kim	2018	Developing a STEM Identity Among Young Women: A Social Identity Perspective	Review of Educational Research	328
3	Morris	2017	Reconceptualizing the Sources of Teaching Self-Efficacy: a Critical Review of Emerging Literature	Educational Psychology Review	288
4	McGee	2017	The Troubled Success of Black Women in STEM	Cognition and Instruction	256
5	Pinkard	2017	Digital Youth Divas: Exploring Narrative-Driven Curriculum to Spark Middle School Girls' Interest in Computational Activities	Journal of the Learning Sciences	252
6	Zidny	2020	A Multi-Perspective Reflection on How Indigenous Knowledge and Related Ideas Can Improve Science Education for Sustainability	Science and Education	239
7	Leonard	2016	Using Robotics and Game Design to Enhance Children's Self-Efficacy, STEM Attitudes, and	Journal of Science Education and Technology	224

Rank	Author(s)	Year	Title	Journal Title	Citations
			Computational Thinking Skills		
8	Ives	2020	First-Generation College Students as Academic Learners: A Systematic Review	Review of Educational Research	212
9	Cochran-smith	2016	Initial teacher education: What does it take to put equity at the center?	Teaching and Teacher Education	206
10	Mensah	2018	Preservice and Inservice teachers' ideas of multiculturalism: Explorations across two science methods courses in two different contexts	Journal of Science Teacher Education	189

Table 2 presents the top 10 most cited documents from the set of data that reflects significant literary contributions in the fields of STEM education, teacher training, and professional development. These highly cited documents implies the uplift of academic interest in the topics that includes diversity, equity, and inclusion in STEM disciplines. According to the study of Ong in 2018, about the counterspace for women of color in STEM higher education, leads the list with 487 citations which signifies the importance of creating nurturing environments for marginalized populations. Also, the other notable publications include Kim's (2018) study on the development of STEM identity among young women, which has received 328 citations, and McGee's (2017) examination of the challenges Black women face in STEM fields, with 256 garnered citations. In addition, the research on the integration of indigenous knowledge in science education (Zidny, 2020) and the role of robotics in enhancing STEM skills among children (Leonard, 2016) were highlighted. These highly cited works reflect the evolving focus on fostering inclusive and culturally relevant practices in STEM education which offers valuable data for future research and pedagogical approaches.

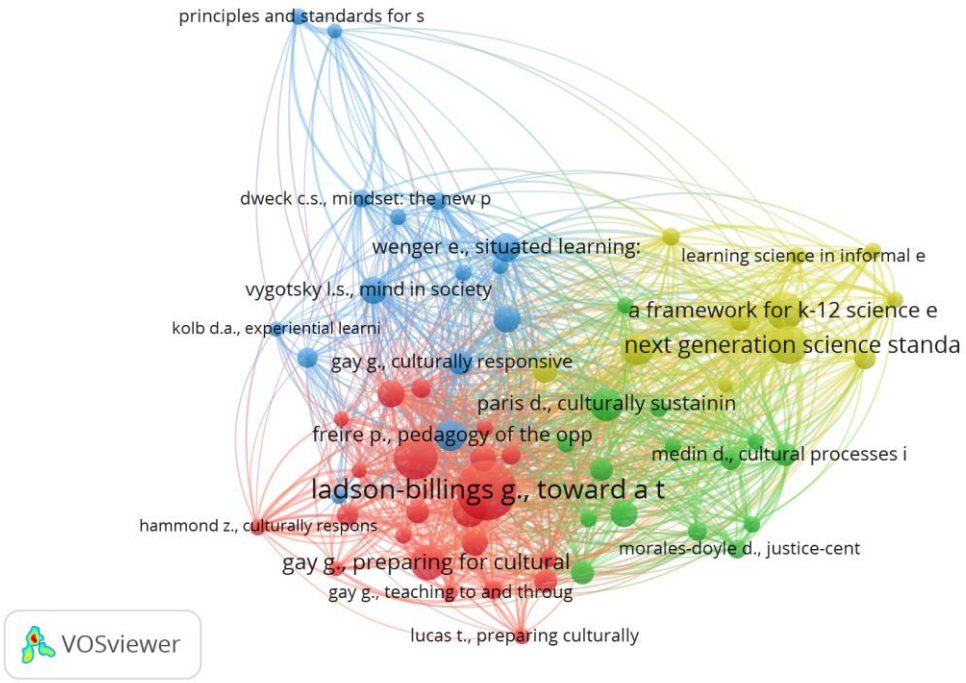
Please use a 10-point font size and justify the text. Manuscripts should be spaced at 1.5 lines. Each paragraph should contain at least three sentences. Footnotes and endnotes are not accepted; all relevant information should be included in the main text. Do not indent paragraphs; instead, leave a 1.5-line space between consecutive paragraphs. Do not underline words for emphasis—use italics instead. Numbered lists and bulleted lists may be used if necessary. Before submitting your manuscript, please ensure that every in-text citation has a corresponding entry in the reference list, and that every reference list entry has a matching in-text citation.

Co-citation Analysis

The co-citation analysis accessed 63 key references (≥20 citations) from a sum of 126,320 cited references that reflects the intellectual structure that emphasizes research about culturally responsive STEM teaching in higher education. Table 2 lists the top ten most co-cited publications, which provide guidance into the core literary foundations of this field.

Table 3. Top 10 Most Co-Cited Documents and Their Total Link Strength

Rank	Author(s)	Year	Title	Citations	Total Link Strength
1	Ladson-Billings, G.	1995	Toward a Theory of Culturally Relevant Pedagogy	240	950
2	National Research Council	2012	A Framework for K-12 Science Education: Practices, Crosscutting Concepts, and Core Ideas	103	821
3	NGSS Lead States	2013	Next Generation Science Standards: For States, By States	107	818
4	Gay, G.	2010	Culturally Responsive Teaching: Theory, Research, and Practice	132	561
5	Paris, D.	2012	Culturally Sustaining Pedagogy: A Needed Change in Stance	78	529
6	Gonzalez, N., Moll, L., & Amanti, C.	2005	Funds of Knowledge for Teaching: Using a Qualitative Approach to Connect Homes and Classrooms	79	517
7	Alim, H. S., & Paris, D.	2017	Culturally Sustaining Pedagogies: Teaching and Learning for Justice in a Changing World	59	437
8	Gay, G.	2000	Culturally Responsive Teaching: Theory, Research, and Practice	87	382
9	Wenger, E.	1998	Communities of Practice: Learning, Meaning, and Identity	64	352
10	Vygotsky, L. S.	1978	Mind in Society: The Development of Higher Psychological Processes	55	350



Source: Author interpretation based on VOSviewer analysis

Figure 3. Co-citation Network of Influential References on Culturally Responsive STEM Teaching in Higher Education

The co-citation analysis implies that the intellectual sources of culturally responsive STEM teaching literature is headed by the work of Ladson-Billings (1995), which is most influential document that garnered 240 citations and 950 total link strength (TLS). This indicates that the theoretical notions about culturally relevant pedagogy are the primary bridges that related different research areas within the field. The other following works are the National Research Council's Framework for K-12 Science Education (2012) and the Next Generation Science Standards (2013), which have TLS scores of 821 and 818, respectively. The immense level of connectivity of these policy documents proves a strong academic effort to apply culturally responsive teaching into the high-quality standards of STEM education.

Furthermore, the mapping has located a change toward more novel frameworks, which are Culturally Sustaining Pedagogy, highlighted by Paris (2012) and Alim & Paris (2017). In addition, the Gay's (2010) research on culturally responsive teaching, makes a dense cluster of pedagogical techniques that emphasize the vitality of students' cultural identities. Additionally, the inclusion of foundational learning theories from Vygotsky (1978) in the top 10 most co-cited works demonstrates that the field is deeply rooted in social constructivism. The mapping proves that culturally responsive STEM teaching in higher education is not a passing trend but a mature academic discipline that successfully blends social justice, psychological learning theories, and standardized scientific practices.

Table 4. Thematic Clusters Identified Through Co-citation Analysis of Research on Culturally Responsive STEM Teaching in Higher Education

Cluster (Color)	Cluster Label	Representative Authors (Year)
Cluster 1 (Red)	Culturally Responsive Pedagogy and Teacher Practice	Ladson-Billings (1995, 2014); Gay (2000, 2010); Hammond (2015); Bandura (1997); Aronson (2002)
Cluster 2 (Green)	Critical Pedagogy, Equity, and Culturally Sustaining Frameworks	Paris (2012); Ladson-Billings (2014); Freire (1970); Crenshaw (1989); Morales-Doyle (2017);
Cluster 3 (Blue)	Sociocultural Learning Theories and Inclusive Pedagogies	Vygotsky (1978); Wenger (1998); Kolb (1984); hooks (1994); Meyer et al. (2014)
Cluster 4 (Yellow)	STEM Curriculum, Standards, and Funds of Knowledge Integration	NGSS Lead States (2013); National Research Council (2012); Gonzalez et al. (2005); Tan (2013); Rogoff (2003)

The connections of culturally responsive STEM teaching into other literatures are organized into four interdependent clusters. At the middle of this structure is Cluster 1 about the foundations of culturally responsive pedagogy and teacher praxis, which is pioneered by the leading works of Ladson-Billings (1995), Gay (2010), and Hammond (2015). This cluster leads the network with a Total Link Strength (TLS) of 950 for Ladson-Billings, implies that the concepts of instructional decision-making and teacher beliefs are growing topics in the culturally responsive teaching domain. In addition, the inclusion of Bandura's self-efficacy theory and Aronson's stereotype

threat signifies that instructional interventions would be needed to align with equity-oriented initiatives.

The framework further stems into Cluster 2, which discusses critical pedagogy, equity, and culturally sustaining frameworks. This cluster emphasizes a strong tendency to systemic analysis, relevant to the literature of Paris (2012), Freire (1970), and Crenshaw's intersectionality. By the reduction of structural inequities relevant to race and power, this cluster signals that the field is engaging in transformative educational implications.

Complementing these critical perspectives is Cluster 3, focusing on sociocultural learning theories and inclusive pedagogical models, which provides the theoretical backbone for understanding learning processes. The presence of Vygotsky (1978) and Universal Design for Learning (UDL) frameworks implies that the lenses of social constructivism and communities of practice could be utilized within collaborative, context-dependent systems.

Finally, Cluster 4 highlights the science education standards, STEM integration, and funds of knowledge that signify the applied disciplinary dimension of the field. This is led by high-impact references that include the NRC Framework (TLS: 821) and NGSS (TLS: 818), alongside the funds of knowledge literature by Gonzalez and Amanti. The prioritization of learners' cultural and community aspects are major components of STEM inquiry. This integrative structure supports the notion that culturally responsive STEM teaching in higher education is a growing academic discipline. This culturally responsive teaching combines foundational theories and social justice frameworks with the high-level academic requirements of changing science education.

Co-word Analysis

The co-word analysis unveiled the conceptual connections and thematic trends about the research on culturally responsive STEM teaching in higher education. From a sum of 3,437 unique author keywords, 66 met the minimum occurrence threshold and were utilized to generate the co-occurrence network. The mapping showed three major thematic clusters, each representing an interrelated research focus. Table 5 presents the top 15 most frequently occurring keywords, while Figure 4 visualizes the co-word network structure.

Table 5. Top 15 Keywords Identified in the Co-Occurrence Network Analysis

Rank	Keyword	Occurrences	Total Link Strength
1	students	187	872
2	teaching	141	643
3	engineering education	118	514
4	curricula	78	369
5	education computing	73	360
6	human	49	352
7	education	56	346
8	humans	43	327
9	stem (science, technology, engineering and mathematics)	51	260
10	student	35	236

Rank	Keyword	Occurrences	Total Link Strength
11	teachers'	47	232
12	female	25	196
13	male	24	193
14	professional aspects	36	180
15	curriculum	31	179

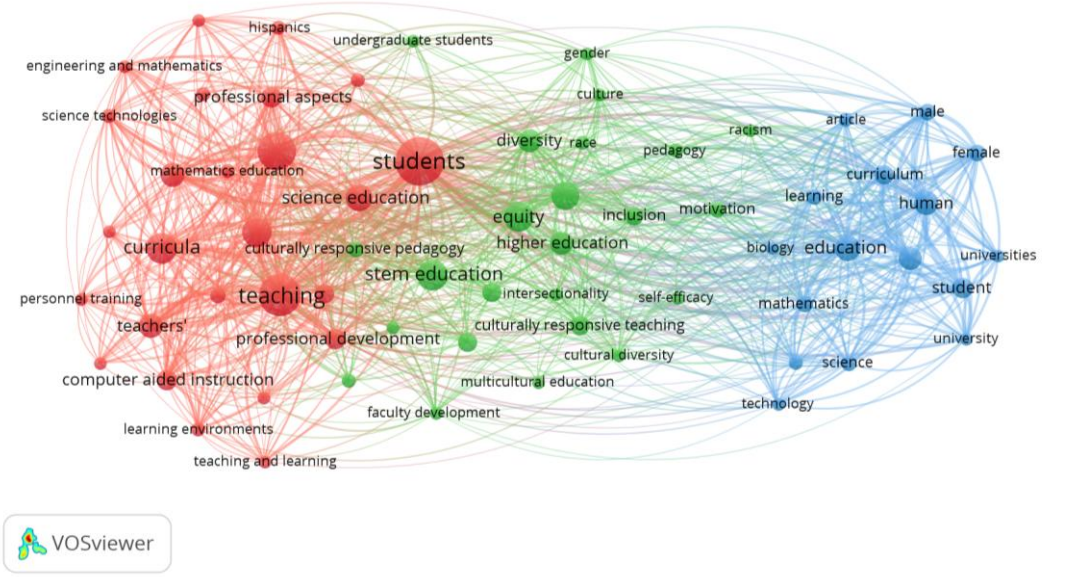


Figure 4. Co-word Network Visualization of Research on Culturally Responsive STEM Teaching in Higher Education

Cluster 1: Pedagogical Practice and Teacher Development

The red cluster is packed with terms that include "teaching," "students," "curricula," "science education," "mathematics education," and "professional development." This cluster presents the instructional and institutional focus of the field, which implies how culturally responsive approaches are applied in classroom practice and teacher preparation.

The terms "computer-aided instruction" and "learning environments" signify that pedagogical innovation, including technology integration, is embedded within culturally responsive teaching. In addition, the terms "Hispanics" and "engineering and mathematics" signify the underappreciated groups in STEM, reinforcing the applied, practice-oriented nature of this cluster. This cluster shows a strong emphasis on implementation, where culturally responsive STEM teaching is operationalized through curriculum design, instructional strategies, and teacher professional learning.

Cluster 2: Equity, Diversity, and Theoretical Foundations

This cluster has keywords that include "equity," "diversity," "inclusion," "culture," "intersectionality," and

"culturally responsive pedagogy." The center and connection to other keywords unveil that it acts as the conceptual reference of the network. The terms "higher education," "STEM education," "self-efficacy," and "motivation" signify that this second cluster connects macro-scale equity concerns with more specific learner results. The strong co-occurrence of "equity" and "pedagogy" signifies that culturally responsive teaching is intended as a method and as a civic duty. This cluster connects the field of equity-driven and culturally grounded frameworks by interacting with both research agendas and pedagogical orientations.

Cluster 3: Learning Contexts and Disciplinary Applications

The third cluster is composed of terms such as "education," "students," "learning," "science," "mathematics," "technology," and "universities." Compared to the first red cluster, which depicts pedagogy, the third cluster emphasizes learning processes, disciplinary contexts, and institutional settings.

The included demographic words, such as "male" and "female", focus on learner variability and participation patterns, while terms like "curriculum" and "learning" reveal outcome-oriented research. This cluster represents the contextual and empirical dimension of the field, where culturally responsive STEM practices are examined across disciplines and learner populations in higher education.

Table 6. Co-Word Analysis Clusters

Cluster (Color)	Cluster Label	Representative Keywords
Cluster 1 (Red)	Pedagogical Practice and Teacher Development	Active learning, case studies, curricula, engineering education, learning environments, professional development, science education, sense of belonging, social justice, teaching practices.
Cluster 2 (Green)	Equity, Diversity, & Critical Pedagogy	Broadening participation, cultural diversity, culturally relevant pedagogy, culturally responsive teaching, equity, intersectionality, multicultural education, race, racism, self-efficacy.
Cluster 3 (Blue)	STEM Disciplines & Higher Education Context	Biology, engineering, mathematics, science, technology, human/humans, female, male, universities, undergraduate students.

Although the co-word network reveals dominant themes in culturally responsive STEM teaching, it is also important to consider what remains less visible in the visualization. The prominence of terms such as “teaching,” “students,” “equity,” “diversity,” “professional development,” and “computer-aided instruction” suggests that the field is strongly shaped by institutional, pedagogical, and technology-oriented concerns. However, the limited visibility of keywords related to indigenous knowledge systems, decolonial education, multilingual learning, local ecological knowledge, and regional pedagogical traditions indicates that several epistemologies remain underrepresented in the indexed literature. This absence is analytically important because culturally responsive STEM teaching should not only adapt dominant STEM curricula to diverse learners but also recognize alternative

ways of knowing, community-based science practices, and non-Western intellectual traditions. Therefore, the co-word visualization should be interpreted not only as a map of dominant research themes but also as evidence of continuing gaps in whose cultural knowledge and regional experiences are made visible in global STEM education scholarship.

Overlay Visualization

The overlay visualization in Figure 5 visualizes a temporal mapping of the research about culturally relevant teaching in tertiary education. The crafted visualization simplifies the connections about culturally responsive STEM teaching that have turned from foundational theories to more technology-relevant applications between the year 2022 and 2024. The color changes, shifting from blue (2022) to yellow (2024), locates the changing trajectory of the scholarly field in culturally responsive teaching. In the earlier stages of this period, which are represented in blue and teal, the focus was concentrated on establishing the sociopolitical and theoretical framework for equity, with high activity around terms like "diversity", "higher education", and "culturally responsive pedagogy". This phase served as the platform for defining the field's core values and its necessity within the broader university context.

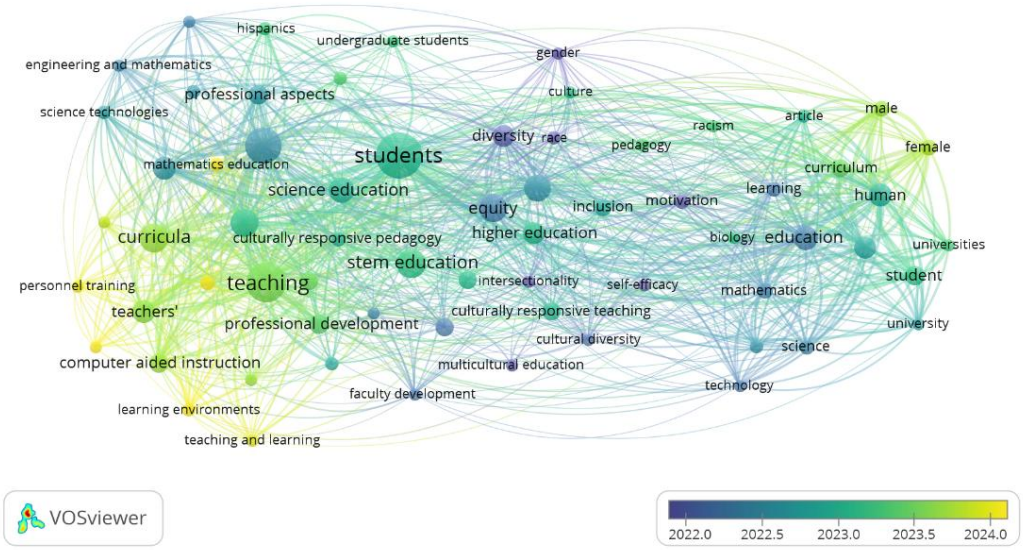


Figure 5. Overlay Visualization

As the research period reached the mid-2023, there was a profound calibration toward the social-psychological and disciplinary aspects of learning. With this given specific period, the words that include "self-efficacy" and "multicultural education" have a high influence, which indicates a sucession of probes into the process of cultural aspects and student performance in STEM subjects. This period aligned the general advocacy for diversity to understanding the internal processes that includes student's belief in their own capability.

As represented with yellow nodes (2024), the visualization map offers data about an uplift in demand about technological integration and teacher development programs. The current literary trends are revolving around "computer-aided instruction", "learning environments," and "professional development." This signifies that the culturally responsive teaching field is now redirecting focus on the process of digital transformation. For example,

the process on how AI and computer-mediated tools can be designed and used by educators to facilitate culturally responsive environments were being studied. The clusters of yellow nodes connecting to the teaching practices and instructors training emphasize that one of the priorities in this field is the equipping of the next generation of STEM faculty with the practical skills that are important to implement the theoretical frameworks.

Discussion

The bibliometric findings of this research offer a reliable guide of the evolution, intellectual foundations, and thematic paths of culturally responsive STEM teaching in higher education. The results display a field that has changed from a localized area of inquiry into a generally recognized accelerating research field.

The 45 times increase in literary output between 2015 and 2025 implies a significant paradigm shift in STEM education. This trajectory shows a re-route from traditional instructional models to an explicit recognition of the role that culture and identity play in higher education STEM learning settings. But the geographic analysis reveals an imbalance, with the United States acting as the primary knowledge producer. This dense research contribution from a country is due to the deep-seated historical roots of culturally relevant pedagogy (CRP) in American discourse, as discussed in the leading work of Ladson-Billings (1995). While the birth of contributions from Indonesia, South Africa, and Nigeria implies an increasing internationalization, the field remains primarily anchored in Western systems. For the discipline to achieve true global relevance, there is a need for cross-cultural validation of these frameworks in non-Western contexts where indigenous knowledge and different histories mold the STEM experience.

The co-citation analysis provides an intellectual structure built on three distinct layers. At the foundation lies the CRP (Ladson-Billings, 1995) and Culturally Responsive Teaching (CTR) (Gay, 2010). These works provide pedagogical implications for the field. The second layer integrates these theories with national science standards (NRC, 2012; NGSS, 2013), suggesting that scholars are successfully "operationalizing" equity within the rigorous constraints of STEM curricula. The third layer displays an evolutionary change toward culturally sustaining pedagogy (CSP) (Paris, 2012; Alim & Paris, 2017). While relevance seeks to connect school to home, sustainability seeks to actively perpetuate and foster linguistic and cultural pluralism as a democratic project. The inclusion of Vygotsky (1978) proves that these practices are not merely social interventions but are grounded in the social constructivist understanding that all learning is a socially situated process.

A compelling finding in the co-word analysis is the emerging role of technology, specifically artificial intelligence (AI) and computer-aided instruction, as mediators of culturally responsive teaching. The analysis suggests that AI is no longer viewed as a neutral instrument. Instead, as seen in Cluster 1, technology is being embedded within learning environments and professional development frameworks. The thematic alignment between Cluster 2 focusing on equity, intersectionality, and race and the technological keywords indicates a growing body of research concerned with algorithmic bias and the digital divide. There are existing inquiries on how AI can be utilized to support diverse funds of knowledge (Gonzalez et al., 2005) than an autonomous agent that enforces standardized, monocultural norms.

The findings of the present study extend recent bibliometric scholarship on culturally responsive teaching. Karagöl's (2025) broad mapping of CRT scholarship confirms the growing visibility of culturally responsive teaching as a research field, while Tien et al. (2024) demonstrates how science mapping can reveal thematic patterns in a specific educational level. However, the present analysis shows that culturally responsive STEM teaching in higher education has a distinct intellectual and thematic structure. Its dominant patterns are shaped not only by culture, identity, and equity, but also by STEM standards, faculty professional development, AI, computer-aided instruction, and the practical implementation of inclusive pedagogy. Thus, this study complements earlier bibliometric work by narrowing the focus to STEM higher education and by identifying how technological and equity-oriented themes are emerging within this specialized domain.

The overlay visualization locates a crucial maturation cycle of the research. In 2022, the discourse was mainly terminological and theoretical, focusing on defining diversity and higher education inclusivity. By 2023, the focus shifted to affective and psychological mechanisms, specifically self-efficacy and motivation. This move recognized that equity is not just about access, but about the internal identity-building of the student. By 2024, the frontier has moved into instructional praxis. The yellow nodes focused on personnel training and computer-aided instruction suggest that the current challenge is not why we should teach this way, but how we can train faculty to use modern digital tools to implement these theories at scale.

Limitations

This study has limits that must be assessed before the interpretation of the results. First, the dataset was limited to publications indexed in the Scopus database. Therefore, the findings would not represent all journal outputs about culturally responsive STEM teaching in higher education due to the existence of other publications from local journals, institutional repositories, books, and non-indexed sources.

Also, the study covered publications from the inclusive years, 2015 to 2025. This ten-year period was selected to highlight the recent development of culturally responsive STEM teaching. These outputs are related to equity, higher education, and emerging technologies. However, this timeframe may not include the prior works that contributed to the foundation of the field, except when such works appeared in the co-citation network.

Third, the search string was limited by the specific keywords and inclusion criteria utilized in this bibliometric study. Other relevant studies may have applied different terms such as culturally sustaining pedagogy, equity-centered STEM instruction, inclusive STEM education, indigenous science education, or justice-oriented STEM teaching. Therefore, the results should be analyzed as a bibliometric representation of the literature retrieved through the defined search parameters.

In addition, this study relied on bibliometric indicators such as publication output, citation counts, co-citation links, keyword co-occurrences, and total link strength. These parameters are essential for identifying research trends, intellectual structures, and thematic patterns, but these do not directly measure the quality, depth, or classroom effectiveness of individual studies. Thus, highly cited publications may indicate scholarly influence,

but they do not necessarily reflect stronger empirical evidence or greater practical impact in culturally responsive STEM teaching.

Conclusion

This bibliometric analysis about culturally responsive STEM teaching in higher education (2015–2025) showed an area that changed from a simple domain into a globally recognized discipline, supported by a 45-fold increase in the publication volume. As a highlight, the United States remained the primary source of the research outputs, but there are increasing contributions from the Global South. The increase in publications in other territories implies a widening international commitment to promote equity in science, technology, engineering, and mathematics. Moreover, the co-citation analysis revealed that the intellectual bases remain anchored in the works of Ladson-Billings and Gay, but there is a shift toward the transformative frameworks of culturally relevant pedagogy. This development was confirmed by the embedding of social justice theories with national science standards. These relevant activities prove that equity has recently been categorized as an important component of high-quality STEM instruction.

The appearance and growth of keywords related to artificial intelligence, computer-aided instruction, and faculty professional development imply that culturally responsive STEM teaching is moving from theoretical advocacy toward practical and technology-supported implementation. Furthermore, the co-word analysis confirmed an essential technological shift, where artificial intelligence and computer-aided instruction were framed as cultural mediating tools. By the implications from the publication growth, geographic expansion, co-citation patterns, and keyword evolution, insights were acquired about the future of this field. The future of culturally responsive STEM teaching in higher education depends on the application of equity-centered pedagogy, faculty capacity-building, and advanced instructional technologies. Therefore, this bibliometric study concludes that the digital transformation of STEM requires a combination of social constructivist theories and advanced instructional technology to sustain learners' diverse funds of knowledge in increasingly automated classrooms.

Recommendations

Educational institutions should prioritize faculty professional development in inclusive technologies by moving beyond general diversity training and equipping STEM faculty with practical skills to integrate computer-aided instruction and AI in ways that would sustain learners' cultural identities. Researchers should aim to globalize more the culturally responsive frameworks by conducting more studies in non-Western contexts by shifting the academic center away from a U.S.-centric perspective to include localized STEM knowledge. Department heads and curriculum designers must include equity into technical educational curricula by using the NGSS and NRC frameworks as models to connect culturally sustaining practices directly into the technical requirements of science and engineering courses.

As the field advances toward a digital frontier, developers and educators must assess AI and digital learning tools for bias to ensure that the STEM learning software does not reinforce structural inequities or stereotypical threats

as identified in co-word analysis. Teaching interventions should focus on student self-efficacy and belonging, as the data shows that motivation and identity-affirmation are crucial bridges between inclusive pedagogy and academic success in STEM. Universities should foster interdisciplinary collaborations by encouraging partnerships between Education departments and STEM colleges to co-design culturally responsive instructional models, given the strong link between sociocultural learning theories and STEM standards.

Funding agencies must aid longitudinal research on STEM by prioritizing studies that track how culturally sustaining pedagogies impact the long-term retention and career success of underrepresented populations in higher education. Finally, educators should increase funds of knowledge in curriculum design by actively incorporating students' community and home-based knowledge as assets in science inquiry and transforming STEM classrooms into collaborative spaces where diverse perspectives drive innovation.

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References

Admane, R., Sawale, P. S., Jayasree, R., Kurup, S. J., & Thomas, S. A. (2024). Artificial Intelligence in Education: Tailoring Curriculum to Individual Student Needs through AI-Based Systems. *Library of progress-*

library science, information technology & computer, *44*(3).

Akçay, B. (2024). Sustainable Development Through STEM Education. *Studies on Education, Science, and Technology*, 144.

Alim, H. S., & Paris, D. (2017). Culturally Sustaining Pedagogies: Teaching and Learning for Justice in a Changing World. *Harvard Education Press*.

Ammar, M., Al-Thani, N. J., & Ahmad, Z. (2024). Role of pedagogical approaches in fostering innovation among K-12 students in STEM education. *Social Sciences & Humanities Open*, *9*, 100839. https://doi.org/10.1016/j.ssaho.2024.100839

Aronson, J. (2002). Stereotype threat and the intellectual underperformance of African Americans. *Educational Psychologist*, *37*(2), 93-105. https://doi.org/10.1006/jesp.2001.1491

Bandura, A. (1997). Self-efficacy: The exercise of control. *W.H. Freeman and Company*.

Bullock, E. (2017). Only STEM can save us? Examining race, place, and STEM education as property. *Educational Studies*, *53*(6), 628-641. https://doi.org/10.1080/00131946.2017.1369082

Chen, L. C., & Lien, Y. H. (2011). Using author co-citation analysis to examine the intellectual structure of e-learning: A MIS perspective. *Scientometrics*, *89*(3), 867-886. https://doi.org/10.1007/s11192-011-0458-y

Cochran-Smith, M. (2016). Initial teacher education: What does it take to put equity at the center? *Teaching and Teacher Education*, *54*, 130-140. https://doi.org/10.1016/j.tate.2016.03.006

Crenshaw, K. (1989). Demarginalizing the intersection of race and sex: A Black feminist critique of antidiscrimination doctrine, feminist theory and antiracist politics. *University of Chicago Legal Forum*, *1*, 139-167.

Donthu, N., Kumar, S., Mukherjee, D., Pandey, N., & Lim, W. M. (2021). How to conduct a bibliometric analysis: An overview and guidelines. *Journal of Business Research*, *133*, 285-296. https://doi.org/10.1016/j.jbusres.2021.04.070

Fitri, H. S. A., Agustin, E. P., Chuchai, S., Joronavalona, R., & Ali, S. (2024). Trends in Culturally Responsive Teaching for Science Education: A Bibliometric Analysis. *Journal of Technological Pedagogy and Educational Development*, *1*(2), 36-52.

Freire, P. (1970). *Pedagogy of the oppressed.* Herder and Herder.

Gay G. (2010). *Culturally responsive teaching: Theory, research, and practice* (2nd ed.). New York, NY: Teachers College Press.

Gay, G. (2000). *Culturally responsive teaching: Theory, research, and practice.* Teachers College Press.

Gonzalez, N., Moll, L., & Amanti, C. (2005). Funds of knowledge for teaching: Using a qualitative approach to connect homes and classrooms. *Lawrence Erlbaum Associates*.

Hutson, J., Jeevanjee, T., Vander Graaf, V., Lively, J., Weber, J., Weir, G., ... & Edele, S. (2022). Artificial intelligence and the disruption of higher education: Strategies for integrations across disciplines. *Creative Education*, *13*(12). https://doi.org/10.4236/ce.2022.1312253

Ives, M. R. (2020). First-generation college students as *academic learners: A systematic review. Review of Educational Research*, 90(3), 347-381. https://doi.org/10.3102/0034654319899707

Karagöl, İ. (2025). Culturally Responsive Teaching: A Bibliometric Investigation of Scholarly Trends. *Dokuz Eylül Üniversitesi Buca Eğitim Fakültesi Dergisi*, (64), 2255-2272.

https://doi.org/10.53444/deubefd.1625031

Kaswan, K. S., Dhatterwal, J. S., & Ojha, R. P. (2024). AI in personalized learning. *In Advances in technological innovations in higher education* (pp. 103-117). CRC Press.

Kim, M. (2018). Developing a STEM identity among young women: A social identity perspective. *Review of Educational Research*, *88*(3), 373-402. https://doi.org/10.3102/0034654318779957

Klarin, A. (2024). How to conduct a bibliometric content analysis: Guidelines and contributions of content co-occurrence or co-word literature reviews. *International Journal of Consumer Studies*, *48*(2), e13031. https://doi.org/10.1111/ijcs.13031

Ladson-Billings, G. (1995). Toward a theory of culturally relevant pedagogy. *American Educational Research Journal*, *32*(3), 465-491. https://doi.org/10.3102/00028312032003465

Leon, C., Lipuma, J., & Oviedo-Torres, X. (2025, July). Artificial intelligence in STEM education: A transdisciplinary framework for engagement and innovation. *Frontiers in Education, 10*, 1619888. *Frontiers*. https://doi.org/10.3389/feduc.2025.1619888

Leonard, J., Buss, A., Gamboa, R. et al. Using Robotics and Game Design to Enhance Children's Self-Efficacy, STEM Attitudes, and Computational Thinking Skills. *J Sci Educ Technol, 25*, 860–876 (2016). https://doi.org/10.1007/s10956-016-9628-2

Lin, M. P. C., Liu, A. L., Poitras, E., Chang, M., & Chang, D. H. (2024). An exploratory study on the efficacy and inclusivity of AI technologies in diverse learning environments. *Sustainability*, *16*(20), 8992. https://doi.org/10.3390/su16208992

Lynch, S. J., Burton, E. P., Behrend, T., House, A., Ford, M., Spillane, N., ... & Means, B. (2018). Understanding inclusive STEM high schools as opportunity structures for underrepresented students: Critical components. *Journal of Research in Science Teaching*, *55*(5), 712-748. https://doi.org/10.1002/tea.21437

McGee, E. O. (2017). The troubled success of Black women in STEM. *Cognition and Instruction*, *35*(3), 335-358. https://doi.org/10.1080/07370008.2017.1355211

Mensah, F. M. (2018). Preservice and inservice teachers' ideas of multiculturalism: Explorations across two science methods courses in two different contexts. *Journal of Science Teacher Education*, *29*(6), 674-691. https://doi.org/10.1080/1046560X.2018.1425820

Mergen, A., Çetin-Kılıç, N., & Özbilgin, M. F. (2025). Artificial intelligence and bias towards marginalised groups: Theoretical roots and challenges. In J. Vassilopoulou & O. Kyriakidou (Eds.), *AI and diversity in a datafied world of work: Will the future of work be inclusive?* (pp. 17–38). Emerald Publishing Limited. https://doi.org/10.1108/S2051-2333202512

Morales-Doyle, D. (2017). Culturally relevant teaching and the critical race theory. *Theory into Practice*, *56*(1), 14-21.

Moravec, J. W., & Martínez-Bravo, M. C. (2023). Global trends in disruptive technological change: social and policy implications for education. *On the Horizon: The International Journal of Learning Futures*, *31*(3-4), 147-173. https://doi.org/10.1108/OTH-02-2023-0007

Morris, T. (2017). Reconceptualizing the sources of teaching self-efficacy: A critical review of emerging literature. *Educational Psychology Review*, *29*(4), 693-713. https://doi.org/10.1007/s10648-016-9378-y

National Research Council, Board on Science Education, & Committee on a Conceptual Framework for New K-

12 Science Education Standards. (2012). *A framework for K-12 science education: Practices, crosscutting concepts, and core ideas*. national academies press.

Ong, M., Smith, J. M., & Ko, L. T. (2018). Counterspaces for women of color in STEM higher education: Marginal and central spaces for persistence and success. *Journal of Research in Science Teaching*, *55*(2), 206-245. https://doi.org/10.1002/tea.21417

Paris, D. (2012). *Culturally sustaining pedagogy: A needed change in stance.* Teaching for Change.

Pierszalowski, S., Bouwma-Gearhart, J., & Marlow, L. (2021). A systematic review of barriers to accessing undergraduate research for STEM students: problematizing under-researched factors for students of color. *Social Sciences*, *10*(9), 328. https://doi.org/10.3390/socsci10090328

Pinkard, N. (2017). Digital youth divas: Exploring narrative-driven curriculum to spark middle school girls' interest in computational activities. *Journal of the Learning Sciences*, *26*(3), 362-396. https://doi.org/10.1080/10508406.2017.1307199

Porayska-Pomsta, K. (2016). AI as a methodology for supporting educational praxis and teacher metacognition. *International Journal of Artificial Intelligence in Education*, *26*(2), 679-700. https://doi.org/10.1007/s40593-016-0101-4

Rogoff, B. (2003). *The cultural nature of human development.* Oxford University Press.

Salas-Pilco, S. Z., Xiao, K., & Oshima, J. (2022). Artificial intelligence and new technologies in inclusive education for minority students: A systematic review. *Sustainability*, *14*(20), 13572. https://doi.org/10.3390/su142013572

Tavdgiridze, L., Didmanidze, I., Khasaia, I., Sherozia, N., Dobordginidze, D., Akhvlediani, D., & Akhvlediani, Z. (2024). STEM teaching in contemporary education. *Challenges to National Defence in Contemporary Geopolitical Situation*, *1*(1). https://doi.org/10.3849/cndcgs.2024.296

Teessar, J. (2024). Ethics in Science: Foundations, Contemporary Challenges, and Future Directions.

Tien, C. L., Hung, H. Y., Hsieh, W. H., & Chen, B. C. (2024). Using Science Mapping to Review Research on Culturally Responsive Teaching in Early Childhood Education. *Educational Innovations and Emerging Technologies*, *4*(4), 1-11.

Van Eck, N., & Waltman, L. (2010). Software survey: VOSviewer, a computer program for bibliometric mapping. *Scientometrics*, *84*(2), 523-538. https://doi.org/10.1007/s11192-009-0146-3

Vygotsky, L. S. (1978). *Mind in society: The development of higher psychological processes.* Harvard University Press.

Wenger, E. (1998). *Communities of practice: Learning, meaning, and identity.* Cambridge University Press.

Zeng, Y., Isleem, H. F., Tejani, G. G., Jahami, A., & Alnowibet, K. A. (2025). Examining the impact of culturally responsive teaching and identity affirmation on student outcomes: A mixed-methods study in diverse educational settings. *International Journal of Educational Development*, *117*, 103376. https://doi.org/10.1016/j.ijedudev.2025.103376

Zidny, D. M. (2020). A multi-perspective reflection on how indigenous knowledge and related ideas can improve science education for sustainability. *Science and Education*, *29*(7), 1351-1374.

Zupic, I., & Čater, T. (2015). Bibliometric methods in management and organization. *Organizational Research Methods*, *18*(3), 429-472. https://doi.org/10.1177/1094428114562629