Pak. j. life soc. Sci. (2024), 22(1): 2668-2690 E-ISSN: 2221-7630;P-ISSN: 1727-4915

Pakistan Journal of Life and Social Sciences
www.pjlss.edu.pk

https://doi.org/10.57239/PJLSS-2024-22.1.00199

RESEARCH ARTICLE

A bibliometric Analysis of the Scientific Production and Thematic Trends of Ethnopedagogy in STEM Education

Muhamad Imaduddin[1*], Alfu Nikmah[2], Pasiningsih[3], Monera Salic-Hairullah[4], Rica Mae Guarin[5]

[1,2,,3]Institut Agama Islam Negeri Kudus, Indonesia

[4,5]Mindanao State University-Iligan Institute of Technology, Philippines

ARTICLE INFO

Received: Apr 24, 2024

Accepted: Jun 26, 2024

Keywords

Bibliometric analysis

Ethnopedagogy

Scientific production

STEM education

Thematic trends

***Corresponding Author:**

imad@iainkudus.ac.id

ABSTRACT

This study examines the landscape of ethnopedagogical research in STEM education through a comprehensive bibliometric analysis of academic publications over many years. It explores trends in research, the output of students, and the thematic preoccupations of scholarly publications in the field of intelligent learning environments. The Scopus database was used to retrieve a total of 319 datasets consisting of English-language journal articles, conference proceedings and book chapters. A bibliometric analysis was used to provide a comprehensive overview of trends, topics and scientific output in the field of intelligent learning environments. The first paper on ethnopedagogy in STEM education was published in 1981, according to the bibliometric analysis. Among other sources, the ASEE Annual Conference and Exposition and the Journal of Physics: Conference Series are the most relevant publications that have issued articles concerning this subject. Notably, the publication by Shadle S.E., published in 2017, is the most cited among the studies under investigation. The United States possesses the highest quantity of scientific productions and persists as the most significant country regarding ethnopedagogy in STEM education. In addition, the results reveal the identities of prominent academics and leading institutions in their respective fields. It is noticeable that popular phrases that include 'students', 'teaching', 'computing education', 'education' and 'technology' are currently in vogue. Furthermore, thematic analysis shows "STEM education", "robotics", and "outreach" programs are the major drivers of ethnopedagogical research. This study provides a valuable contribution to the field by presenting a meticulous outline and highlighting the research and thematic focus, as well as future directions. These findings will help researchers, especially younger scholars in the field of intelligent learning environments, to identify research foci and potential areas of exploration.

INTRODUCTION

STEM (Science, Technology, Engineering, and Mathematics) is increasingly popular at all levels of education worldwide. STEM education focuses on teaching science, mathematics, engineering, and technology, encompassing lifelong learning activities for all educational levels, from preschool to post-doctorate (Ultay et al., 2020). The STEM approach promotes improved learning quality by integrating science with other knowledge disciplines instead of treating it as a separate and exclusive subject. In addition, STEM learning enables students to develop skills in innovation, invention, independent working, logical thinking, and technology literacy (Afriana et al., 2016). However,

learning never takes place in isolation. Culture plays a vital role in the interpretation and implementation of learning. This is also applicable to STEM education. Research in STEM education has revealed that a cultural element can assist pupils in gaining a thorough comprehension of STEM studies and their connection to their surroundings.

Hence, the term ethnopedagogy was coined, which derives from the amalgamation of the words "ethno" and "pedagogy". According to the Merriam-Webster Dictionary, "ethno" denotes race, people, or cultural group, whilst pedagogy refers to the art, science, or profession of teaching. From this, ethnopedagogy can be defined as the art of teaching that takes into account one's culture, or as a teaching practice that integrates culture into the learning experience. Selasih & Sudarsana (2018) provide a definition of ethnopedagogy as being "a form of education which incorporates local wisdom, cultural values and behaviour standards associated with a particular ethnic group" (pp. 297-298). The concept of ethnopedagogy was first introduced by Volkov during the 1960s and 1970s. In the field of science, Volkov described ethnopedagogy as a specific area of study that investigates a nation's pedagogical approach by using their experiences, perspectives, and way of life (Alagöz Hamzaj & Selvi, 2020).

Alagöz Hamzaj & Selvi (2020) elaborate on the two significant functions of ethnopedagogy as a novel pedagogical approach. Firstly, it honours and acknowledges a nation's local knowledge and wisdom. Secondly, these values and knowledge are concrete and, thus, available to be further explored for research purposes. Using ethnopedagogy holds potential advantages for learning practices. It can be argued that the transmission of a nation's culture to students is an important endeavour to ensure cultural maintenance and sustainability (Rido, 2022). Ethnopedagogy has been shown to be a valuable tool in linking STEM education with cultural values (Rahmawati et al., 2020). By employing ethnopedagogy, students can cultivate an appropriate appreciation of their cultural heritage. It is possible for each country to have their own unique approach to incorporating ethnopedagogy within their STEM learning curriculum, influenced by their respective cultures. Integration of social sciences with STEM is increasingly common in schools and is widely recognized as an educational best practice (Siegner & Stapert, 2020).

The emerging area of ethnopedagogy in STEM education has gained scholarly attention in recent times. The significant expansion of this field presents an occasion to investigate trends in ethnopedagogy in STEM education through existing literature and the evolution of discourse among scholars. The significant expansion of this field presents an occasion to investigate trends in ethnopedagogy in STEM education through existing literature and the evolution of discourse among scholars. An exhaustive survey of the ethnopedagogical literature in STEM education is imperative. It will offer an overview of the scholars' advancements and their current status. Secondly, it will provide crucial guidance for researchers in determining the focal points of their future investigations (field hotspots), as well as appropriate publication venues. To attain this objective, the current study analyses the scope of ethnopedagogical research in STEM education in order to acquire a holistic comprehension of research undertakings from a multidisciplinary standpoint, patterns, and potential avenues for future studies in this area.

Many scholars across the globe have conducted research on ethnopedagogy in relation to STEM fields. Examples include studies conducted in the United States (Davison & Miller, 1998), Brazil (Sotero et al., 2020), Germany-Indonesia (Zidny & Eilks, 2020), and Indonesia (Sudarmin et al., 2019; Wati et al., 2021). However, there is limited research that focuses on trends in ethnopedagogy and the application of bibliometric analysis. Bibliometrix R package's science mapping technique is a valuable tool for bibliometric analyses of scientific publications (Aria & Cuccurullo, 2017).

Bibliometric studies enable the analysis of the development of scientific fields through intellectual contributions, social frameworks, and conceptual structures (Zupic & Čater, 2015). Many similar studies employ bibliometric analysis to provide an overview of specific research fields. Recent and noteworthy areas include the landscape of learning analytics research (Waheed et al., 2018), multimedia learning research (Li et al., 2019), augmented reality research (Arici et al., 2019), and classroom dialogue research (Song et al., 2019). These studies highlight the leading academic papers, publishing platforms, prolific scholars, research themes, and patterns within their fields.

This study aims to provide an in-depth review of ethnopedagogy in STEM education. Therefore, a bibliometric analysis is deemed suitable. No extensive bibliometric literature studies on ethnopedagogy in the field of STEM education have been carried out to date, to the best of our knowledge. This study presents the initial field bibliometric analysis with a specific goal of scrutinising trends in ethnopedagogy in STEM education over time. The research examines diverse themes of ethnopedagogy in STEM education as presented in scholarly articles and identifies leading scholars who have significantly contributed to the field of intelligent learning environments. Additionally, the study analyzes publication networks and collaborations among various institutions, countries, and regions over time. The aim is to identify shifts in the scope of ethnopedagogy in STEM education by analyzing extensive existing research.

The valuable findings will benefit novice scholars, particularly those beginning research in this emerging field. For instance, fledgling academics have the capacity to expeditiously identify leading articles based on the quantity of citations, productive authors, and research institutions. In addition, information on popular topics and thematic directions of ethno-pedagogy in STEM education, which predict future trends, can help young researchers choose their research interests. The main objective of this study is to examine the development of research in ethnopedagogy within STEM education over time, focusing on scientific output, thematic breakthroughs, scholars' contributions, and future research directions.

METHODS

In this study, we carried out a bibliometric mapping analysis, a method that is growing in popularity across various fields (Aria & Cuccurullo, 2017; Arici et al., 2019; Song et al., 2019). Possibly, the applicability of bibliometrics in scientific mapping could be the reason for its increasing popularity among (Aria & Cuccurullo, 2017). The methodology for performing bibliometric mapping analysis in this study, encompassing data collection, screening, extraction, and synthesis, is explicated in this section.

Literature search and data collection

Firstly, we started our search with a query of the Scopus database by means of a combination of compound keywords linked by the OR and AND operators. Since the study was restricted to the Scopus database, the authors acknowledge that the data compilation is not exhaustive. There is a possibility of missing data from other databases like Web of Science, PubMed, and ERIC. If a compatible formatting standard exists, merging data from various databases could be feasible. Unfortunately, the bibliometrix R-package software used in this research does not support this capability. WoS broadly covers natural sciences and engineering, whereas Scopus has comparatively greater coverage of social sciences (Mongeon & Paul-Hus, 2016). However, Scopus covers a significant volume of articles and achieves greater citation records.

Filling in the Scopus search database columns was carried out with seven search columns using terms related to ethnopedagogy in the field of STEM learning. The first search column refers to the selection option "Article title, Abstract, Keyword" with the entries "ethno pedagogy" OR "ethnopedagogy" OR "ethno-pedagogy" AND "science" OR "technology" OR "engineering" OR "mathematics" OR "STEM ". In the second column further exploration is used with the operator "OR" and the fields "ethnoscience"

OR "ethno-science" AND "teaching" AND "learning". In the second column the focus is on the terms "ethno" and "science" in relation to implementation in learning. In columns three to seven, still use the "OR" operator to look for equivalent terms that are consistent with the first and second columns. In columns three to five, the science terms in the second column are replaced with "technology", "engineering", and "mathematics". In the sixth column, the disbursement is focused on the possibility of using the term STEM, so that the column filling becomes "ethno-STEM" AND "teaching" AND "learning", and at the end the focus is on the potential for the word "ethno" which is interpreted with locality so that the keyword becomes "STEM" AND "teaching" AND "local" AND "learning". As for the entire disbursement as a whole using the filling:

(TITLE-ABS-KEY ("ethno pedagogy" OR "ethnopedagogy" OR "ethno-pedagogy" AND "science" OR "technology" OR "engineering" OR "mathematics" OR "STEM") OR TITLE-ABS-KEY (" ethnoscience" OR "ethno-science" AND "teaching" AND "learning") OR TITLE-ABS-KEY ("ethnotechnology" OR "ethno-technology" AND "teaching" AND "learning") OR TITLE-ABS-KEY (" ethnoengineering" OR "ethno-engineering" AND "teaching" AND "learning") OR TITLE-ABS-KEY ("ethnomathematics" OR "ethnomathematics" AND "teaching" AND "learning") OR TITLE-ABS-KEY (" ethno-STEM" AND "teaching" AND "learning") OR TITLE-ABS-KEY ("STEM" AND "teaching" AND "local" AND "learning"))

Data search and collection were carried out on October 26, 2023. The outcomes were subsequently screened to eliminate irrelevant items following our inclusion and exclusion criteria. Table 1 presents our inclusion and exclusion criteria. Below are the combined search strings, operators and filtering process using the standards outlined in Table 1.

Table 1. Inclusion and exclusion criteria for retrieving the dataset

Inclusion Criteria (IC)	Code	Criteria	Comment
Inclusion Criteria (IC)	IC 1	Articles containing any of the keywords in the title, abstract, or keywords.	This study performed a search using seven keywords combined with the OR operator (see string combination). AND and OR operators were also used within each search column to combine relevant keywords effectively.
	IC 2	Documents written in English.	Only articles written in English were considered for further study in this study.
	IC 3	All date of publication	To uncover trends in the field and identify when scholarly discussions began, we did not set a date range.
	IC 4	Articles in journals, conferences, and book chapters	The search is focused on documents published in journals as scientific article, conferences, book chapters only
Exclusion Criteria (EC)	EC1	Articles with publication stage “in press”	This study considered only final articles that had been successfully published.

EC 2	Article whose source is a trade journal	For this study, articles from trade journals were excluded because they do not undergo peer review. Trade journals are primarily written to educate, inform, or promote specific trades or industries, and they are typically published online or in newspapers and magazines.

Data extraction, loading, and conversion

The initial search yielded 355 documents. Of these, 341 were in English, with a total of 322 published in journals, conferences, and book chapters. Three articles were still in the "in press" stage. Following refinement based on the criteria outlined in Table 1, 319 documents were collected for analysis. These data were exported for further analysis. Unlike Web of Science (WoS), which limits exports to a maximum of 500 records, Scopus allows exporting up to 2000 records simultaneously in various formats such as BibTeX, CSV, Plain Text, RIS, etc. For this study, the data were exported in BibTeX format, suitable for import into bibliometric tools like biblioshiny (Aria & Cuccurullo, 2017).

Bibliometric analysis and software package

This research employed the bibliometrix R-package software, an open-source tool designed for conducting quantitative bibliometric analysis. Developed by Aria and Cuccurullo and scripted in the R language (Aria & Cuccurullo, 2017), this package includes essential algorithms for statistical analysis and science mapping. Later versions of bibliometrix R-package (2.0 and beyond) feature a web-based interface app named Biblioshiny, aimed at facilitating bibliometric analysis for users without programming expertise. The Biblioshiny interface enables users to import data from Scopus or Web of Science databases in BibTex, CSV, or Plain Text format, as well as filter data. For our study, we utilized the opportunities offered by Biblioshiny for bibliometrix to import data from Scopus in BibTex format. The result section provides an overview of our analysis.

Data synthesis

Table 2 provides a summary of the dataset, detailing the types of documents included. Conference papers (n=178) constitute the largest category, followed by articles (n=119) and book chapters (n=22). These 319 documents were directly analyzed from the Scopus search database. However, according to biblioshiny interpretation, only 316 documents were extracted from the BibTeX metadata dataset. In this study, author's keywords (DE) refer to a specific set of keywords (typically fewer than ten) chosen by authors to describe the focus of their study, as indicated in the full-text. In contrast, keyword plus (ID) refers to extended keywords and phrases generated by the Scopus system, incorporating keywords from the references cited by the authors of a publication (Tripathi et al., 2018). Additionally, "authors per document" denotes the average number of authors contributing to each document, while "co-author per document" represents the average number of appearances by authors across all documents. Both metrics assess collaboration among authors.

Table 2. Data synthesis indicating primary information and summary of the dataset

Description	**Result**

Timespan	1981:2023
Sources (Journals, Books, etc)	173
Documents	319
Annual Growth Rate %	8,52
Document Average Age	5,47
Average citations per doc	4,87
References	1
DOCUMENT CONTENTS	
Keywords Plus (ID)	1543
Author's Keywords (DE)	726
AUTHORS	
Authors	1037
Authors of single-authored docs	46
AUTHORS COLLABORATION	
Single-authored docs	49
Co-Authors per Doc	3,55
International co-authorships %	12,34
DOCUMENT TYPES	
article	119
book chapter	22
conference paper	178

RESULTS AND DISCUSSIONS

This section presents insights into the growth and trends of Ethnopedagogy in STEM, including published works, their distribution, sources, and citations, as well as information on prolific scholars, affiliations, and social networks, and the thematic focus of the field of Ethnopedagogy in STEM.

Growth and trends of research about ethnopedagogy in STEM education

In this section, we present the annual academic production article on Ethnopedagogy in STEM Education. Figure 1 shows that research on ethnopedagogy in STEM fields started in 1981 with Borzak, L. (1981) being the first and only article to use the term ethnoscience in its abstract. Analysis of the bibliometrix R package reveals an 8.52% annual growth rate in scientific output for the field of ethnopedagogy in STEM Education between 1918 and 2023.

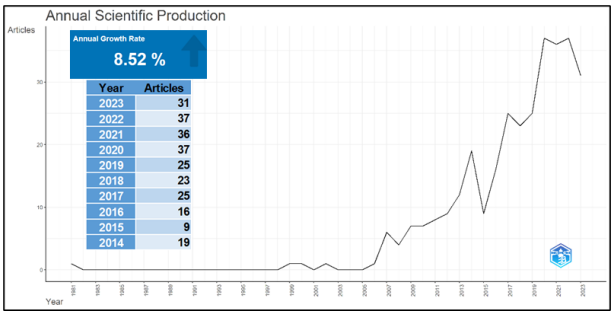


Figure 1. Annual scientific progression of Ethnopedagogy in STEM Education. The R-package computed a compound annual growth rate using a geometric progression with a constant scientific production rate over a certain period.

Since its initial appearance in 1981, articles concerning ethnopedagogy indexed on Scopus were absent until 1999. Conditions for producing articles in this field have fluctuated but have started to show signs of growth since 2007, with six documents now being published annually. A burgeoning trend in STEM ethnopedagogy research is gradually emerging, resulting in the creation of over 30 articles annually between 2020 and 2023.

Table 3 displays the average citations per article and per year regarding publications on ethnopedagogical topics concerning STEM education. These results indicate the research impact on publications or other research. The number of citations surpassed 200 in 2017, 2019, and 2020, signifying that in those years, research relating to ethnopedagogy in the field of STEM education had a widespread influence.The number of citations has risen steadily since 2013, exceeding 50 citations annually. Nonetheless, there was a reduction in citations in both 2002 and 2023. The highest average number of citations per annum occurred in 2019. This figure is based on the ratio between the quantity of existing citations and the number of years over which the cited articles were published. In 2022 and 2023, there was no notable increase in scientific publications pertaining to this topic. a decline in the average number of citations per annum.

Table 3. Average citation per article and per year

Year	Total of Article	Total Citation	Citable Years	Average of Total Citation per Article	Average of Total Citation per Year
2023	31	7	1	0.23	0.23
2022	37	43	2	1.16	0.58
2021	36	92	3	2.56	0.85
2020	37	215	4	5.81	1.45
2019	25	216	5	8.64	1.73
2018	23	87	6	3.78	0.63
2017	25	219	7	8.76	1.25
2016	16	82	8	5.12	0.64
2015	9	113	9	12.56	1.40
2014	19	99	10	5.21	0.52
2013	12	61	11	5.08	0.46

Year	Total of Article	Total Citation	Citable Years	Average of Total Citation per Article	Average of Total Citation per Year
2012	9	33	12	3.67	0.31
2011	8	17	13	2.12	0.16
2010	7	25	14	3.57	0.26
2009	7	73	15	10.43	0.70
2008	4	12	16	3	0.19
2007	6	27	17	4.5	0.26
2006	1	11	18	11	0.61
2002	1	15	22	15	0.68
2000	1	15	24	15	0.62
1999	1	2	25	2	0.08
1981	1	75	43	75	1.74
	316				

Relevant sources and documents of publications about ethnopedagogy in STEM Education

Figure 2 illustrates the findings of the top 20 sources that prioritised publishing articles related to Ethnopedagogy in STEM education. Scopus data from October 2023 was used for this analysis. The ASEE (American Society for Engineering Education) Annual Conference and Exposition emerged as the most noteworthy source with 62 documents, closely followed by the Journal of Physics: Conference Series with 31 documents. This is followed by journals and proceedings whose production number does not exceed 10. The maximum yearly output amounts to eight records pertaining to this ethnopedagogical investigation. Figure 3 demonstrates this.

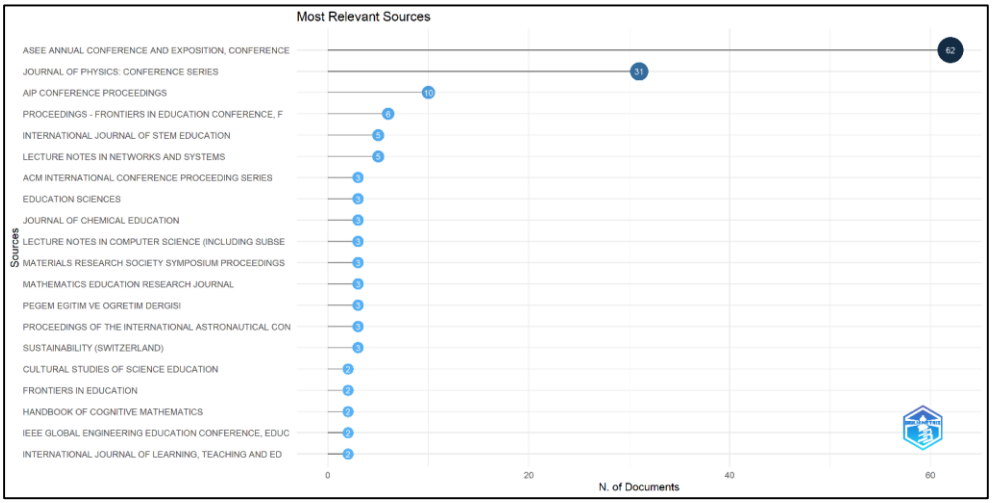


Figure 2. Distribution of articles by relevant sources from 1981 to October-2023.

Based on total citations (Figure 3.), the International Journal of STEM Education is the most cited source with an H-index of 4. The H-index achievement is lower compared to the ASEE Annual Conference and Exposition and the Journal of Physics, both of which have an H-index of 5. The H-index is practical in assessing the scientific impact of a source or researcher because it considers the number of papers published and the number of times those papers have been cited by other researchers (Fassin, 2023; Hirscha & Buela-Casal, 2014).

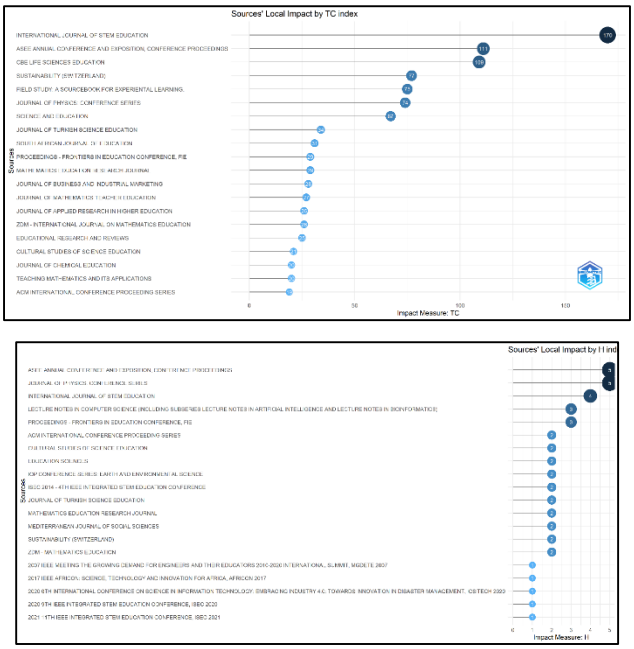


Figure 3. Comparison of source's local impact based on Total Citation (TC) and H-index

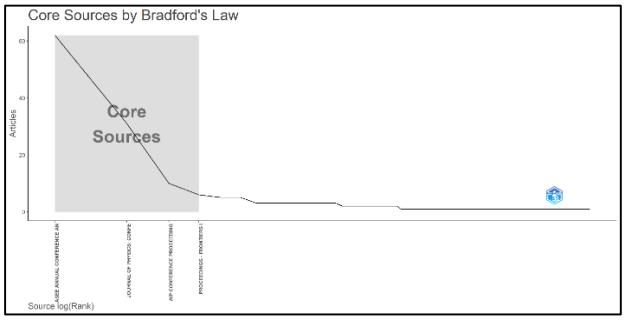


Figure 4. Core Sources by Bradford's Law

The identification of core sources is based on Bradford's Law, which declares that when journals are arranged in descending order of articles on a given subject, there will be successive zones of periodicals containing the same number of articles on that subject in the simple geometric series $1:n_S:n^2_S:n^3_S$ (Biblioshiny, 2019). Accordingly, sources are divided into three zones according to Bradford Law. Zone 1, depicted by gray and vertical gridlines in Figure 4, shows high productivity and represents the core sources with four sources and 109 papers. Zone 2 demonstrates moderate productivity with 65 sources and 103 papers, whereas zone 3 exhibits low production with 104 sources and 104 papers. The core sources have published 34.5% of the entire collection, which amounts to 316 papers.

Citations from papers extracted from the database can be analyzed globally each year. Table 4 indicates that globally impactful writings on etnopedagogy, specifically discussing STEM education, were published during various periods, starting from the earliest in 1981 and the latest publication in 2020.

Table 4. Top 10 cited papers by global citations.

Authors	**DOI**	**Total Citations**	**TC per Year**
Shadle, Marker, and Earl (2017)	10.1186/s40594-017-0062-7	122	17.43
Dewsbury and Brame (2019)	10.1187/cbe.19-01-0021	109	21.8
Borzak (1981)	NA	75	1.74
Zidny, Sjöström, and Eilks (2020)	10.1007/s11191-019-00100-x	67	16.75
Tran et al. (2020)	10.3390/su12104195	63	15.75
Nkopodi and Mosimege (2009)	10.15700/saje.v29n3a273	31	2.07
Parmin et al. (2016)	10.12973/tused.10163a	29	3.63
Guercini and Runfola (2015)	10.1108/JBIM-12-2012-0256	28	3.11
Owens (2015)	10.1007/s10857-014-9271-x	27	3
Sabah and Du (2018)	10.1108/JARHE-11-2017-0144	26	4.33

Scientific publication production by region/countries

This study analyses the number of publications and contributions to ethnopedagogy in STEM education across various regions and countries. Results indicate that the United States has the highest number of publications, followed by Indonesia from Asia. European countries, such as the UK, Greece, Italy, Spain, Germany, and Turkey, have significantly contributed to the study. Australia is making a significant contribution to this field within its region, while in Africa, various nations including South Africa, Zimbabwe, and Nigeria have all contributed to the field of ethnopedagogy for STEM education, as evidenced by the results.

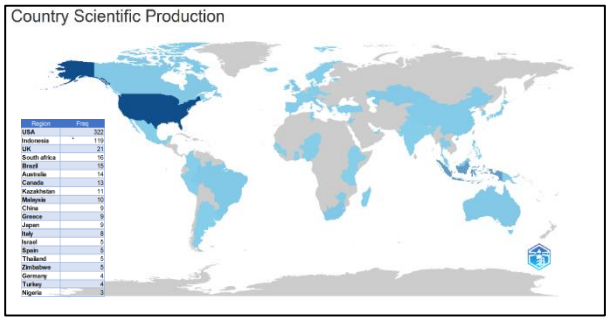


Figure 5. Top 20 countries that produce scientific publications and map of the distribution of origins of publications about Ethnopegaogy in STEM Education

Further analysis indicates the top 20 countries based on both total and average citations. The United States is the leading country, followed by Indonesia. Interestingly, Sweden and Australia, which appear to have a low number of publications compared to other countries, are ranked third and fourth in terms of total citations (Figure 5). The average citations for these countries are 67 and 41 respectively. Although Sweden and Australia may have published minimal scientific articles in this field, the few publications made had a substantial impact. Similarly, South Africa and Italy, highlighted in Figure 6, are noteworthy contributors in this area.

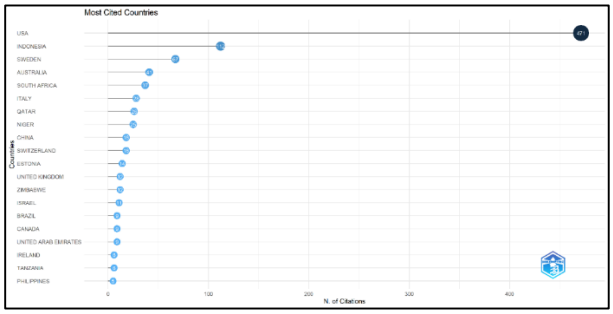


Figure 6. Most Cited Countries

Prolific scholars, institutions, and collaboration network

Prolific scholars in the field of ethnopedagogy in STEM Education

Figure 7 depicts the productivity of the top twenty researchers who have contributed to the field of ethnopedagogy in STEM education between 1981 and October 2023, based on the data set. Consistency is evident among these researchers in their contributions to this area of research. The findings reveal that Sunzuma G. from Zimbabwe has produced a total of 6 documents and maintained consistent productivity between 2020-2022 (Figure 7).

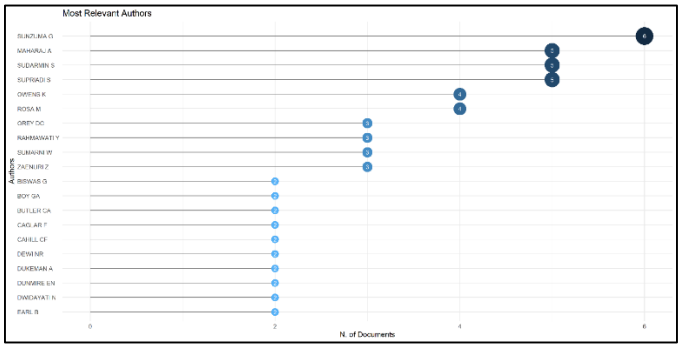


Figure 7. Top 20 Most Relevant Authors

The most prolific author in this area is Owens K from Australia, who commenced publishing in 2011 with the highest total citation of 56. Furthermore, Sudarmin S and Supriadi S from Indonesia have exhibited remarkable consistency in producing research in this field up until 2023 (Figure 8). Owens and Sudarmin achieved the highest total citations and g-index of 4, as presented in Table 5. The table ranks the top 20 authors based on impact metrics including h-index, g-index (where an author's top 10 publications have received at least 100 citations), m-index (the h-index divided by the number of years the researcher has been active), total citations (TC), and net production (NP).

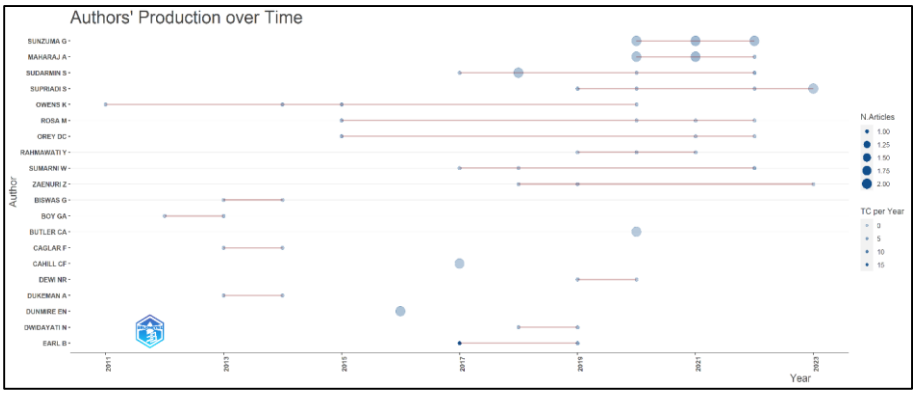


Figure 8. Top 20 authors productivity over the years: The line displays the author's timeline, with bubbles representing the number of documents produced annually. Bubble colour reflects the total number of citations each year. The first bubble indicates the author's beginning in the field. Bubble size corresponds to the annual article output, with larger bubbles indicating a higher number of articles. Greater bubble colour intensity equates to a higher citation count.

Table 5. Top 20 authors by author local impact (h_index in the analyzed collection).

Authors	h-index	g-index	m-index	TC	NP
Owens, K	3	4	0.231	56	4
Sudarmin, S	3	4	0.429	19	5
Sumarni W	3	3	0.429	15	3
Biswas G	2	2	0.182	10	2
Boy G.A	2	2	0.167	19	2
Caglar F	2	2	0.182	10	2
Dukeman, A	2	2	0.182	10	2
Dunmire, A	2	2	0.25	8	2
Dwidayati n	2	2	0.333	13	2
Earl b	2	2	0.286	145	2
Ganesh t	2	2	0.143	6	2
Gokhale a	2	2	0.182	10	2
Hill lb	2	2	0.4	16	2
Hora mt	2	2	0.2	6	2
Huang t	2	2	0.25	8	2
Hunter ab	2	2	0.2	6	2
Krause s	2	2	0.143	6	2
Langhoff np	2	2	0.25	8	2
Maharaj a	2	3	0.5	13	5

Mian a	2	2	0.25	7	2

Figure 9 depicts a visual representation of researchers, their respective countries and areas of interest. The figure showcases the contributions made by countries, authors, and themes in the area of intelligent learning environments. The left column of the plot represents countries that are currently active in this field, while the middle column shows the names of contributing researchers from these countries. The right column displays the most frequently used keywords by authors. The frequency of these keywords determines the 'theme' in this research. Note the height of the box and thickness of the connecting lines. Regarding countries, the USA and Indonesia exhibit more author affiliations, with 8 authors connected to each country, which is coherent with their citation rate. Upon close analysis of the connections between countries and authors, the data demonstrates that Earl B and Dunmire E.N. are the primary contributors to paper publications originating from the USA, which currently has the highest level of paper productivity within this field. Notably, Sudarmin, S. and Rahmawati are the significant Indonesian writers who have contributed significantly to this area of study. The primary keywords forming themes in ethnopegogy research in STEM education are those pertaining to ethnomathematics. Six out of twenty authors utilise this keyword. The exceptional instance occurs with the Covid-19 keyword employed by Sumarni from Indonesia.

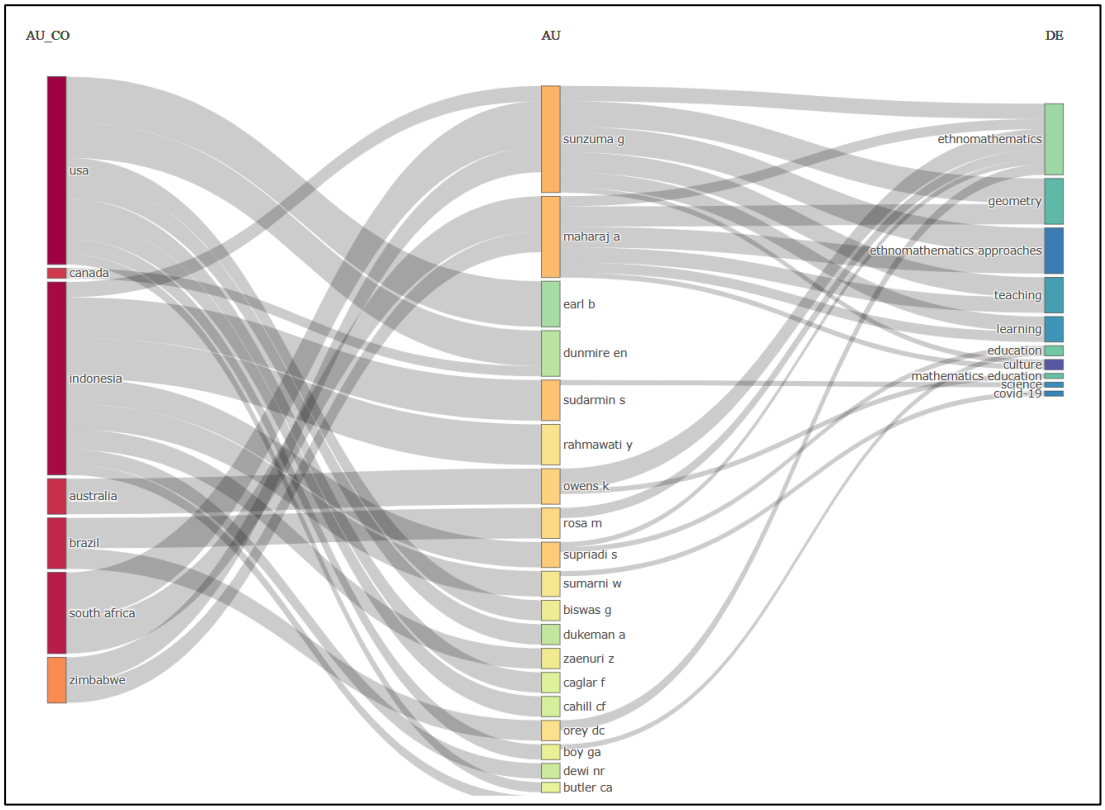


Figure 9. A plot depicting countries, authors, and themes of ethnopegagy in STEM Education is presented with a focus on the height of each box and thickness of the connecting lines. The significance of each box increases with its height and thickness of the connecting lines indicate greater information or volume of work produced.

Institutions, co-authorship, and collaboration network

This section examines the institutions contributing authors on the topic of ethnopedagogy research in STEM education, analyzing the publication output of the top 20 institutions. The findings reveal

that Arizona State University, USA holds the top position with 24 documents. The University of California (USA) holds the second position with a total of 13 documents. Meanwhile, Semarang State University (Indonesia) is the leading university in Southeast Asia, producing 12 research documents on this topic. Next, in the African region lies the Bindura University of Science Education, which has a total of six documents on this topic. Further details of each affiliate, along with the number of publications they have produced, can be viewed in Figure 10.

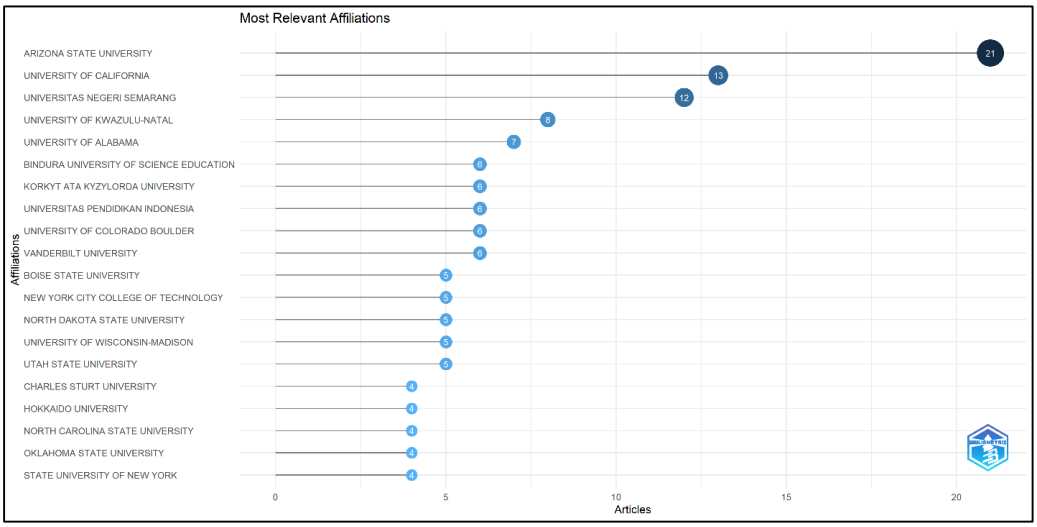
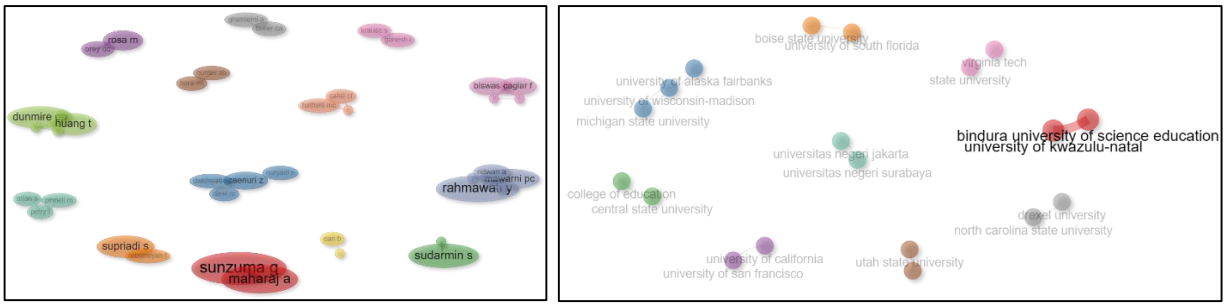


Figure 10. Top 20 of most relevant Affiliations

In relation to co-authorship and social collaboration analysis, this study examines the social structure aspect of the R package bibliometrix (Aria & Cuccurullo, 2017) available on the biblioshiny user interface (UI). As per experts, a field's social network illustrates the links between multiple individuals, institutions, or nations in the context of collaboration (Prell et al., 2009; Song et al., 2019). These connections are depicted within a network diagram where individual nodes symbolize authors, and the links that join them indicate their relationships. Our study involves displaying an author collaboration network, rendered in Figure 11, and an institutional collaboration network, illustrated in Figure 11. The research on this subject was a collective effort by Sunzuma, Maharaj, Sudarmin, Rahmawati, Mawarni, Ridwan, Supriadi, Robiansyah, and numerous other scholars. Despite author collaboration being common, isolated nodes still exist in research on this topic.

Bindura University of Science Education and the University of Kwazulu-Natal, both located in Africa, have developed institutional relationships similar to those of collaborating authors. However, collaboration in this field appears to be lacking in terms of institutional connections for developing ethnopedagogical research topics in STEM education. The predominant institutional linkages comprise three universities, namely, the University of Alaska Fairbanks, the University of Wisconsin-Madison, and Michigan State University.



(a) (b)

Figure 11. (a) Visualization of authors' collaboration network: Author names are depicted in boxes, with larger boxes indicating extensive collaboration networks. Sub-networks within larger networks may also be present. (b) Mapping of institutional collaboration and social networks: Institutions with significant collaboration networks are emphasized with larger representations, whereas those with fewer or no connections appear smaller in size.

Thematic focus of the field of ethnopedagogy in STEM education

This section examines the principal themes in the landscape of ethnopedagogy research in STEM education and the areas that academics have focused on over a prolonged period. Moreover, this research aims to establish whether there has been a change in the subjects discussed among specialists in the field. To initiate, we scrutinised the author's keywords and their prevalence. Following that, we analysed trends in keywords, current popular topics, co-occurrence networks, and thematic territories in the discipline.

Keywords analysis, co-occurrence network, and trend topics

Keyword, co-occurrence, and trending topics analysis play pivotal roles in exploring popular research domains and the academic concentration within the area (Song et al., 2019). Through this analysis, the keywords help in the quick identification of the topics and the focus of the publications. Figure 12 depicts a word cloud with prevalent keywords frequently used in intelligent learning environment research.

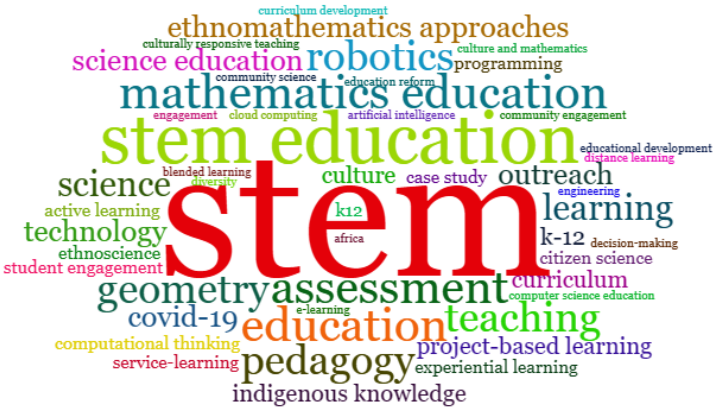


Figure 12. A word-cloud visualization of frequently used keywords in ethnopedagogy within the STEM education field reveals the most common repetitive terms in this domain.

Figure 13 depicts the word dynamics of 10 keywords used most commonly by authors. The illustration indicates that these keywords commenced appearing in the research landscape circa 2006 and have since continued to grow. The usage of keywords by authors is progressively increasing every year.

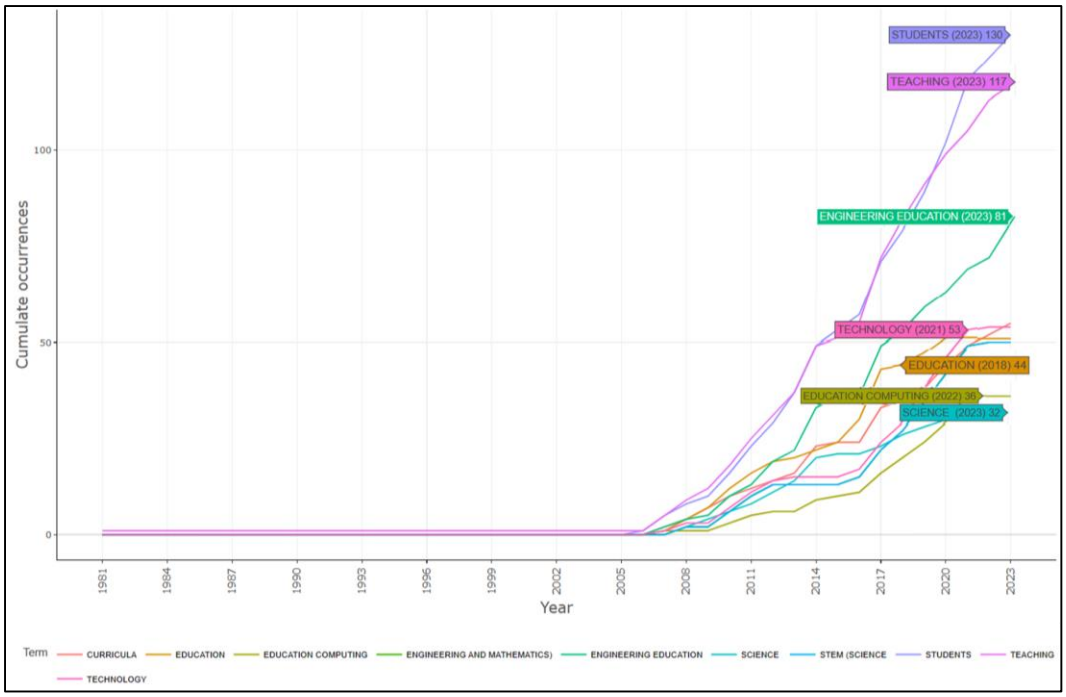


Figure 13. Word dynamics of the authors' most used keyword

"Students" has emerged as a highly popular keyword since 2013 and is expected to grow considerably until 2023. This discovery suggests that students have become a central topic in ethnopedagogy within the field of STEM education during this period. Additionally, the term "teaching" is experiencing a steady rise in usage annually. Over time, other keywords like "computing education", "engineering education", "education", and "technology" have emerged and persisted (refer to Figure 13). The results suggest that research on ethnopedagogy in STEM education will persist in exploring current topics. Furthermore, this investigation examines keyword co-occurrence networks (KCN) to obtain additional understanding of patterns in the area of ethnopedagogy in STEM education. The KCN analysis establishes connections between terms in the literature, revealing the structure of knowledge in the field (Esfahani et al., 2019). Hence, our findings demonstrate that KCN not only detects commonly used key terms as illustrated in Figure 12, but further uncovers the connections linking them, as evidenced by Figure 14. Certain key terms exert more influence on the network than others. For instance, a thorough review of the colour-coded keywords reveals a cohesive connection between the wider keywords, represented by their width, and the narrower keywords. One example, "ethnomathematics," is linked to culture, the intersection of culture and mathematics, Africa, pedagogy, geometry, approaches to ethnomathematics, teaching, and learning. Nevertheless, other keywords are also present that do not have a direct link to other significant keywords. Keywords connected to Covid-19 and distance learning are interrelated but distinct from other keyword groups, indicating exceptional research conditions linked to the pandemic situation that recently occurred.

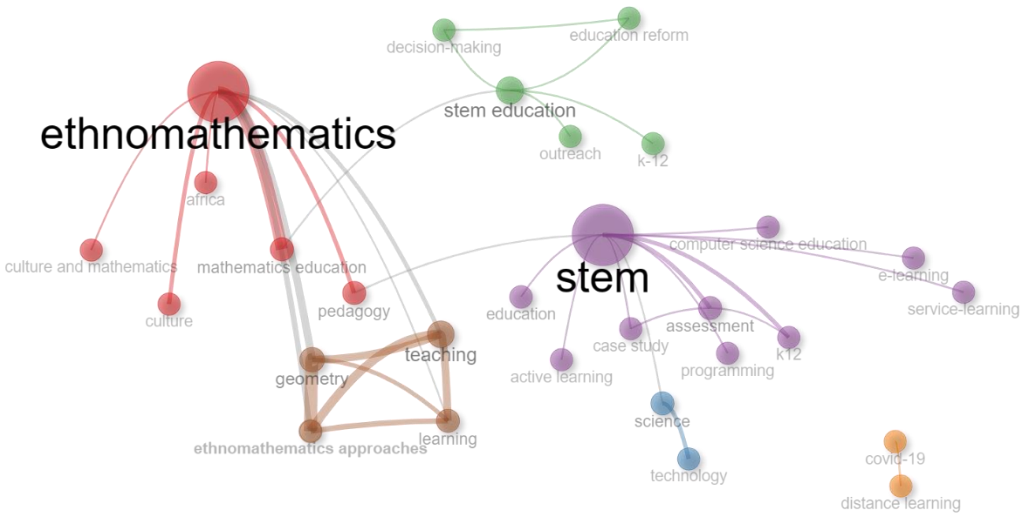


Figure 14. Co-occurrence network of keywords: Thicker lines denote a strong association between those keywords while thinner ones indicate weaker associations. Keywords unconnected by lines suggest no established relationship.

Trending topics and thematic analysis of the field of ethnopedagogy in STEM Education

Trending topic analysis was conducted using the author's keywords from the dataset. The analysis was done with the specified settings of a time range from 1981 to 2023, minimum word frequency of 5, five words per year, and a word label size of 5. Article keywords, determined by the author and linked to the publication content, were adequate in deriving topical aspects of a field (Song et al., 2019). This report presents a comprehensive and objective evaluation of the major themes connected to the appearance of keywords in ethnopedagogy in STEM education. While the authors' key terms as presented in Figure 12 are useful, Figure 15 delivers a more organized depiction of the analysed concepts arranged hierarchically by year. The topics introduced by the authors every year can be correlated to the field of ethnopedagogy in a variety of ways.

The topics introduced by the authors every year can be correlated to the field of ethnopedagogy in a variety of ways. For instance, ethnomathematics is the predominant subject matter of discussion in 2022, particularly within the pedagogical domain of research topics in ethnopedagogy and STEM education. The trend on the subject matter began to emerge in 2015, whilst research on STEM education related to ethnopedagogy started to appear in 2016. As illustrated, the trend of research on ethnopedagogy in STEM education is a topic that is being explored through science education.

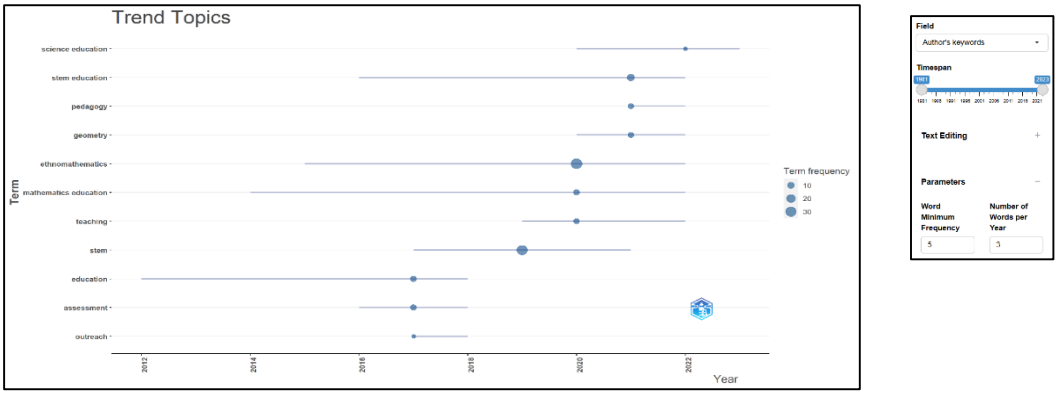


Figure 15. Trending topics per years about ethnopedagogy in STEM Education

With regards to contemporary topic trends, an analysis delves into how the evolution of themes unfolds in ethnopedagogy research studies that pertain to STEM education (Figure 16). Key words that frequently appear in works by authors can help to establish a basis for this evolution. The expansion of the theme's scope and evolution's flow indicate a shift from its initial focus on ethnomathematics to a more comprehensive consideration of STEM, STEM education, assessment, and robotics.

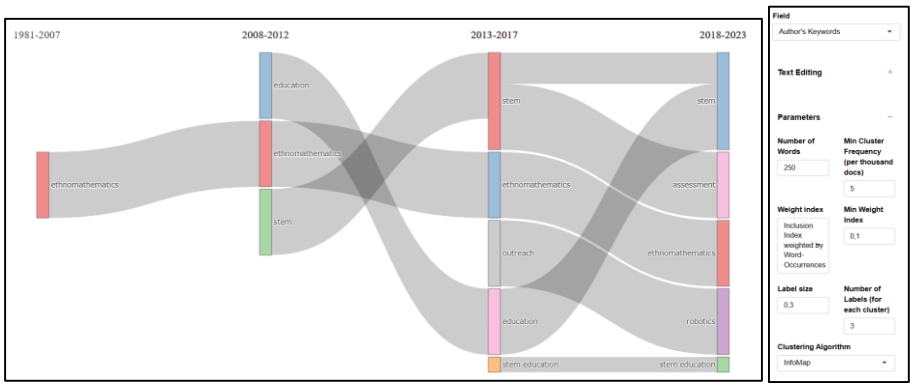


Figure 16. Thematic Evolution based on author's keyword

Another aspect to be investigated in this research is the creation of a thematic map exploring the role of ethnopedagogy in STEM education. The aim is to gain insight into the current state of the study area and its future viability. Such analysis is crucial in providing knowledge to researchers and stakeholders regarding potential future developments in thematic areas. Thematic analysis obtains themes from the author's keyword groups and their relationships. The themes are identified by their features, namely density and centrality, which are plotted on the vertical and horizontal axis, respectively.

Centrality denotes the extent of correlation between diverse topics, while density measures the connection between nodes (Esfahani et al., 2019). Density and centrality gauge the significance and maturity of a particular topic. The greater the number of connections a node has with other nodes in a thematic network, the higher its centrality and significance, placing it in a crucial position within the network. Additionally, a node's cohesiveness, which indicates the density of a research field, reflects its ability to grow and maintain itself. Figure 17 depicts a thematic map of the field of environmental ethnopedagogy in STEM education, divided into four quadrants (Q1 to Q4).

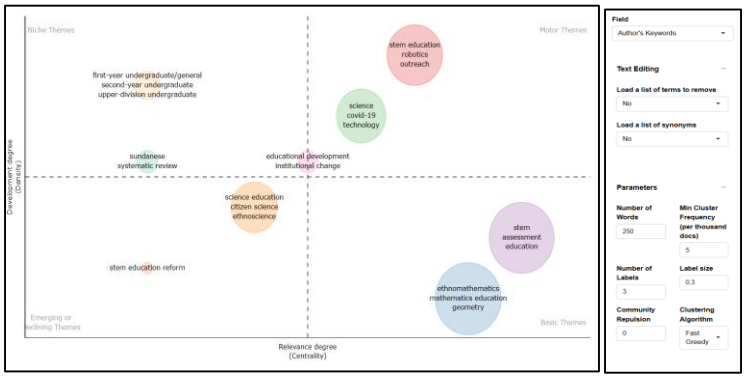


Figure 17. Thematic Map: Q1 contains the main theme; Q2 contains highly developed and specialised themes that link to the main theme; Q3 contains missing or emerging themes; Q4 consists of basic and cross-cutting themes.

The upper right quadrant (Q1) represents the driving themes, the lower right quadrant (Q4) the basic themes, the upper left quadrant (Q2) the highly specialised themes and the lower left quadrant (Q3) the emerging and disappearing themes. Based on this visual representation, the theme of educational development and institutional change occupies the central position within the quadrant. Themes related to this have been widely explored and offer ample opportunity for further investigation. The predominant themes in the first quarter indicate that STEM education, robotics, and outreach programmes are the major drivers of ethnopedagogical research. Implementing robotics projects to apply academic material practically makes lessons engaging for students. Websites like http://botbrain.com/index.html provide classroom sets of LEGO kits and curriculum ideas to support teachers in enhancing STEM instruction (Roberts, 2012). This research focus is founded on STEM, assessment, and educational research. Furthermore, it is acknowledged that ethnomathematics, mathematics education, and geometry are fundamental concepts that can be the primary focus of research in the field of ethnopedagogy within STEM education (Q4).

Nevertheless, section Q2 indicates that the specific examination of ethnopedagogy in undergraduate STEM education makes only a modest contribution to this research topic. Ethno-pedagogy can help shape the ethnic identity of pre-service teachers at universities. The research findings offer general recommendations for university faculty to develop pre-service teachers' ethnic identity and self-awareness, as well as to promote interethnic tolerance (Valiakhmetova et al., 2017). Additionally, it is necessary to diversify certain cultures like the "Sundanese" to make wider contributions to this field of study. To expand contributions to ethnopedagogical studies in STEM education, various systematic reviews are required. The theme of Q3, "STEM education reform," seems to have arisen only recently, subsequent to themes concerning science education, citizen science and ethnoscience. These themes should be upheld to avoid losing their contribution to ethnopedagogy research in STEM education. This endeavour is necessary to broaden the field of ethnopedagogical studies and to support it with diverse scientific knowledge, instead of being solely dominated by mathematical studies related to culture.

CONCLUSION

This study aims to conduct a comprehensive review of scholarly literature on ethnopedagogy in STEM education over time, utilizing bibliometric analysis. This study examines themes of ethnopedagogy in STEM fields as presented in scientific publications. It analyzes the works of eminent authors and their contributions while exploring collaborative networks across institutions, countries, and regions over time. Additionally, a thematic analysis of the current state of the field and potential areas for future growth in STEM education and ethnopedagogy is provided. Objective, value-neutral language is used throughout the text; technical terms are explained, and abbreviations are defined upon first use. Complete adherence to formal structure, consistent citation, and a clear, concise cause-and-effect structure is observed. A total of 319 documents were retrieved from the Scopus database for this study, although 316 documents were successfully analysed via biblioshiny. This study offers significant contributions to the research field. Firstly, it was discovered that the initial paper on ethnopedagogy in the STEM education field was released in 1981, although this topic ceased to exist after that time and resurfaced in 1999. It has been widely researched and examined since 2006. The ASEE Annual Conference and Exposition and the Journal of Physics: Conference Series are the most pertinent publications that have published articles on this topic. Particularly noteworthy is the 2017 publication by Shadle S.E. which is the most cited among the studies under scrutiny. The United States has produced the largest number of scientific publications and remains the foremost country in terms of ethnopedagogy in STEM education. Furthermore, the study identified the notable figures and top-rated institutions in their fields. The prevalent terms observed in current discourse comprise 'students', 'teaching', 'computing education', 'education' and

'technology'. In addition, the thematic analysis highlights "STEM education", "robotics", and "outreach" initiatives as the driving forces behind ethnopedagogical research.

Between 2018 and 2023, various new robotics-related topics have emerged and become a focal point of research in the field of ethnopedagogy within STEM. These discoveries highlight the significance of conducting further research in utilizing robotics for creating learning environments that explore local culture. This study puts forward several suggestions for future research in the field of ethnopedagogy in STEM education as part of our conclusion.

(1) Developing wider research collaborations between academics and institutions is crucial in creating a far-reaching impact on the potential of ethnopedagogy in STEM education to improve learning experiences.

(2) Research indicates that it would be advantageous for researchers to dedicate more effort towards STEM learning related to assessment, technology, and outreach programs, as these are key research topics in the field of ethnopedagogy.

Study limitation

This research has several constraints that must be acknowledged in the collection of sample data. Additionally, technical limitations were encountered during the analysis, as the software used could not combine data from various databases at the time. The sample data was obtained from the Scopus database, which may have led to the exclusion of pertinent data. Collecting representative data from a variety of reliable databases can significantly enhance research quality. Additionally, increasing the use of relevant search terms in database queries may improve accuracy. These identified limitations should prompt future studies investigating collection of data from multiple and comprehensive keyword databases for more comprehensive analysis.

Our findings shed light on the research landscape and identify important areas for future inquiry. This study aims to offer valuable insights to researchers, particularly those with an interest in ethnopedagogy, specifically in relation to STEM fields. For instance, aspiring young researchers can reference this study to identify prominent literature, prolific authors and active research centres in the field of ethnopedagogy and STEM education. Furthermore, this research highlights emerging areas within the realm of ethnopedagogy in STEM education that require further development to align with ethnopedagogy's objectives. The findings of the study provide an insight into the progress of the field over the years and give useful indications of possible future directions in the field of ethnopedagogy.

Authors' Contributions

Muhamad Imaduddin: Conceptualization, Methodology, Software, Visualization, Formal analysis, Writing – original draft; **Alfu Nikmah**: Writing – review & editing; **Pasiningsih**: Visualization, formal analysis; and project Administration; **Monera Salic-Hairullah**: Formal analysis and supervision; **Rica Mae Guarin**: Supervision and project administration.

Acknowledgments

This study is funded by an international collaboration between Institut Agama Islam Negeri (IAIN) Kudus, Indonesia, and the College of Education, MSU-IIT, Philippines. We would like to acknowledge the research management support from the Center for Research and Community Service (Lembaga Penelitian dan Pengabdian kepada Masyarakat/LPPM), IAIN Kudus, which was provided through the BOPTN 2023 scheme

REFERENCES

Afriana, J., Permanasari, A., & Fitriani, A. (2016). Project based learning integrated to stem to enhance

elementary school's students scientific literacy. *Jurnal Pendidikan IPA Indonesia*, *5*(2), 261–267. https://doi.org/10.15294/jpii.v5i2.5493

Alagöz Hamzaj, Y., & Selvi, K. (2020). Investigation of Ethnopedagogical Factors in Teacher Education: Kyrgyzstan Sample. *Uluslararası Eğitim Programları ve Öğretim Çalışmaları Dergisi*, *10*(2), 319–338. https://doi.org/10.31704/ijocis.2020.011

Aria, M., & Cuccurullo, C. (2017). Bibliometrix: An R-tool for comprehensive science mapping analysis. *Journal of Informetrics*, *11*(4), 959–975. https://doi.org/10.1016/j.joi.2017.08.007

Arici, F., Yildirim, P., Caliklar, Ş., & Yilmaz, R. M. (2019). Research trends in the use of augmented reality in science education: Content and bibliometric mapping analysis. *Computers and Education*, *142*(August), 103647. https://doi.org/10.1016/j.compedu.2019.103647

Biblioshiny. (2019). *Biblioshiny*. https://www.bibliometrix.org/home/index.php/layout/biblioshiny

Borzak, L. (1981). *Field study : a sourcebook for experiential learning* (L. Borzak (ed.)). Sage Publications.

Davison, D. M., & Miller, K. W. (1998). An Ethnoscience Approach to Curriculum Issues for American Indian Students. *School Science and Mathematics*, *98*(5), 260–265. https://doi.org/10.1111/j.1949-8594.1998.tb17299.x

Dewsbury, B., & Brame, C. J. (2019). Inclusive teaching. *CBE Life Sciences Education*, *18*(2), 1–5. https://doi.org/10.1187/cbe.19-01-0021

Esfahani, H. J., Tavasoli, K., & Jabbarzadeh, A. (2019). Big data and social media: A scientometrics analysis. *International Journal of Data and Network Science*, *3*(3), 145–164. https://doi.org/10.5267/j.ijdns.2019.2.007

Fassin, Y. (2023). The h a-index: The average citation h -index . *Quantitative Science Studies*, 1–22. https://doi.org/10.1162/qss_a_00259

Guercini, S., & Runfola, A. (2015). "Actors' roles in interaction and innovation in local systems: a conceptual taxonomy" Vol. 30 No. 3/4, pp. 269-278. https://doi.org/. *Journal of Business & Industrial Marketing*, *30*(3/4), 269–278. https://doi.org/10.1108/JBIM-12-2012-0256

Hirscha, J. E., & Buela-Casal, G. (2014). The meaning of the h-index. *International Journal of Clinical and Health Psychology*, *14*, 161–164.

Li, J., Antonenko, P. D., & Wang, J. (2019). Trends and issues in multimedia learning research in 1996–2016: A bibliometric analysis. *Educational Research Review*, *28*(June), 100282. https://doi.org/10.1016/j.edurev.2019.100282

Mongeon, P., & Paul-Hus, A. (2016). The journal coverage of Web of Science and Scopus: a comparative analysis. *Scientometrics*, *106*(1), 213–228. https://doi.org/10.1007/s11192-015-1765-5

Nkopodi, N., & Mosimege, M. (2009). Incorporating the indigenous game of morabaraba in the learning of mathematics. *South African Journal of Education*, *29*(3), 377–392. https://doi.org/10.15700/saje.v29n3a273

Owens, K. (2015). Changing the teaching of mathematics for improved Indigenous education in a rural Australian city. *Journal of Mathematics Teacher Education*, *18*(1), 53–78. https://doi.org/10.1007/s10857-014-9271-x

Parmin, P., Sajidan, S., Ashadi, A., Sutikno, S., & Yoris, M. (2016). Preparing prospective teachers in integrating science and local wisdom through practicing open inquiry. *Journal of Turkish Science Education*, *13*(2), 3–14. https://doi.org/10.12973/tused.10163a

Prell, C., Hubacek, K., & Reed, M. (2009). Stakeholder analysis and social network analysis in natural resource management. *Society and Natural Resources*, *22*(6), 501–518. https://doi.org/10.1080/08941920802199202

Rahmawati, Y., Ridwan, A., Cahyana, U., & Wuryaningsih, T. (2020). The integration of ethnopedagogy in science learning to improve student engagement and cultural awareness. *Universal Journal of Educational Research*, *8*(2), 662–671. https://doi.org/10.13189/ujer.2020.080239

Rido, H. (2022). Etnopedagogic Approach in Elementary School Student'S Learning. *Jurnal Pendidikan*

Dan Teknologi, *1*(1), 8–16.

Roberts, A. (2012). A justification for STEM education. *Technology and Engineering Teachere*, *May/June*(June), 1–5. http://botbrain.com/index.

Sabah, S., & Du, X. (2018). University faculty's perceptions and practices of student centered learning in Qatar: Alignment or gap? *Journal of Applied Research in Higher Education*, *10*(4), 514–533. https://doi.org/10.1108/JARHE-11-2017-0144

Selasih, N. N., & Sudarsana, I. K. (2018). Education Based on Ethnopedagogy in Maintaining and Conserving the Local Wisdom: A Literature Study. *Jurnal Ilmiah Peuradeun*, *6*(2), 293. https://doi.org/10.26811/peuradeun.v6i2.219

Shadle, S. E., Marker, A., & Earl, B. (2017). Faculty drivers and barriers: laying the groundwork for undergraduate STEM education reform in academic departments. *International Journal of STEM Education*, *4*(1). https://doi.org/10.1186/s40594-017-0062-7

Siegner, A., & Stapert, N. (2020). Climate change education in the humanities classroom: a case study of the Lowell school curriculum pilot. *Environmental Education Research*, *26*(4), 511–531. https://doi.org/10.1080/13504622.2019.1607258

Song, Y., Chen, X., Hao, T., Liu, Z., & Lan, Z. (2019). Exploring two decades of research on classroom dialogue by using bibliometric analysis. *Computers and Education*, *137*(April), 12–31. https://doi.org/10.1016/j.compedu.2019.04.002

Sotero, M. C., Alves, Â. G. C., Arandas, J. K. G., & Medeiros, M. F. T. (2020). Local and scientific knowledge in the school context: Characterization and content of published works. *Journal of Ethnobiology and Ethnomedicine*, *16*(1), 1–28. https://doi.org/10.1186/s13002-020-00373-5

Sudarmin, S., Zahro, L., Pujiastuti, S. E., Asyhar, R., Zaenuri, Z., & Rosita, A. (2019). The development of PBL-based worksheets integrated with green chemistry and ethnoscience to improve students' thinking skills. *Jurnal Pendidikan IPA Indonesia*, *8*(4), 492–499. https://doi.org/10.15294/jpii.v8i4.17546

Tran, T., Hoang, A., Nguyen, Y., Nguyen, L., Ta, N., Pham, Q.-H., Pham, C.-X., Le, Q.-A., Dinh, V.-H., & Nguyen, T.-T. (2020). Toward sustainable learning during school suspension: socioeconomic, occupational aspirations, and learning behavior of vietnamese students during covid-19. *Sustainability*, *12*, 4195.

Tripathi, M., Kumar, S., Sonker, S. K., & Babbar, P. (2018). Occurrence of author keywords and keywords plus in social sciences and humanities research : A preliminary study. *COLLNET Journal of Scientometrics and Information Management*, *12*(2), 215–232. https://doi.org/10.1080/09737766.2018.1436951

Ultay, N., Zıvalı, A., Yılmaz, H., Bak, H. K., Yılmaz, K., Topatan, M., & Kara, P. G. (2020). STEM-Focused activities to support student learning in primary school science. *Journal of Science Learning*, *3*(3), 156–164. https://doi.org/10.17509/jsl.v3i3.23705

Valiakhmetova, N., Akhmadullina, R., Pimenova, T., Prof, A., Federal, K., & Federation, R. (2017). *Ethno-pedagogy as a means of ethnic identity formation of pre-service teachers in Russia*. *July*, 387–392.

Waheed, H., Hassan, S. U., Aljohani, N. R., & Wasif, M. (2018). A bibliometric perspective of learning analytics research landscape. *Behaviour and Information Technology*, *37*(10–11), 941–957. https://doi.org/10.1080/0144929X.2018.1467967

Wati, E., Yuberti, Saregar, A., Fasa, M. I., & Aziz, A. (2021). Literature Research: Ethnoscience in Science Learning. *IOP Conference Series: Earth and Environmental Science*, *1796*(1). https://doi.org/10.1088/1742-6596/1796/1/012087

Zidny, R., & Eilks, I. (2020). Integrating perspectives from indigenous knowledge and Western science in secondary and higher chemistry learning to contribute to sustainability education. *Sustainable Chemistry and Pharmacy*, *16*(December 2019), 100229. https://doi.org/10.1016/j.scp.2020.100229

Zidny, R., Sjöström, J., & Eilks, I. (2020). A multi-perspective reflection on how indigenous knowledge and related ideas can improve science education for sustainability. *Science and Education*, *29*(1), 145–185. https://doi.org/10.1007/s11191-019-00100-x

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