Ethnomathematics Challenges and Opportunities in Mathematics Research and Learning: A Bibliometric Study Using the VosViewer

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Abstract. The ethnomathematics approach could complement mathematics learning at all levels of education. This study aims to determine the progress map of the ethnomathematics research. The literature review was carried out from April to May 2021 by searching through the Scopus, Google Scholar, and Crossref database using 'ethnomathematics' as the keyword with the help of the VosViewer software. The results showed the development of research and publications on ethnomathematics in the last twelve years (2015 to 2021) from three international databases including Scopus with 200 articles, Crossref with 142 articles, and Google Scholar with 840 articles. The progress map of the ethnomathematics publication based on co-words was grouped into 5 clusters. The authors found four keywords; pedagogy, problem-solving ability, elementary school student, and teaching materials in the collected ethnomathematics publications that can be developed for future research and learning studies at Elementary School Teacher Education Study Program.

Key words: bibliometric study; ethnomathematics; elementary school teacher candidates; mathematics research; mathematics learning.

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INTRODUCTION

Ethnomathematics is one of the approaches in mathematics introduced by D'Ambrosio in 1985. It is able to complement mathematics learning setting aside the education levels, strengthen students' understanding of the universality and contextuality of mathematical knowledge, promote cultural diversity, and present social and cultural artifacts and practices that are specifically developed in other cultures [1]. Another opinion stated that teachers have a significant influence in forming the boundary between the two formal fields of mathematics and ethnomathematics, as well as the comprehensive integration of everyday mathematical activities into formal mathematics [2]. Ethnomathematics defines culture as an embodiment of mathematical concepts, thus showing that mathematics and culture are two things interrelated [3]. Bridging culture and mathematics is a pivotal step in recognizing the different ways of thinking that can lead to different forms of mathematics. This is a field of study called ethnomathematics [3].

Indonesia is an archipelago that has cultural diversity. Its heterogenous culture could be experience in college life. Elementary School Teacher Education Study Program (PGSD) students at Universitas Negeri Semarang come from various regions in Indonesia, not only from Java. In recent years, there have also been students from affirmation and PPGT programs who reside in various islands in Indonesia. In 2021, the PGSD of Universitas Negeri Semarang, in its independent campus program, collaborates with universities in Bali and West Java Province. The diversity of origin and the existence of an independent campus program creates opportunities to get to know various cultures from various regions in Indonesia.

There have been many studies on mathematics raised from local culture, and this type of study is called ethnomathematics. It becomes the main attraction and characteristic of the area being studied. Some examples of the studies on local culture include Sasak [4], Dayak [5], Lampung [6], Kudus [7], Tuban [3], and Yogyakarta[8]. These studies affirm that there are various mathematical concepts in culture, thus showing that mathematics and culture are two correlated things. Several mathematical concepts contained in culture include the scope of geometry [1], [9], measurement [5], [10], numbers [11], arithmetic, algebra [5], and many more. The examined culture can be in the physical form like buildings

(temples [10], [12], [13]), inscriptions, traditional houses, houses of worship), traditional tools [2] and pottery, traditional clothes [3], traditional food, traditional games [14], local units, and local languages used by the community. Moreover, it also involves non-physical culture in the form of values and philosophies underlying the development of culture as well as studies that can be related to mathematical concepts. The trend towards the ethnomathematics approach to mathematics curriculum and pedagogy reflects comprehensive developments in mathematics education. The approach is intended to create relevant and meaningful mathematic learning for students and to improve the overall quality of education [15].

Nevertheless, the PGSD mathematics subject cluster has not yet touched on ethnomathematics, thus, the opportunity to introduce this study is widely open. This can be seen as a chance as well as a challenge for the PGSD Study Program as a producer of elementary school teacher candidates who not only learn the content knowledge but also pedagogical knowledge as well as pedagogical content knowledge. In the context of the curriculum, content knowledge (CK) is given at the beginning of the semester as a scientific provision for prospective teachers while pedagogical knowledge (PK) and pedagogical content knowledge (PCK) are given starting in the third semester. Content knowledge (CK) is knowledge of the subjects taught to students. Pedagogical knowledge (PK) is knowledge related to teaching methods, lesson planning, assessment, and general classroom management skills. Pedagogical content knowledge (PCK) is related to knowledge about how to teach certain content to students [16]. The challenge is to concoct the ethnomathematics approach in higher education at universities whose study materials consist of CK and PCK based on a research map informing the ethnomathematics studies that have been carried out.

The objective of this paper is to examine the map of ethnomathematics research development as opportunities and challenges in curriculum development, mathematics research, and learning at the PGSD Study Program.

METHODS

This literature study employed international publication data on ethnomathematics taken from the Scopus, Crossref, and Google Scholar database. The data were collected through publication tracing in the three databases using the keywords ‘ethnomathematics’ and ‘education’ in the category of ‘article’ and ‘book chapter’ dating from 2010 to 2021. Data in the form of yearly publication numbers and journals containing articles on ethnomathematics were analyzed in Microsoft Excel. Meanwhile, the trend of publication development was analyzed in VosViewer software.

RESULTS AND DISCUSSION

This study intends to determine the map of the research development on ethnomathematics. It was conducted from April to May 2021 by searching through the Scopus, Google Scholar, and Crossref database using the keyword ‘ethnomathematics’. The searching results were then analyzed descriptively based on the publication year from 2010 to 2021, research topics, and keywords that are closely related to ethnomathematics. To obtain a research development map, the gathered data were stored in a CSV (Comma Separated Values) file format, which was then processed and analyzed using the VosViewer application program to find out the bibliometric map of ethnomathematics research development. The results of the study indicated that Scopus had 200 articles, Crossref had 142 articles, and Google Scholar had 840 articles on ethnomathematics. The details are presented in Table 1.

Table 1. The Number of Publication in Three Databases

No	Database	Total of Publication	The year 2010-2015	The year 2016-2021
1	Scopus	200	63	137
2	Crossref	142	6	136
3	Google Scholar	840	253	587
	Total	1182	322	860

Publication Progress Map by Year

The processed publication data were limited to the publications of the last twelve years from 2010 to 2021. The data of 986 publications processed using the VosViewer resulted in a progress map based on the trend of the publication year as shown in Figure 1. The color gradient marks the trend of the publication year starting from the darkest color, purple, which means the 2016 publication until the brightest color, yellow, which means the 2019 publication. This trend conveys the keywords appearing in those years of publication as shown in Figure 1. Fairly new publications, around 2019, appear

with 'seemingly unrelated' keywords such as *mathematical concept, mathematical activity, teaching materials, pattern, cultural element, elementary school student, student worksheet, realistic mathematics, contextual learning, Indonesia, Yogyakarta, Banyuwangi*.

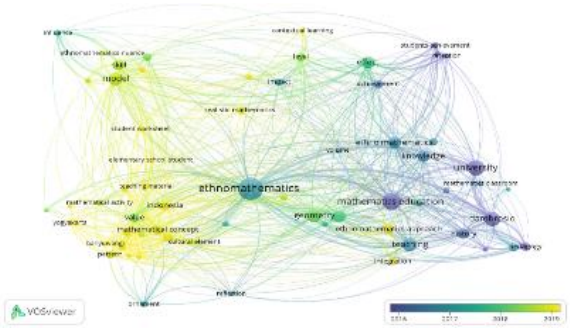


Figure 1. The Publication Progress Map According to Publication Year

The Publication Progress Map by Keywords

As many as 986 publication titles and book chapters obtained from 3 databases; Scopus, Crossref, and Google Scholar, were processed using VosViewer software. The analysis results showed that there were 5 closely related keyword clusters as shown in Figure 2. The size of the circle on each keyword shows the appearance of these keywords in the publication. The larger the circle size, the more often it appears in the publication.

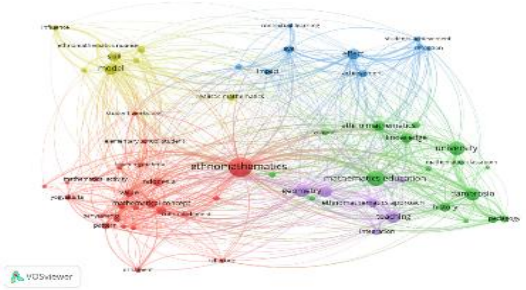


Figure 2. The Co-Word Map of Publication on Ethnomathematics

The five clusters represent keywords that appear and are related to each other in 986 publications. The five clusters are presented in five different colors; red, green, blue, yellow, and purple. The keywords in each cluster are listed in Table 2. The keywords in every cluster indicate the closeness of these keywords in each publication. Meanwhile, the network that associates these keywords shows links between keywords in the same publication.

Table 2. The Keywords of Five Cluster

No.	Cluster (Color)	List of Keywords
1	1 (red)	*Mathematical activity, mathematical concept, mathematical idea, mathematics learning, ornament, pattern, teaching material, traditional game, value, cultural element*, Indonesia, *Javanese culture, elementary school students*, Yogyakarta, Banyuwangi, *Sundaness ethnomathematics*
2	2 (green)	*Critical mathematics education, history, knowledge, mathematics classroom, mathematics education, pedagogy, university, social justice*, d'ambrosio
3	3 (blue)	*Contextual learning, achievement, mathematical problem, retention*, Nigeria, *effect, impact, level, student achievement*
4	4 (yellow)	*Effectiveness, problem-solving ability, mathematical representation, realistic mathematics, skill, model, influence*
5	5 (purple)	*Ethnomathematics application, geometry, teacher, teaching, challenge*

The Map of Research Opportunities Based on Keyword Intensity

The intensity of publication topics on ethnomathematics can be observed in Figure 3. Keywords appearing in light areas (yellow) indicate frequently used keywords in publications of the last twelve years, while keywords in dark areas (green and purple) tend not to be widely used. This shows several keywords that may become the research opportunities on ethnomathematics topics to be studied further.

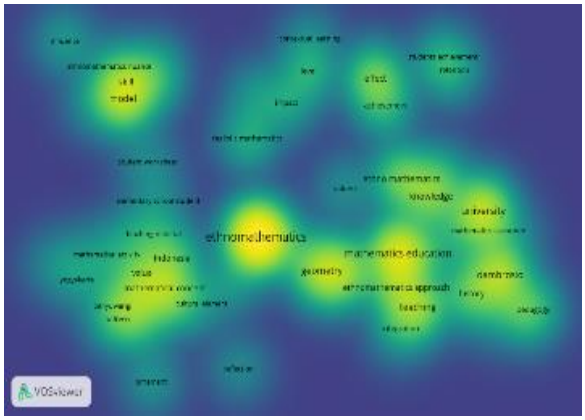
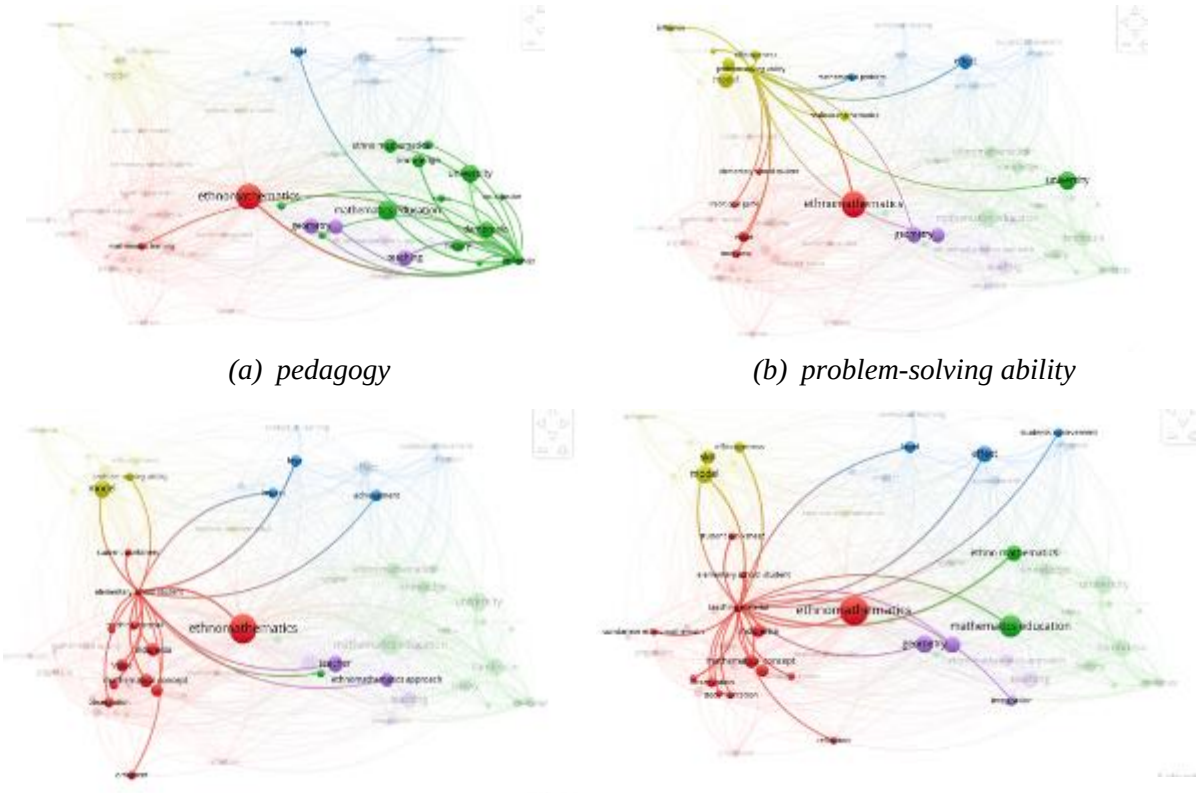


Figure 3. The Map of Publication Intensity Based on Keywords

Challenges and opportunities for the ethnomathematics topic in mathematics research and learning at PGSD can be drawn from the results of this bibliometric study. The linkage between the keywords appeared in several clusters like problem-solving ability, teaching material, pedagogy, an elementary school student is presented in Figure 4. The correlation of these keywords in the publication trend of the last twelve years illustrates that the four keywords have no network. Another bibliometrics study on mathematics education shows that research trends on mathematics in primary schools, teacher education, pedagogical content tools have been carried out quite a lot from 1980 to 2018 [17].



(a) pedagogy *(b) problem-solving ability*

(c) *elementary school student* *(c) teaching material*

Figure 4. Keyword Network between Pedagogy, Problem Solving Ability, Elementary School Student and Teaching Material in Publications on Ethnomathematics

The research opportunity is captured as the four keywords are not related to each other. Therefore, there is still a chance to find a novelty for further research. Nevertheless, the challenge that arises is to return to the understanding of ethnomathematics according to D'ambrosio (in [15]) as follows:

"*The prefix ethno is today accepted as a very broad term that refers to the social-cultural context and therefore includes language, jargon, and codes of behavior, myths, and symbols. The derivation of mathema is difficult, but tends to mean to explain, to know, to understand, and to do activities such as ciphering, measuring, classifying, inferring, and modeling. The suffix tics is derived from techné, and has the same root as technique* (p. 81)".

A challenge obtained from the notion of ethnomathematics is to translate appropriate mathematics learning studies at the level of undergraduate students for prospective elementary school teacher candidates. The socio-cultural context includes the appearing language, jargon, codes of behavior, myths, and symbols that could be experienced from sources of artifacts or cultural actors/informants. Furthermore, the mathematical content is to be interpreted, explained, and understood by carrying out activities such as interpreting, measuring,

classifying, concluding, and modeling. Research on ethnomathematics at the tertiary level for prospective elementary school teachers has been carried out to improve geometry competencies [1].

CONCLUSION

Based on the results and discussion, it concludes the development of research and publications on ethnomathematics in the last twelve years (2015-2021) of the three international databases; Scopus (200 articles), Crossref (142 articles), and Google Scholar (840 articles). The research progress map of ethnomathematics publication based on co-word is grouped into 5 clusters. The authors found four keywords of *pedagogy*, *problem-solving ability*, *elementary school student*, and *teaching material* in publications on ethnomathematics that can be developed for future research and learning in the Elementary School Teacher Education Study Program.

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