

Ethnomathematics: culture exploration and the improvement of mathematical teaching process

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Abstract

The study aimed at investigating ethnomathematics in relation to exploring culture and improving thinking process in mathematics. This is a systematic literature review study conducted by identifying, investigating, evaluating, and interpreting the available research in the field. The review was conducted by summarizing, reviewing, and analyzing 15 articles in the field of ethnomathematics which were published in reputable journals. The articles were searched using online database including Google Scholar, SINTA, and Scopus. The study found that the development of ethnomathematics studies has not only increased the curiosity of various cultures, but also conserve the nearly lost cultures during the modernization era. Furthermore, the invention of mathematical concepts related to ethnomathematics has been resulted in the increase of problem-solving skills and mathematical thinking process among students.

Keywords: Ethnomathematics, Culture, Mathematical Thinking, Systematic Literature Review

Introduction

Mathematics is a social science; most human activities involve mathematics (Freudenthal, 2002; Sfard, 2006; Björklund, 2008; Ernest, 2016; Bakker & Hubmann, 2017). It has been practiced with the help of people for generations, as mathematical calculations were used alongside equipment and media in historic times (Monaghan, et al., 2016). In fact, each region has its own characteristics and traits in performing mathematical activities, resulting in a distinct regional culture (Bishop, 1994). However, in some areas, mathematics is still widely regarded as a science that transcends lifestyle and culture (Prahmana & D'Ambrosio, 2020).

Culture is a component of human action that shapes a community into a single unit with various appearances (Widada, et al., 2019). It is also a habit that contains vital

values that are passed down from generation to generation. Cultural activities are changing along with the times and innovation. This phenomenon can be viewed as a result of current global modernization, which necessitates consideration and management in order to preserve culture for future generations. As a result, one of the steps that can be taken is to incorporate culture into the execution of the instruction, including math learning.

Mathematics is a system of concept where cultural values have a position in its emergence and development (Sam & Ernest, 1997; Entremont, 2015; Zaslavsky, 1998). The application of this science within the culture of society is an essential issue to discover in order to understand it more comprehensive and to experience it directly in life (Afriansyah, 2016). In 1977, D'Ambrosio, a mathematician from Brazil, first introduced the integration between mathematics and culture, which was given the term ethnomathematics. This term is defined as mathematics utilized by community/cultural corporations, which includes city and rural communities, corporations of workers/laborers, expert corporations, children, indigenous peoples, and lots of different corporations which are identified from the goals and tradition (D'Ambrosio, 1985). Ethnomathematics is able to bridge between culture and mathematics (Wahyuni et al., 2013) and even become a science used to understand how mathematics is adapted from a culture (Marsigit, 2016).

Since ethnomathematics has been popularized, the application of this approach has been well known in both workplace and school learning. There are many studies show that integrating an ethnomathematical approach into the mathematics curriculum improves both mathematics learning activities and student mathematic achievement ((Barton, 1996; Brenner, 1998; Gutstein, 2003; Pierre & Gerdes, 2015; Rosa and Orey 2013; Madusise & Mwakapenda, 2014; Bazinet & Marshall, 2015). In fact, in developed countries such as the United States, the application of ethnomathematics is increasingly popular in learning mathematics which is heading to the majority in the development of science (Rowlands & Carson, 2002). A study reported that one of the successes of Japan and China in education due to the emphasis learning on local wisdom or culture (Rowlands & Carson, 2002; Zaenuri et al., 2018). Teaching culturally relevant mathematics helps students learn more about reality, culture, society, environmental issues, and themselves (Orey & Rosa, 2006).

This research is expected to provide a reference as a preliminary study in (1) describing the framework and projections of ethnomathematical studies in relation to cultural preservation through the integration of mathematics learning into cultural contexts; (2) taking steps for the integration of ethnomathematics in the curriculum and teaching-learning mathematics; and (3) exploring deeply of how ethnomathematics has been carried out in various studies. In fact, various ethnomathematical studies have been conducted using quantitative and qualitative research methods with participants of all ages from preschool to higher education. Through this article, it is important to preserve and sustain the study of mathematical concepts embedded in the culture. Culture is not only history that has meaning but is far from it, the culture can be studied in learning mathematics leading the teaching-learning process to become more meaningful and interesting and resulting in a positive effect on both the thinking process and the student achievement.

Research Method

A systematic literature review was conducted as the research design used in this study. It was purposively performed to identify, assess, and interpret the results of related studies and to answer the research questions (Brereton et al., 2007). In this study, a comprehensive review of 15 journals with excellent publication quality of the index levels Q1, Q2, Q3, and Q4 as well as the categories Sinta 1 and Sinta 2 was

carried out. Criteria for the selection of the articles in this study were considered as follows: a) Articles according to the research topic on ethnomathematics; b) the articles published in 2019-2022; c) international articles from Scopus-indexed journals and national articles from Sinta-indexed journals; and d) full text. The search process for indexed international journals was performed by using the Publish application or Perish 8 and for national journals using Google Scholar. In the item search, the string function was used to specify the items as well as to avoid filtering items from unrelated data articles. The search term in this study is ethnomathematics.

Results

The analysis results of 15 national and international journals published on ethnomathematics between 2019 and 2022 revealed the following results in Table 1:

Table 1. Searching Results on Ethnomathematical Articles

Title	Publisher and Year	Research Finding
1. The Wittgensteinian Perspective and Ethnomathematics: An Analysis of Language Games and the Rules Governing Their Uses in Certain Work Activities (Osterberg & De Lara, 2019)	Journal Acta Scientiae (Q2) Year 2019	This study adopts a Wittgensteinian perspective to analyze language games involving mathematical concepts in human activity and compares ethnomathematics in the form of rules for the use of language concepts with rules in school mathematics. Here mathematics is present in the activities of life in the form of language games that become culture. In fact, ethnomathematics creates school math a different way of doing math resulted from language culture.
2. Teacher-related Challenges Affecting the Integration of Ethnomathematics Approaches into the Teaching of Geometry (Sunzuma & Maharaj, 2019)	EURASIA Journal of Mathematics, Science and Technology Education (Q2) Year 2019	This study explores the challenges faced by teachers in integrating ethnomathematics into geometry material. The findings indicate that the challenges faced by teachers in teaching geometry with ethnomathematics are lack of knowledge in composing geometry content, misunderstanding of ethnomathematical approaches, and lack of competence and confidence in teaching geometry. Since knowledge of geometry content and conceptual understanding of ethnomathematics are important components for the integration in ethnomathematical approach, an effective development and cultural knowledge are necessarily needed to encourage the teachers.
3. Ethnomathematics in Sasaknese Architecture (Supiyati et al., 2019)	Journal on Mathematics Education (Q2) Year 2019	This research investigated various cultural elements in Lombok, specifically Sasak architecture such as houses (<i>bales</i>), religious structures (mosques), and rice treasuries (<i>sambis</i>). The measurement methods, designs, and forms of buildings that exist in Sasak culture demonstrate the ethnomathematics practiced by the Sasak people. As a result, this research focuses on

<p>4. Math and Mate in Javanese <i>Primbon</i>: Ethnomathematics Study (Utami et al., 2019)</p>	<p>Journal on Mathematics Education (Q2) Year 2019</p>	<p>extracting historical data about mathematical conventions so that the knowledge gained can be used to teach mathematics in schools.</p> <p>By using <i>Primbon</i> as a predictor of the fate of married couples, this study investigated Javanese culture in terms of Javanese numerical values. According to the findings of this study, matching with Javanese <i>Primbon</i> is related to numerical basis, remainder theorem, modulus, and modulus of congruence in formal mathematics. Thus, matchmaking pairs using knowledge through Javanese <i>Primbon</i> is a potential material as an ethnographic context for learning mathematics. Because of the limitations of this study, it cannot be used to further investigate its empirical use in teaching mathematics with this topic.</p>
<p>5. The ability of mathematical representation through realistic mathematics learning based on ethnomathematics (Widada, Nugroho, et al., 2019)</p>	<p>Journal of Physics (Q4) Year 2019</p>	<p>This study proved that learning mathematics through a realistic ethno-mathematical approach can improve student ability to understand and process mathematical reasoning. This learning can help students improve their mathematical expression skills. The findings revealed that there were differences in mathematical abilities between students who received <i>ethnomus</i> oriented learning and those who did not, and that there was an interactive effect of learning approaches and orientation of mathematics materials on mathematical expressive abilities.</p>
<p>6. Contribuição da Etnomatemática para a Manutenção e Dinamização da Cultura Guarani e Kaiowá na Formação Inicial de Professores Indígenas (Cunha, 2020)</p>	<p>Journal Education Policy Analysis Archives (Q2) Year 2020</p>	<p>The purpose of this study is to develop ethno-mathematics in primary education for indigenous mathematics teachers and to contribute to the preservation and development of Guarani and Kiowa culture. The study concludes that ethno-mathematics as a pedagogical alternative contributes to the preservation and promotion of Guarani and Kiowa culture in the early education of indigenous mathematics teachers, a teaching strategy that leads to respect, appreciation, and strengthening of indigenous languages and cultural roots.</p>
<p>7. Towards African humanicity: Re-mythologising Ubuntu through reflections on the ethnomathematics</p>	<p>Critical Studies in Teaching and Learning (Q3) Year 2020</p>	<p>This study establishes ethnomathematics as a discipline that integrates mathematical ideas with a cultural context in order to respect diversity and promote cultural heritage respect. Ethnomathematics allows African cultures to shed light on the critical factors influencing African students' success in</p>

<p>of African cultures (Chahine, 2020)</p>		<p>mathematics. Many African Ethnomathematical ideas are presented with reference to the extensive literature on African cultural ingenuity, which penetrate indigenous knowledge systems and can be applied to school mathematics curricula.</p>
<p>8. Ethnomathematics Activities: Reflections From The Design And Implementation Process (Ergene et al., 2020)</p>	<p>Turkish Journal Of Computer and Mathematics Education (Q3) Year 2020</p>	<p>One of this study outcomes is to raise the awareness of ethnomathematics among prospective and current teachers. They had previously claimed that there was either no relationship or a very weak relationship between culture and mathematics. At the study's conclusion, prospective and current teachers agreed that mathematics and culture had a one-way or reciprocal relationship. This study demonstrates that using ethnomathematics has a number of advantages, including increasing students' interest in the lesson, making class more enjoyable, and allowing for the incorporation of cultural elements into instruction.</p>
<p>9. In-service Zimbabwean teachers' obstacles in integrating ethnomathematics approaches into the teaching and learning of geometry (Sunzuma & Maharaj, 2021)</p>	<p>Journal of Curriculum Studies (Q1) Year 2020</p>	<p>This study investigates the factors that impede the integration of ethno-mathematical approaches into geometry schools and learning, and it suggests potential solutions for mathematics education in Zimbabwe. The study's findings include curriculum challenges, insufficient resources such as textbooks with few examples, and cultural activities as factors influencing the integration of ethnomathematical approaches in geometry learning. (The study recommends a collaborative culture in which teachers, CDU members, ZIMSEC examiners, and MOPSE officials work together to improve the integration of ethnomathematics approaches in geometry teaching.)</p>
<p>10. Learning Sets Theory Using Shadow Puppet: A Study of Javanese Ethnomathematics (Charitas & Prahmana, 2021)</p>	<p>Mathematics Journal (Q2) Year 2021</p>	<p>This study aims to explore the mathematical elements that potential to be found in the context of Javanese <i>wayang kulit</i> and, to discuss the values of life that can be internalized by students in learning mathematics through <i>wayang kulit</i> culture. The findings show that there are several interesting elements, characteristics, and patterns in Javanese <i>wayang kulit</i>, which can be used as a starting point for studying the concept of sets. In addition, the values and philosophies of <i>wayang kulit</i> culture have the potential in building good character and behavior for students.</p>

11. Ethnomathematics : <i>pranatamangsa</i> system and the birth-death ceremonial in Yogyakarta (Charitas et al., 2021)	Journal on Mathematics Education (Q2) Year 2021	This study aims to explore the culture of Yogyakarta from the context of learning mathematics. The results of this study indicate that the people of Yogyakarta use mathematical modelling to determine the system of seasons and burial dates, these models have the potential to be used as starting points in learning mathematics. This research has shown that a culture that contains mathematical modelling has the potential to be used in studying mathematical topics. This can be a reference for educators in Yogyakarta to improve students' understanding and students' relation with mathematics, culture, and life.
12. Exploration of Students' Statistical Reasoning Ability in the Context of Ethnomathematics : A Study of the Rasch Model (Ramadhani, Saragih, & Napitupulu, 2022)	Mathematics Teaching Research Journal (Q4) Year 2022	This study aims to explore the ability of statistical reasoning in descriptive statistics learning in ethnomathematical contexts. In this study, posing problems in ethnomathematics contexts can help students understand the problems presented and assist students in analyzing and justifying the data obtained. These findings suggest that researchers incorporate cultural and traditional contexts familiar to students when presenting mathematical problems. According to the findings of this study, students can practice statistical reasoning skills through ethnomathematics-based problem-solving while also considering other demographic factors.
13. Measuring Changes of Students' Statistical Reasoning Taught by Ethnomathematics Approach Assisted TinkerPlots: A Stacking Analysis Study (Ramadhani, Saragih, Maulida, et al., 2022)	JTAM (Jurnal Teori dan Aplikasi Matematika) (Sinta 2) Year 2022	The purpose of this study is to assess students' statistical reasoning abilities in descriptive statistics learning in the cultural environment of Nias using an ethnomathematical approach aided by TinkerPlots. The findings revealed that students who received the ethnomathematical approach aided by TinkerPlots outperformed students who received traditional learning. With the use of an ethnomathematical approach, the students' statistical reasoning ability improved significantly.
14. Decolonizing Tacit Knowledge of The Bugis Traditional House through Ethnomathematics	Local Wisdom Scientific Online Journal (Sinta 2) Year 2022	The purpose of this research is to uncover the logical factors underlying traditional house cultural values. Using photo documentation, this study reconstructs various patterns of Bugis house forms using an ethnomathematical study approach. The Bugis vernacular house forms are frequently described as the embodiment of non-physical

<p>(Yusran et al., 2022)</p> <p>15. Ethnomathematics in the Concept of Tri Hita Karana Traditional Village in Bali (Atmaja et al., 2022)</p>	<p>ITALIENISCH Journal (Q4) Year 2022</p>	<p>(intangible) basic knowledge in the form of culture, belief, and community life principles. However, when the building process, rules, and sizes are considered, as well as the development of its form and typology, a Bugis house is not only an embodiment of the cosmological concept, but also an embodiment of form that implements scientific knowledge. This highlights the significance of efforts to decolonize tacit knowledge, which is still anchored in traditional architectural knowledge.</p> <p>The study aimed at investigating ethnomathematics in traditional villages logic in Bali related to community social system, which has not been investigated in the field of ethnomathematics studies before. The findings showed that the concept of trihita karana traditional village implicitly consisted of logic dan set. The concept of Ethnomathematcs of trihita karana in traditional villages in Bali can be an alternative source for teachers and students learning mathematics in the topic of logic and set.</p>
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Discussion

Based on search engine results, 15 literature studies published between 2019 and 2022 discovered that ethnomathematics is a growing field of study in mathematics that plays an important role in exploring cultural values as well as a form of representation of everyday mathematical practice in a socio-cultural environment. Ethnomathematics has an impact on mathematics learning, the integration of mathematics with culture creates the learning context more meaningful, increases students' interest, and motivates and assists students in the process of thinking and problem-solving. However, research studies have discovered some challenges in applying ethnomathematics to specific materials due to the teacher's lack of cultural content knowledge. Therefore, a comprehensive understanding of the context and culture is necessarily needed in implementing ethnomathematics.

Various studies comprehensively reported on the ethnomathematical approach which can improve student performance in mathematics (Bishop, 2000; D'ambrosio, 2001; Gerdes, 2005). Ethnomathematics can help students improve their problem-solving abilities, and cognitive processes through higher levels of thinking, creative and critical thinking, and communication skills so that they can perform mathematical representations and communicate correctly (Widada and Herawaty, 2017; 2018). Students who received ethnomathematics-based mathematics instruction outperformed those who received conventional instruction (Achor et al., 2009). Culture appreciation is an important goal of ethnomathematics (d'ambrosio & rosa, 2017). Furthermore, a mathematics curriculum that incorporates cultural elements will benefit students. ethnomathematics encourages students to gain a deeper understanding of cultural elements, which has been shown to improve students' perceptions of mathematics as a part of everyday life, transforming mathematics from a meaningless subject to be studied.

Conclusions

In conclusion, ethnomathematical research studies have investigated specific local cultures as mathematical activities in society. The study of ethnomathematical literature is expected to be used as a foundation for ethnomathematical inquiry as an approach to learning mathematics in schools in community activities. The findings of this study suggest that the advancement of ethnomathematical research can spark interest in certain regional cultures while also preserving cultures that have been largely forgotten as a result of modernization's effects. Furthermore, it has been demonstrated that understanding mathematical concepts related to ethnomathematics improves problem solving skills and mathematical thinking processes, allowing ethno-mathematics to improve students' mathematical performance

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