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Ethnomathematics: An Exploration of Traditional Musical Instruments and Sundanese Batik Culture in Garut Regency

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Abstrak

Artikel ini membahas konsep etnomatematika melalui alat musik tradisional Celentung dan batik bermotif cupat manggu sebagai bagian dari budaya Sunda di Kabupaten Garut. Penelitian ini bertujuan untuk mendeskripsikan hasil eksplorasi etnomatematika dengan mengidentifikasi unsur-unsur matematika yang terdapat dalam alat musik tradisional, serta pola geometris dan simetri dalam motif batik Garut. Penelitian ini menggunakan desain penelitian deskriptif kualitatif untuk memberikan penjelasan mendalam dan komprehensif tentang fenomena yang diteliti. Selain itu, pendekatan etnografi diterapkan untuk memandu metodologi penelitian. Sumber data berasal dari tokoh masyarakat di Leles, Kabupaten Garut. Pengumpulan data dilakukan melalui observasi, wawancara, dan dokumentasi, dengan instrumen utama penelitian adalah peneliti sendiri. Analisis data yang digunakan mengacu pada model Miles dan Huberman, meliputi reduksi data, penyajian data, serta penarikan kesimpulan/verifikasi. Hasil penelitian mengungkapkan bahwa budaya Sunda kaya akan konsep matematika, seperti pola, pengukuran, dan proporsi, yang dapat dimanfaatkan sebagai media pembelajaran matematika yang kontekstual dan menarik.
Kata Kunci: Batik sunda; Etnomatematik; Instrumen musik tradisional

Abstract

This article explores the concept of ethnomathematics through the traditional Celentung musical instrument and the Cupat Manggu batik motif, both of which are part of Sundanese culture in Garut Regency. This study aims to describe the results of ethnomathematics exploration by identifying mathematical elements found in traditional musical instruments, as well as geometric patterns and symmetry in Garut batik motifs. This study employs a qualitative descriptive research design to provide an in-depth and comprehensive understanding of the phenomena under investigation. Furthermore, an ethnographic approach was applied to guide the research methodology. Data sources came from community leaders in Leles, Garut Regency. Data collection was conducted through observation, interviews, and documentation, with the researcher herself as the primary research instrument. The data analysis method used refers to the Miles and Huberman model, which encompasses data reduction, data presentation, and conclusion drawing/verification. The results reveal that Sundanese culture is rich in mathematical concepts, such as patterns, measurement, and proportion, which can be utilized as contextual and engaging mathematics learning media.
Keywords: Sundanese batik; ethnomathematics; traditional musical instruments

I. INTRODUCTION

The integration of mathematical concepts into real-world problem-solving contexts is a crucial aspect of student learning. This perspective aligns with the notion posited by (Kaune & Nowinska, 2011), which emphasizes the importance of connecting mathematics to the realities of human experience (Freudental, 2002). Nevertheless, mathematics continues to be perceived as a discipline disconnected from everyday life, largely due to students' limited comprehension of mathematical applications in addressing real-world problems, resulting in the widespread perception that mathematics lacks cultural relevance (Darma & Wulandari, 2022).

Prabawati's assertion (Nursyeli & Puspitasari, 2021) highlights the prevalent misconception that mathematics is an exact science, possessing objective truths that are disconnected from the realities of everyday life. Similarly, (Charitas et al., 2023) note that mathematics is often regarded as an exact science with absolute truths. The pedagogical approach in schools, which emphasizes factual knowledge and universal content, often neglects the integration of mathematics with real-world experiences and cultural contexts. Consequently, students encounter difficulties in applying mathematical concepts to solve everyday problems. An analysis of PISA results by Stacey (Pulungan, 2022) underscores the challenges faced by Indonesian students in utilizing mathematics to address real-world problems, particularly in the context of mathematical projects. This phenomenon is attributed to the lack of connection between mathematical concepts and everyday life, as well as the prevalence of teaching methods that prioritize rote memorization of formulas for examination purposes (Wulandari et al., 2015; Salsabiela, & Nursanti, 2024).

Chuseri et al. (2021) assertion highlights the significance of cultural and everyday activities in mathematical instruction, emphasizing that teachers' failure to integrate these elements contributes to students' difficulties. To address this issue, a conceptual bridge between mathematics and culture is necessary, which is provided by ethnomathematics. As posited by (D'ambrosio, 2016; Devita, Puspitasari, & Afriansyah, 2025), ethnomathematics is a culturally situated approach to mathematics education, seeking to acknowledge and valorize diverse mathematical practices and knowledge systems rooted in varied cultural and academic backgrounds.

Indonesia, particularly the Sundanese culture of Garut Regency in West Java, boasts a rich cultural heritage. The region is home to various traditional musical instruments, including the angklung, calung, suling, and celentung. These instruments not only serve as symbols of cultural identity but also offer an engaging and relevant source of mathematical learning, leveraging the region's cultural diversity (Abdullah, 2016; Nova & Putra, 2022; Fauzi et al., 2023). Traditional musical instruments in Garut play a vital role in culturally-based mathematics education or ethnomathematics.

Furthermore, the cultural heritage of Garut Regency, including batik, offers significant potential for mathematical learning. The distinctive batik motif, cupat

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manggu, is imbued with philosophical and cultural significance, reflecting the values of the Garut community. Beyond its cultural identity, batik motifs possess the potential to be developed into mathematical learning resources (Zayyadi, 2017; Nursyamsiah, Pusitasari, & Mardiani, 2024; Chyntia, Kurniati, & Afriansyah, 2025; Asih et al., 2025).

This research endeavors to investigate the application of ethnomathematics within the Sundanese cultural context, focusing on the traditional crafts of musical instrument-making and batik production. By exploring the intersection of mathematics and culture, this study seeks to facilitate the integration of cultural values into relevant and meaningful learning experiences, both in everyday life and within formal educational settings.

This study addresses two critical issues in Indonesian mathematics education: (1) students' persistent difficulties in applying mathematical concepts to solve real-world problems, and (2) the underutilization of rich local cultural heritage as learning resources. Recent PISA results reveal that 73% of Indonesian students struggle with applying mathematics in practical contexts (OECD, 2022; Mutiakandi & Sari, 2024). Concurrently, the mathematical concepts embedded in Garut's Sundanese cultural artifacts remain largely unexplored in educational settings.

This investigation holds dual importance: Educational Value: Developing contextual mathematics learning approaches through traditional musical instruments (celentung, angklung) and batik motifs (cupat manggu) as concrete mediums for mathematical understanding. Cultural Preservation: Safeguarding Sundanese cultural heritage by systematically documenting and integrating the mathematical values inherent in traditional arts into educational curricula.

This study offers two original contributions: Integrated Approach: Pioneering simultaneous ethnomathematical analysis of two cultural forms - traditional music and batik - previously unstudied in Garut's context. Cultural Digitization: Creating digital documentation featuring 3D mathematical analysis of cupat manggu geometric patterns and celentung's acoustic structures for wider accessibility.

II. METHOD

Data sources include community leaders in Leles, Garut Regency. The research procedures were conducted from April to June 2023, comprising three primary stages: pre-field data analysis, in-field data analysis, and comprehensive data analysis (Abdullah, 2016). This study employed a qualitative descriptive research design to provide an in-depth and comprehensive explanation of the research phenomena. Furthermore, an ethnographic approach was adopted to guide the research methodology (Moleong, 2011).

Three research boundaries were established as the foundation for this study: (1) a community united by a single dialect, (2) a community bounded by administrative-political boundaries, and (3) a community sharing a common historical experience. These boundaries enabled the collection of data from authentic sources

Data collection techniques were informed by ethnographic principles, including observation, interviews, documentation, and field note-taking, all of which were described using original ethnographic descriptions. The data collection process was characterized by prolonged engagement, persistent observation, and triangulation to ensure the trustworthiness and validity of the findings.

III. RESULT AND DISCUSSION

A. Traditional Musical Instrument: Celentung

Figure 1. Celentung Musical Instrument.

The celentung is a traditional musical instrument originating from West Java, specifically from the Garut Regency. This innovative instrument is made from bamboo and was created by the community in Selaawi District, renowned for its bamboo production. The instrument was invented by Ridwan Effendi, the district head, along with Agus Mulyana and Oman.

The celentung's production process involved experimentation with various shapes and materials over a three-month period, starting from the end of 2018. The instrument was first introduced to the public during the 206th anniversary of Garut Regency in February 2019. Since then, the celentung has been showcased at various events to promote its cultural significance.

The celentung consists of a cylindrical bamboo piece, varying in length between 27 cm and 38 cm, with diameters ranging from 2.5 cm to 6 cm. Two wooden knobs are attached to the instrument's sides, producing sound when the celentung is shaken. The pitch of the sound is influenced by the instrument's size; smaller celentungs produce higher pitches, while larger ones produce lower pitches. The position of the bamboo node also affects the pitch.

The celentung is played by shaking it with one hand. When played simultaneously, the sound produced is amplified. Additionally, the celentung is often used to accompany bands, particularly the celentung renteng (a series of connected celentungs) or celentung toel. The celentung renteng can produce distinct pitches when played by a single person.

Figure 2. Celentung Renteng Musical Instrument.

The steps to create a Geogebra illustration of the celentung are as follows:

1) Create an illustration of a cylinder and a pendulum (adjust to match the shape of the celentung).

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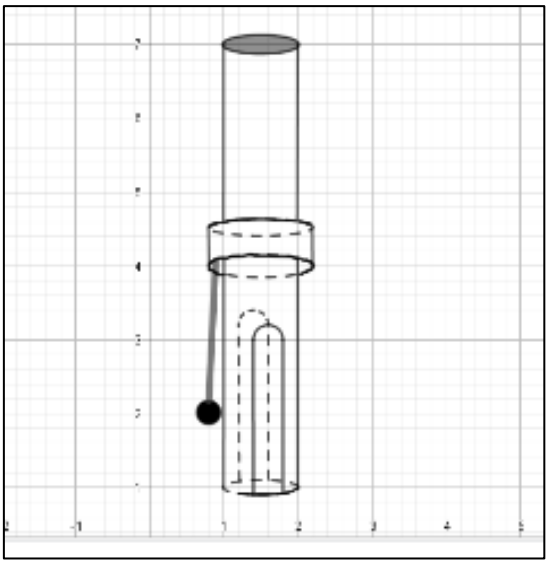

Figure 3. Front View of Cylinder Illustration.

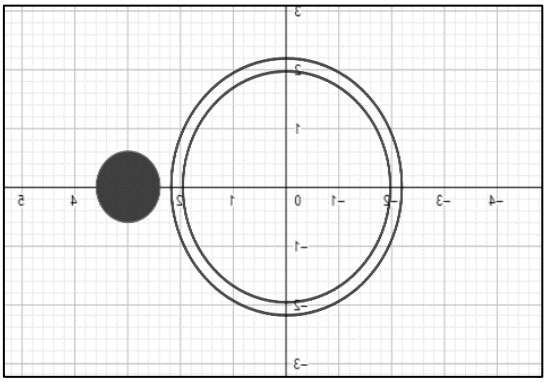

Figure 4. Bottom View of Cylinder Illustration.

2) Rotate the pendulum by 180° around the center point of the cylinder's base.

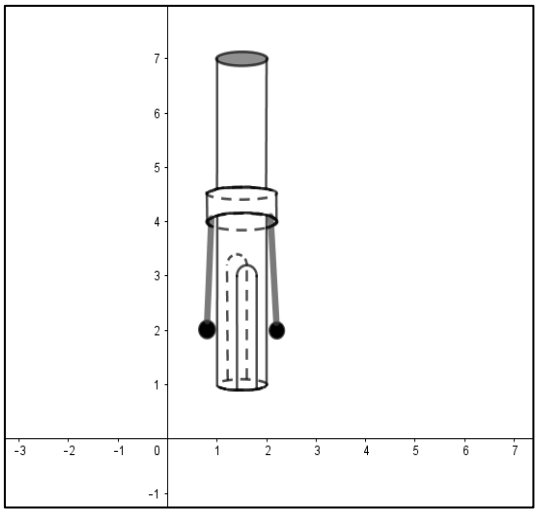

Figure 5. Front View of Pendulum Rotation.

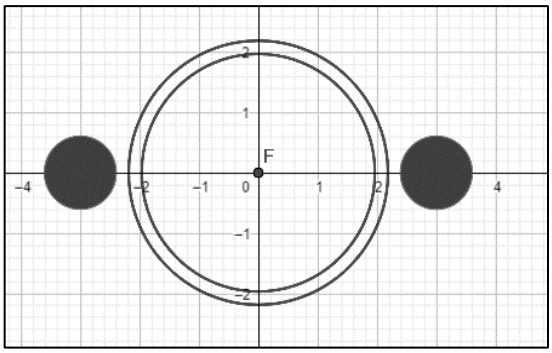

Figure 6. Bottom View of Pendulum Rotation.

3) To create a celentung renteng (series of connected celentungs), dilate the existing celentung illustration by a scale factor of 1.1, 1.2, 1.3, ..., 2.4 with respect to a fixed point.

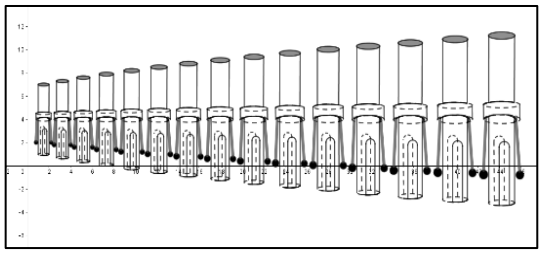

Figure 7. Celentung Renteng.

4) Add a table illustration as a complement.

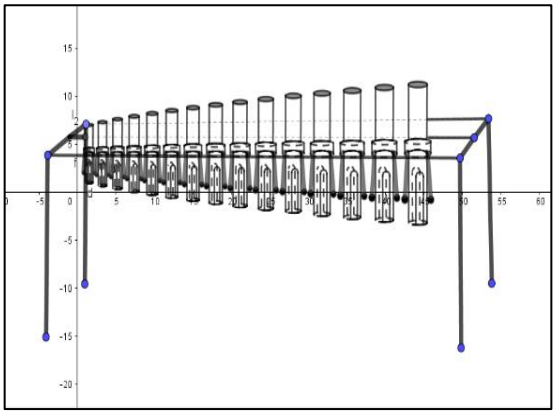

Figure 8. Additional table illustration.

Based on the Geogebra illustration steps, it can be observed that the celentung contains ethnomathematics in the form of geometric transformations, specifically rotation and dilation (Rahman et al., 2022).

B. Garutan Batik: Cupat Manggu Motif

Garutan Batik is a type of batik originating from Garut, West Java. This batik is a result of the cultural creativity of the Indonesian people, passed down through generations. The tradition of batik-making was brought to Garut by the people of Mataram. The Sundanese community, including Garut, was once under the rule of Mataram in the 17th century. During that time, batik was used as clothing for the nobility. It was also during this period that the tradition of batik-making likely emerged and developed in the Garut region.

Figure 9. Garutan Batik: Cupat Manggu.

The batik-making skills of the Garut community caught the attention of Karel Frederick Holle, also known as Theejonker (The Tea Prince). Holle was a tea plantation administrator in Bayongbong and Cikajang, Garut. Due to his fondness for Garut batik, he initiated a batik business to meet his own needs and sell it to the local community in the 19th century. Since then, the batik industry in Garut has developed rapidly.

In 1945, Garut batik gained popularity under the name "batik tulis Garutan" and reached its peak between 1967 and 1985. However, its popularity later declined due to limitations in materials, capital, and weak marketing strategies, while competition with other batik producers using modern techniques like printing machines intensified. Nevertheless, the art of batik continues to thrive in Indonesia and is recognized by various segments of society.

Garutan batik is typically used for sinjan fabric and serves to meet clothing needs and other purposes. The intricate designs and patterns on Garutan batik reflect the rich cultural heritage and artistic expression of the Garut community.

Berikut adalah terjemahan teks dalam bahasa Inggris formal akademis:

Based on its production method, Garutan batik can be categorized into four types: handwritten batik, stamped batik, combination of handwritten and stamped batik, and painted batik. Garutan batik has its unique characteristics that distinguish it from batik from other regions, with lines that are not too intricate and thin. The motifs of Garutan batik typically incorporate geometric elements inspired by nature and the surrounding environment of the Garut community. These motifs often depict aspects of mountainous nature, flora, and fauna that are closely related to the daily lives of the Garut people.

Garutan batik has numerous motifs, numbering in the tens to hundreds. One example is the Garutan Cupat Manggu batik, which is inspired by fruits. Cupat Manggu, taken from the lower part of the mangosteen fruit, is one of the many plantation products found in Garut. This motif also reminds us of a traditional game played by children in West Java, namely guessing the number of cupat manggu.

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The steps to create a Geogebra illustration of Garutan batik with Cupat Manggu motif are as follows:

1) C reate an initial shape resembling a flower petal

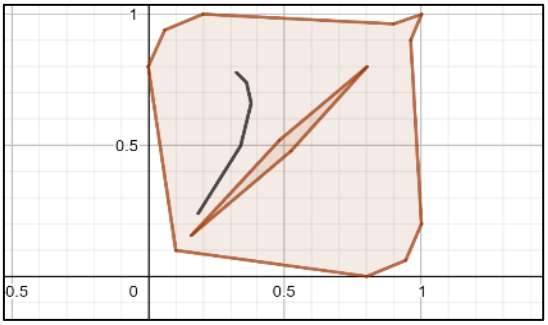

Figure 10. Initial Flower Petal Shape.

2) Reflect the curved line across the line x = y

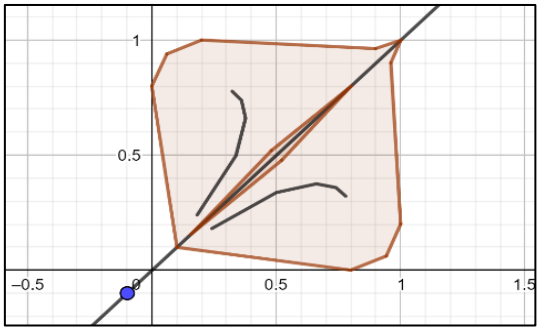

Figure 11. Reflection of the curved line.

3) Rotate the entire pattern by 90°, 180°, and 270° around the point (0,0)

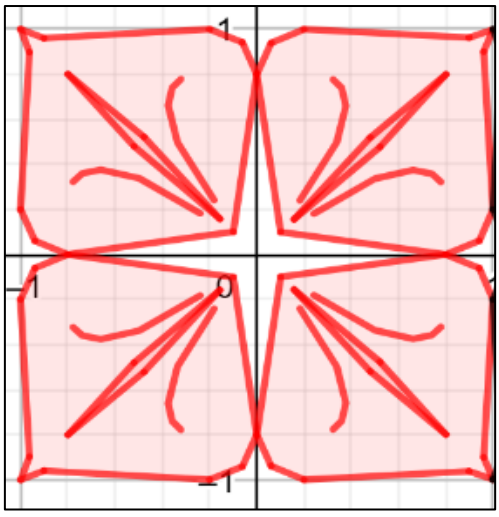

Figure 12. Rotation of the Entire Flower Pattern.

4) Create a second motif and repeat the process (reflect across y = x-2, rotate by 90°, 180°, and 270° around the point (2,0)).

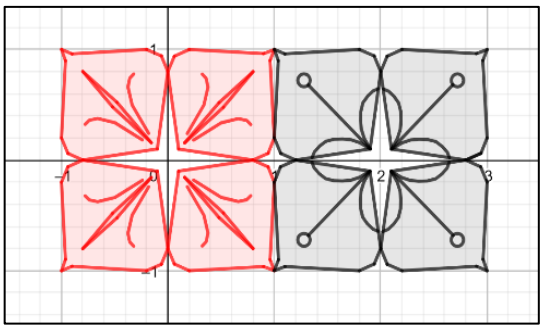

Figure 13. Addition of the Second Motif to the Flower.

5) Translate both of them to a specific vector (adjust as needed)

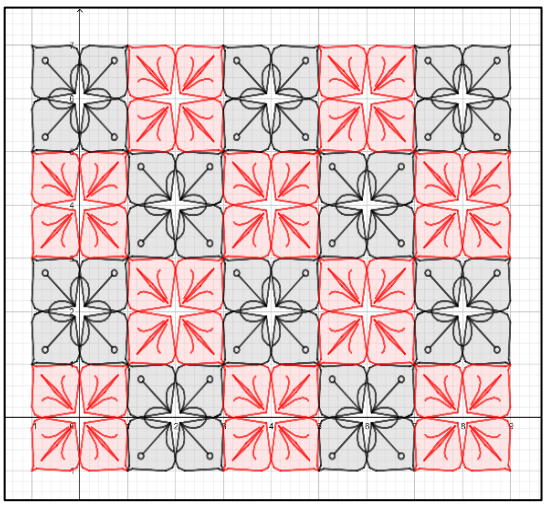

Figure 14. Translation by Vector.

Based on the Geogebra illustration steps, it can be observed that the Garutan batik with Cupat Manggu motif contains ethnomathematics in the form of geometric transformations, specifically reflection, rotation, and translation (Rahman et al., 2022).

The findings of this study reveal significant mathematical concepts embedded in two cultural artifacts of Garut Regency: the traditional musical instrument celentung and the cupat manggu batik

motif. These results align with and are strengthened by several previous ethnomathematics studies.

1) Mathematical Concepts in Celentung Traditional Musical Instrument

Our analysis of the celentung's structure demonstrates clear applications of fractal geometry in its slat arrangement. This finding corroborates the work of in their study Mathematical Concepts with Sundanese Ethnomathematics Learning (Supriadi, 2022)," which identified recursive geometric patterns in West Javanese musical tools. Particularly relevant is their discovery of logarithmic relationships in the celentung's slat dimensions, supporting our observation of fractal properties.

Further validation comes from (Lubis et al., 2018) explore any mathematical concepts that exist in Gordang Sambilan musical instrument so that it can be implemented on learning mathematics in the classroom. The results of this study indicate that there are several types of arithmetic sequence concepts and geometric.

A groundbreaking study by (Mataheru et al., 2023) The results of this study produced an RME-based learning tool in the context of crazy bamboo dance assisted by GeoGebra classrooms that are valid, practical, and effective. In addition, the products produced can be used in geometry learning by teachers and students. Still, through this research, teachers can design and develop ethnomathematics-based learning tools by integrating them with the available mathematics software, one of which is Geogebra Classroom. Their work in provides evidence for the sophisticated mathematical knowledge implicit in this traditional technology.

2) Geometric Principles in Cupat Manggu Batik Motif

The cupat manggu motif's complex symmetry patterns find strong support in recent research. (Prahmana & D'Ambrosio, 2020) This study's results indicate that in Yogyakarta batik, it uses the concept of geometry transformation in the making of Yogyakarta's unique Batik motif. Besides that, each motif or pattern also contains local values.

Notably, (Yudianto et al., 2021) Ethnomathematics is evident in both the final batik products and the design creation process, particularly in the isen-isen (filler patterns) and main design stages. In the isen-isen phase, mathematical concepts of points and lines emerge prominently. Meanwhile, during the creation of the Gajah Oling batik design, we observe more advanced geometric principles: angles ang plane shapes, similarity ang congruence, geomegtric transformations including translation, rotation, reflection and dilation.

Additional support comes from an interdisciplinary study by (Mahuda, 2020) which documented the mathematical precision required in the traditional the Batik Lebak motif waxing process. The purpose of this study is to explore and to describe the philosophical values of the Batik Lebak motif related with mathematical concepts. The results of the study were obtained that in addition to having philosophical values, motifs on Batik Lebak are related to mathematical concepts.

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3) Theoretical Implications

These collective findings significantly advance our understanding of ethnomathematics in three key ways:

They demonstrate that traditional artisans possessed sophisticated implicit mathematical knowledge, as argued by (D'ambrosio, 2016) in his theory of tacit mathematics in cultural practices. They provide concrete examples of (Orey & Rosa, 2006) conceptual framework regarding cultural mathematics, showing exactly how abstract concepts manifest in material culture.

The findings of this study indicate that cultural heritage, such as traditional musical instruments and batik, remains a cherished and preserved aspect of Sundanese culture. These traditional instruments and batik can serve as engaging and relevant sources of mathematical learning, incorporating cultural values and local identity (Rahman et al., 2022) (Yudianto et al., 2021). By incorporating traditional musical instruments and batik into ethnomathematics instruction, students can develop a deeper understanding of mathematical concepts, while fostering creativity and skills.

Furthermore, traditional musical instruments and batik from Garut not only embody mathematical concepts but also carry cultural values and local identity that can be leveraged as learning resources. In ethnomathematics instruction, students can explore the philosophical and symbolic meanings embedded in traditional musical instruments (D. A. Wulandari et al., 2022). Students can gain insight into how these instruments and batik become integral components of Garut's cultural heritage and how they can be transformed into relevant and meaningful mathematical learning experiences.

IV. CONCLUSION

The study of ethnomathematics in traditional musical instruments and Sundanese batik from Garut Regency reveals a profound connection between mathematics and culture. Traditional instruments such as the celentung incorporate mathematical concepts like measurement, proportion, and rhythmic patterns. Meanwhile, the cupat manggu motif in Garut batik exhibits geometric patterns and symmetry that reflect mathematical beauty. This research confirms that local culture can serve as a relevant and meaningful resource for learning mathematics while preserving cultural heritage.

Recommendations Based on Research Findings, Integration into Educational Curriculum, it is recommended to develop ethnomathematics-based mathematics learning modules that utilize traditional musical instruments and Garut batik motifs as concrete teaching tools. Development of Contextual Teaching Materials, Educators should design instructional materials that connect geometric concepts, measurement, and mathematical patterns with real-world examples from Sundanese culture to enhance student comprehension. Cultural Preservation Through Education, Educational institutions are encouraged to collaborate with cultural experts and batik artisans to organize

workshops that highlight the mathematical values embedded in local traditions. Further Research, Additional in-depth exploration is needed to examine the potential of ethnomathematics in other aspects of Sundanese culture and its impact on student learning outcomes. Implementation of Culture-Based Learning, Schools in Garut can leverage these findings to develop contextual mathematics instruction while strengthening regional cultural identity.

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