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Mathematics Education Research Trends in the Philippines: A Bibliometric Analysis using Scopus Database

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Abstract

The investigation of research trends in mathematics education in the global landscape has been prominent in the recent years. However, there is a dearth of literature in investigating research trends in mathematics education in the Philippine setting. Thus, this bibliometric analysis on the research in mathematics education in the Philippines from 2013 to 2023 was conducted. This paper aimed to present scientific information about the distribution pattern of research on mathematics education in terms of discipline, the profile of prominent authors, the key subject areas which given emphasis, and the direction of research. A total of 993 articles were obtained from the Scopus database and were analyzed using the VOSviewer software application to see the research trends in mathematics education in the Philippines. Research articles emerged as the predominant document type, followed by conference papers. The pinnacle of mathematics education research in the Philippines was in 2014. Notably, the research trend in the Philippines for the last five years have observable decrease in mathematics education. Results show that in terms of discipline, problem solving, teacher professional development, and curriculum were typically the key areas of emphasis. Moreover, the top author with the greatest number of citations since 2013-2023 is a female researcher from Mindanao. Furthermore, the mathematics subjects that have the most attention are algebra, proof, calculus, technology, geometry, and modeling. Finally, this paper foresees continued growth in mathematics education research in the Philippines, particularly in the realms of professional development and problem-solving.

Keywords: Mathematics education, research trends, bibliometric analysis, distribution pattern, Scopus database

INTRODUCTION

Education is dynamic, hence, the approach used in mathematics education today is different from what it was years ago. Research in mathematics education has shown that traditional methods of teaching and learning have changed over the past few decades (Gallagher et al., 2020). The importance of mathematics education is found in how it helps students develop their capacity for critical thought, enabling them to advance in the age of modernity (Bass & Ball, 2018).

Over the past fifty years, there has been a remarkable growth both in the quantity and diversity of research in the field of mathematics education. Recent research in this area has undertaken comprehensive assessments of the current state of advancement and has also addressed potential directions for future studies, as well as the challenges and issues at hand (Engelbrecht et al., 2020). For instance, Julius et al. (2021) provided an overview of worldwide developments in the realm of mathematics education research, while Yig (2022) delved into contemporary patterns and significant concerns in the field. These investigations, among others, have explored the evolving landscape of mathematics education research on a global scale throughout recent decades.

While researchers have extensively examined global trends in mathematics education, including those specific to various countries, there exists a shortage of literature focusing on the analysis of research trends in mathematics education within the Philippines. Therefore, this study aims to address this gap by utilizing the Scopus database to explore the research patterns within the field of mathematics education in the Philippines. This effort is aimed at providing an up-to-date overview of the research landscape in mathematics education within the Philippines over the last decade.

This study sought to present scientific data on the mathematics education-related research published in the Philippines and that which pertain to the mathematics education in the country indexed in Scopus database. Specifically, this aimed to determine the volume and growth trajectory of mathematics education literature in the Philippines from 2013 to 2023; describe the profile of top authors engaged in mathematics education research in the Philippines from 2013 to 2023; and identify and analyze the ongoing trends in mathematics education research within the Philippines.

The study's findings are significant for researchers, educators, and decision-makers working in the Philippines' mathematics education system. Curriculum planning and resource allocation are informed by an examination of the volume and growth trend of mathematics education literature from 2013 to 2023. Researchers and educators can gain insights from the demographic profiling of top authors, which promotes a varied and cooperative research community. Furthermore, educational institutions can better connect their curricula with current research and improve teaching and learning methods by identifying ongoing trends in mathematics education research. In general, teachers, students, upcoming academicians, and other educational stakeholders could gain from this research's contribution to the ongoing advancement of mathematics education policies and practices.

The research on mathematics education in the Philippines from 2013 to 2023 found in Scopus database is the sole focus of this study. Scopus-indexed journal articles, conference papers, books, and reviews will all be included. Without going in-depth on the qualitative elements or evaluating particular research, the study focused on quantitative bibliometric analysis of publishing trends, authorship patterns, citation analysis, and keyword trends.

In the realm of philosophy of science, numerous theories have been put forth to explain scientific progress. Popper's theory of progress through falsification (Popper, 1959) and Kuhn's concept of progress happening through shifts between periods of normal science and paradigm shifts (Kuhn, 1962) are well-known examples. However, this research will be guided by Lakatos's notion of a scientific research program, which can be seen as an adaptation of Kuhn's ideas (Larvor, 1998). While Kuhn believed that different research approaches or paradigms were incommensurate, Lakatos argued that such a view implies a lack of rational methods for choosing between paradigms, ultimately rendering scientific progress a product of "mob psychology" (Larvor, 1998). Lakatos aimed to reconcile Popper's belief in the rationality of science with Kuhn's historical fidelity.

Lakatos's central concept is that the fundamental unit of research is not an individual research hypothesis or theory, as argued by Popper, but rather a research program. A research program is a historically connected series of theories that share a common "hard core," which comprises key assumptions and beliefs embraced by those working within the program. For example, the hard core of the Newtonian research program included the concept of gravitational action at a distance and Newton's laws of motion. Protecting the hard core against falsification is crucial because modifying it would mean abandoning the entire program.

Research programs often encounter anomalies in empirical observations, and Lakatos acknowledged that programs "grow in a permanent ocean of anomalies." Anomalies can be dealt with in two ways: they are either ignored, with researchers treating them as open questions if the program is making progress, or a "protective belt" is employed. The protective belt consists of auxiliary hypotheses that support the hard core and prevent it from being falsified. Unlike the hard core, the protective belt can be modified or abandoned without endangering the program. To illustrate this, Lakatos used the example of a scientist observing a planet moving in a way inconsistent with Newton's laws; the scientist would modify the protective belt rather than abandoning the hard core (Linton, 2004).

The third component of a research program is its "heuristic," which encompasses the methods and problem-solving techniques researchers use to make progress. The heuristic is closely tied to the program and is sometimes challenging to distinguish from the hard core. Lakatos even suggested that this distinction could be a matter of convention in some cases. For instance, the measurement of response times is a crucial part of the cognitive psychology research program's heuristic, driven by assumptions from the program's hard core (the temporal nature of information processing).

Lakatos's framework attempts to explain scientific progress and theory change by viewing a discipline as a collection of competing programs. He distinguishes between "progressing" programs that regularly generate novel results and "degenerating" programs that struggle to make new discoveries or predictions. Progressing programs may ignore anomalies or modify their protective belts to generate new results, while degenerating programs dedicate their protective belts to accommodating anomalous observations post hoc. Lakatos posits that programs are abandoned when researchers cease trying to accommodate anomalies and join a rival program that is making progress.

Research programs can be examined at various levels. Lakatos pointed out that "even science as a whole can be regarded as a huge research program with Popper's supreme heuristic rule: 'devise conjectures which have more empirical content than their predecessors'" (Lakatos, 1978). However, more commonly, an academic discipline consists of several rival research programs vying for attention, aiming to demonstrate their progress (Gillies, 2007; Larvor, 1998). Lakatos envisioned this competition as constructive, where each program strives to progress due to challenges from its rivals. He even suggested that individual researchers could work within multiple research programs to expedite this process (Lakatos, 1978).

To substantiate his perspective on scientific progress, Lakatos (1978) analyzed historical episodes, such as Niels Bohr's work on light emission, employing "rational reconstructions" of idea development, with historical details relegated to footnotes (Larvor, 1998). The purpose of these reconstructions was to offer a rational explanation of the growth of objective knowledge, rather than a comprehensive historical account (Lakatos, 1970).

LITERATURES

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METHODOLOGY

The objective of this study was to explore and scrutinize the evolving research patterns in the field of mathematics education in the Philippines using an extensive bibliometric analysis. This approach integrated a methodical examination of published articles, encompassing their citations, to evaluate the influence of these articles, as exemplified by Maditati et al. (2018).

Research Design. This research employed quantitative research, particularly descriptive analysis design. To chart the trends on the current subject, several indices such as the distribution of the publication over time, journals, institutions, authors' performances, and the main subjects receiving the most attention and their shifts in foci over time were quantitatively analyzed using a bibliometric tool.

Research Setting. The Philippines served as the study's research locale. A wide range of geographic areas in this geographical context, including urban and rural areas, as well as a wide variety of academic institutions, universities, and research facilities was covered. The Philippines provides a distinctive setting for analyzing trends in mathematics education because of its rich cultural diversity and active educational system. A plethora of

research on mathematics education in the Philippines is also housed in digital databases and repositories, with the Scopus database serving as the focal point. This all-encompassing strategy guaranteed a thorough evaluation of the latest developments in mathematics education research, ultimately fostering a nuanced comprehension of this area in the context of the Philippines.

Data Source. The dataset for this research consisted of articles, conference papers, books, and reviews published in journals related to mathematics education in the Philippines between 2013 and 2023, as indexed in the Scopus database. The selection of the Scopus database was based on its reputation as the most extensive source of peer-reviewed literature, encompassing primary research journals in the domain of mathematics education, as affirmed by Nivens and Otten (2017). The research was identified by using the search query formulation approach which included the terms "mathematics," "education," and "Philippines" in the Scopus database.

The data gathering procedure for this research was designed to ensure the collection of comprehensive and relevant bibliographic data from a reputable source. In the process of gathering data, several systematic steps were followed.

Initially, the Scopus database was selected as the primary source to capture a wide array of research trends in mathematics education pertaining to the Philippines. The following query string: (TITLE-ABS-KEY (mathematics AND (edu* OR teach* OR learn* OR train* OR pedagogy OR student* OR curricul*)) AND PUBYEAR 2012 1979 AND PUBYEAR < 2024 to maximize the relevance of retrieved documents. Subsequently, the researcher executed searches within the chosen database and exported all search results into reference management software, specifically Harzing's Publish or Perish, to facilitate organization and analysis. A stringent screening process was employed to include only pertinent publications, encompassing academic works specifically addressing mathematics education in the

Philippines, such as journal articles, conference papers, books, and reviews while excluding publications in languages other than English and those unrelated to mathematics education.

Bibliometric data, including publication titles, authors, publication year, keywords, abstracts, and citations, was systematically extracted from the selected documents. To ensure data integrity, a meticulous cleaning and preprocessing procedure rectified inconsistencies and eliminate duplicates, with any discrepancies resolved by referencing the source documents.

The data gathering procedure adhered to rigorous and systematic methods, ensuring the reliability and validity of the information collected. This procedure underpinned the quality and integrity of the bibliometric analysis, allowing for a comprehensive exploration of the research trends in mathematics education within the Philippines.

Data Analysis. In this study, a bibliometric analysis of mathematics education–related studies within the Philippines from 2013 to 2023 was employed. In particular, the Microsoft Excel was used to analyze the frequency of the types of documents and the quantity of published works per author and per year, and the VOSviewer text mining software was utilized to reveal research trends, detect leading authors, and scrutinize citation patterns. VOSviewer is a software tool with the capacity to generate visual representations and compile data regarding diverse bibliometric indicators, as described by Van Eck and Waltman (2010). Throughout this process, adherence to ethical standards and copyright regulations was of paramount importance, ensuring proper attribution and citation practices to respect intellectual property rights. Additionally, the Harzing's Publish or Perish software tool was utilized for analysis and citation metrics.

The finalized dataset was subjected to analysis using VOSviewer text mining software, enabling the identification of research trends, prominent authors, institutions, and citation patterns.

RESULTS

Table 1
Frequency distribution of document types of researches on mathematics education in the Philippines-related Documents from 2013–2023.

Type of Document	Frequency	Percentage
1 Article	636	64 %
2 Conference Paper	218	22 %
3 Book Chapter	109	11 %
4 Book	20	2 %
5 Review	10	1 %

Table 1 shows the distribution of published mathematics education in the Philippines–related documents, as indexed in the Scopus database, according to their types: articles, conference papers, book chapters, books, and reviews. Among the 993 total documents, 636 were articles, constituting 64% of the total documents. Conference papers made up 22% of the documents, totaling 218 papers. Book chapters represented 11%, with 109 individual chapters. Twenty books, passing the screening process, accounted for 2% of the total documents. Finally, 10 reviews comprised only 1% of the entire collection.
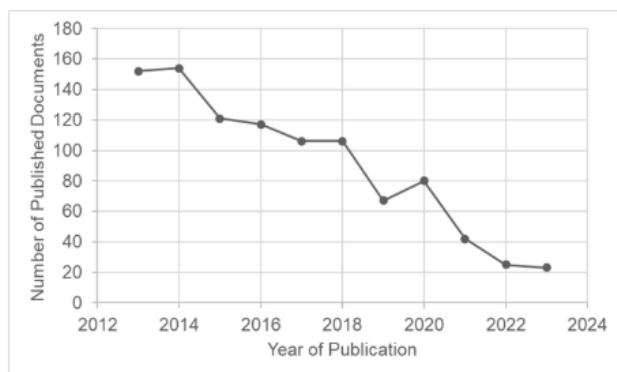

Figure 1.
Distribution of the number of published mathematics education researches in the Philippines from 2013–2023 found in Scopus database.

Table 2
Demographic Profile of Top Authors in Mathematics Education in the Philippines Literature in Terms of the Number of Citations.

	Name	Number of Citations	Gender	Affiliation	Location
1	Perez, A.L.R.	34	Female	Western Mindanao State University	Zamboanga, Philippines
2	Anito, J.C.	16	Male	Jose Rizal University	Mandaluyong, Philippines
3	Rubio, J.S.	16	Female	University of Camarines Norte	Daet, Philippines
4	Mordeno, I.C.V.	13	Female	Mindanao State University – Iligan Institute of Technology	Iligan, Philippines
5	Quinto, E.J.M.	13	Male	Mapua University	Manila, Philippines
6	Lomibao, L.S.	13	Female	Science and Technology of Southern Philippines	Cagayan de Oro, Philippines
7	Tapado, B.M.	10	Female	Catanduanes State University	Virac, Catanduanes, Philippines

Table 2 highlights the demographic profile of leading authors in the field of mathematics education in the Philippines literature, based on citation counts. Authors hailing from the Philippines occupy all the top positions in terms of citations. This is attributed to their scholarly contributions focused on the educational landscape in the Philippines, specifically within the realm of mathematics education (Kilpatrick, 2020).

Perez, A.L.R. from Western Mindanao State University in Zamboanga, Philippines has, insofar, the highest number of citations with a total of 34 citations. Second to her are Anito, J.C. and Rubio, J.S. who are from Jose Rizal University in Mandaluyong, Philippines and University of Camarines Norte in Daet, Philippines, respectively. They both have a current number of citations of 16. With a total of 13 citations, on the list of top authors are Mordeno, I.C.V. from Mindanao State University – Iligan Institute of Technology in Iligan, Philippines, Quinto, E.J.M. from Mapua University in Manila, Philippines, and Lomibao, L.S. from Science and Technology of Southern Philippines in Cagayan de Oro, Philippines. Finally, Tapado, B.M. from Catanduanes State University is among the top authors in mathematics education in the Philippines literature from 2013–2023 with a current total of 10 citations.

Figure 2
Bibliometric map of author keywords co-occurrence with overlay visualization mode.

Figure 2 presents the bibliometric map of keywords, utilizing the VOSviewer overlay visualization mode to accentuate the impact (Schoenfeld, 2016). Encompassing all levels of education, the research landscape exhibits a pronounced focus on various subjects, with algebra, proof, calculus, technology, geometry, and modeling standing out. The most frequently used keywords, as revealed by author keyword analysis, were 'mathematics education' and 'mathematics.'

The result highlights a strong emphasis on problem-solving, professional development of teachers, and curriculum-related research, marking these areas as enduring focal points in the field. Over the recent years, there has been substantial growth in publications across numerous sub-areas of mathematics education. Themes such as mathematical knowledge for teachers, active learning, inquiry-based learning, Geogebra, and statistics education research have gained prominence.

DISCUSSION

This analysis offers an overview of the research landscape in mathematics education in the Philippines from 2013 to 2023. A total of 993 papers were retrieved from the Scopus database during this period, suggesting a negative growth trajectory in the field. Research articles emerged as the predominant document type, followed by conference papers. The pinnacle of mathematics education research in

the Philippines occurred in 2014, with subsequent years maintaining a significant level of scholarly activity. Notably, the last five years witnessed a regress of interest in mathematics education in the Philippines. To note, only 39.48% (392) of the total publications are accessible for free. Therefore, it is recommended to publish articles in journals as an open-access type to promote citations. The literature obtained in this study was published in the English language at 100% (993 articles) because for an article to be indexed in Scopus, the title and abstract have to be written in English. In addition, the query string used in this study does not contain any restrictions on foreign articles, thus allowing the string to capture all articles, and therefore, authors, institutions, and countries that fall within the categories.

Furthermore, results underscores that a significant portion of the top authors are females. This statistic suggests that female researchers have produced noteworthy works in this subject area, contributing to the robust representation of their papers in the Scopus database (Hannula, 2009). It implies a commendable presence of well-crafted research by female authors within the domain of Mathematics Education in the Philippines.

Mathematics education inherently provides a solid groundwork for enhancing problem-solving skills (Gillies, 2007). In addition to common keywords such as 'mathematics education' and 'mathematics,' the term 'problem' emerged as the most frequently encountered keyword. Complementary terms associated with problem-solving include 'evidence,' 'outcome,' and the term 'math' itself.

Moreover, a substantial body of research has delved into the professional development of teachers, exploring the educational context and its correlation with student outcomes (Linton, 2004). As depicted in Figure 1, keywords such as 'professional development,' 'teacher education,' and 'teacher knowledge' are prominently featured, signifying the recurrent focus on assessing teacher growth throughout their careers. Noteworthy among these are the most

frequently used keywords: 'mathematics teacher education,' 'teacher beliefs,' 'mathematics teacher,' and 'teacher learning.' These terms underscore the persistent attention given to understanding and enhancing the dynamics of teacher performance and knowledge in the field of education (Inglis and Foster, 2018).

While the majority of these studies encompassed teachers in a broad sense, it is imperative to underscore the significance of independent investigations differentiating between in-service teachers and pre-service teachers for a more nuanced understanding (Kilpatrick, 2020). Notably, the analysis revealed the prominence of keywords such as 'in-service teacher,' 'pre-service teachers,' 'pre-service teacher education,' 'pre-service mathematics teacher,' and 'pre-service,' indicating the value placed on distinguishing between these two distinct phases of teacher preparation.

The curriculum emerges as another focal point, garnering substantial attention due to its pivotal role in the teaching and learning dynamics within the education system (Haleem et. al., 2020). This examination highlights the recurrent appearance of keywords associated with the curriculum. Additionally, general terms like 'curriculum,' 'mathematics curriculum,' and 'integrated curriculum' featured prominently, underscoring their widespread relevance. Furthermore, influential attributes pertaining to the subject, including curriculum development, reformation, design, and implementation, were also frequently reiterated in the analyzed literature.

Upon closer examination, it becomes evident that research on mathematics education within the selected timeframe has extensively covered various educational levels. In the context of the two-stage educational system, the keyword 'primary school' emerged prominently. Additionally, terms related to the secondary school were equally prevalent, encompassing 'secondary school' and 'secondary school mathematics.' Transitioning to the three-stage educational system, keywords such as 'elementary school' and 'elementary school

mathematics' were consistently encountered. Notably, in comparison to the middle school level, there is a discernible emphasis on research at the high school level, as indicated by the increased frequency of keywords associated with 'high school' and 'high school mathematics,' while references to 'middle school' reported relatively minor occurrences.

Moreover, keywords denoting elements of tertiary-level education surfaced with notable frequency. The most recurrent terms encompassed 'undergraduate mathematics,' 'undergraduate mathematics education,' and 'higher education.' Within the tertiary education sphere, prevalent topics comprised, but were not confined to, calculus, active learning, and differential equations. The breadth of subjects related to mathematics exceeded 100, with keywords prominently featuring areas such as algebra, proof, calculus, technology, geometry, and modeling standing out as the most frequently employed terms among this diverse array of subjects.

In conclusion, the examination of the retrieved documents, guided by the overlaying color range, revealed distinct sub-areas within mathematics education that have witnessed a notable surge in publications in recent years (Cancino et al., 2017). Notably, prominent among these is the research theme centered on 'mathematical knowledge for teachers,' 'active learning,' 'inquiry-based learning,' 'Geogebra,' and 'statistics education research.' These specific sub-areas have garnered significant attention and acclaim within the academic landscape, reflecting a discernible upward trend in scholarly output.

Looking ahead, the study foresees continued growth in mathematics education research, particularly in the realms of professional development and problem-solving. This expansion is anticipated to encompass more sub-areas and assessment methodologies.

The implications of this research extend to various stakeholders, including mathematics education researchers, teachers, school managers, and policymakers in the Philippines.

Insights into authoring patterns can inform the development of mathematics education strategies, while knowledge about top authors and research groups aids newcomers and junior researchers. Policymakers can leverage this information to consult the right scholars during policy formulation.

The identified knowledgebase in mathematics education studies forms clusters for future research, with gaps indicating potential areas for further exploration. For instance, there is a need for studies applying mathematics education to teach analytic knowledge, especially at the lower secondary and high school levels. Lastly, the keywords identified in the study may serve as valuable cues for mathematics education scholars to explore new research topics.

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