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Greening Ethnomathematics: Integrating Banten Batik Geometry and Mangrove Media in Indonesian Primary Education

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Abstract

Geometry learning in primary schools often tends to rely on conventional, non-contextual media, causing geometric concepts to remain abstract and difficult for students to comprehend. Although Banten Batik, a rich cultural heritage, contains various geometric concepts and mangrove leaves hold high potential as eco-friendly natural dyes, their integration into classroom practices remains limited. This community service activity aims to enhance primary school teachers' competence in designing and implementing ethnomathematics-based geometry learning using Banten Batik motifs and mangrove leaf media. The program employed a participatory action research approach, utilising participatory workshops, demonstrations, hands-on activities, and mentoring involving 12 teachers and 40 students at SDN Siring. The social engineering and community empowerment results showed that teachers successfully mastered pedagogical design and identified fundamental geometric shapes (squares, rectangles, triangles, rhombuses, parallelograms, and circles) through batik-making and natural dyeing practices. In contrast, students showed high enthusiasm and improved spatial recognition skills. In conclusion, this program effectively enhances teachers' pedagogical competence, preserves local cultural heritage, and fosters environmental awareness through an innovative, contextual, and sustainable mathematics learning model.

Keywords: Ethnomathematics, Banten Batik, Geometry, Mangrove Leaves, Primary Education

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Abstrak

Pembelajaran geometri di sekolah dasar sering kali cenderung mengandalkan media konvensional yang tidak kontekstual, sehingga konsep-konsep geometri tetap terasa abstrak dan sulit dipahami oleh siswa. Meskipun warisan budaya Batik Banten yang kaya mengandung berbagai konsep geometri dan daun mangrove memiliki potensi tinggi sebagai pewarna alami yang ramah lingkungan, integrasinya ke dalam praktik pembelajaran di kelas masih terbatas. Kegiatan pengabdian masyarakat ini bertujuan untuk meningkatkan kompetensi guru sekolah dasar dalam merancang dan melaksanakan pembelajaran geometri berbasis etnomatematika dengan menggunakan motif Batik Banten dan media daun mangrove. Program ini menggunakan pendekatan penelitian tindakan partisipatif, dengan memanfaatkan lokakarya partisipatif, demonstrasi, kegiatan praktik langsung, dan pendampingan yang melibatkan 12 guru dan 40 siswa di SDN Siring. Hasil rekayasa sosial dan pemberdayaan masyarakat menunjukkan bahwa para guru berhasil menguasai perancangan pedagogis serta mengidentifikasi bentuk-bentuk geometri dasar (persegi, persegi panjang, segitiga, belah ketupat, jajaran genjang, dan lingkaran) melalui praktik pembuatan batik dan pewarnaan alami, sementara para siswa menunjukkan antusiasme yang tinggi serta peningkatan keterampilan pengenalan spasial. Kesimpulannya, program ini secara efektif meningkatkan kompetensi pedagogis guru, melestarikan warisan budaya lokal, dan menumbuhkan kesadaran lingkungan melalui model pembelajaran matematika yang inovatif, kontekstual, dan berkelanjutan.

Kata Kunci: Etnomatematika, Batik Banten, Geometri, Daun Mangrove, Sekolah Dasar

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INTRODUCTION

Primary school mathematics learning plays an important role in developing students' analytical, logical, critical, and creative thinking, as well as their mathematical problem-solving skills. One subject that still encounters learning barriers is basic geometry because its concepts are abstract and visual media in primary schools remain suboptimal, thus requiring concrete media and contextual learning experiences. Learning geometry through conventional lecture methods tends to cause most students to struggle with understanding 2D and 3D shapes, perimeter, area, volume, symmetry, and geometric transformation, which impacts students' low conceptual understanding and mathematical representation skills (van de Walle & Bay-Williams, 2012).

As a bridge between abstract mathematical concepts and students' real-world experiences, the ethnomathematics approach demonstrates that mathematics does not develop solely in the classroom but is deeply embedded in the cultural activities of communities (D'Ambrosio, 1985). The integration of local culture has been shown to enhance conceptual understanding, learning motivation, and critical thinking, while also fostering an appreciation for cultural heritage (Dominikus et al., 2024). Moreover, culturally responsive pedagogical practices are essential for empowering indigenous and local youth, as they validate students' cultural backgrounds and lived experiences within formal academic settings (Castagno & Brayboy, 2008).

Furthermore, Supriadi (2019) states that ethnomathematics based on traditional games can boost elementary school students' geometric thinking skills and creativity. Recent literature reviews also reinforce the finding that batik motifs hold great potential for linking geometric concepts to students' cultural realities such as transformations, plane figures, symmetry, and patterns (Roesdiana et al., 2024). In Banten Province, the rich variety of Banten batik motifs has been shown to incorporate geometric concepts such as rhombuses, rectangles, triangles, circles, and symmetry, making them ideal as contextual learning resources (Subekhi et al., 2021).

Beyond cultural richness, Anyar District in Serang Regency possesses abundant natural resources characterised by coastal mangrove ecosystems. Mangrove leaves, often treated as organic waste, have high potential as environmental learning media and natural dyeing agents for batik. Utilising environment-based media not only supports contextual learning but also strengthens Education for Sustainable Development by fostering awareness of coastal ecosystem conservation (Sianturi et al., 2022). While prior studies predominantly focus on ethnomathematics through cultural artefacts or digital tools (Roesdiana et al., 2024), limited attention has been given to combining cultural heritage with coastal environmental remediation, specifically transforming mangrove biomass waste into instructional media for primary mathematics education.

However, the great potential of this local wisdom has not yet been adequately incorporated into teaching practices at the school level, particularly in the coastal areas of Serang Regency. An analysis of the objective situation and conditions on the ground, conducted through interviews and preliminary observations in July 2026 at SDN Siring in Anyar Village, Serang Regency, revealed the following fundamental challenges faced by the partner. An analysis of the objective situation and conditions in the field, conducted through interviews and preliminary observations in July 2026 at SDN Siring in Anyar Village, Serang Regency, revealed a multifaceted picture of the partner's fundamental challenges. In terms of competencies and learning resources, the percentage of teachers at SDN Siring who utilise environmental media or the ethnomathematics approach is 0%, meaning that mathematics instruction remains entirely dominated by conventional expository methods.

In terms of media availability, the school does not yet have teaching modules based on local wisdom or authentic media that connect geometric concepts to the surrounding environment, and school facilities are very limited, with only one smart TV available, which has not been optimally utilised for culturally based interactive media. On the student side, learners face significant learning barriers, characterised by a low level of familiarity with two-dimensional and three-dimensional shapes. Furthermore, from an ecological perspective, the coastal area of Anyar Village surrounding the school faces environmental challenges in the form of abundant accumulations of mangrove leaf and branch biomass that lack economic value; in fact, they are

often viewed as organic waste that pollutes the coastline and have not yet been processed as a value-added resource, whether as natural dyes for batik or as environmental educational materials.

The selection of the subject and location (SDN Siring) was based on the school's strategic location, situated directly on the coast of the Sunda Strait, with an abundant mangrove ecosystem. These conditions make mangrove leaves a local material that is highly accessible, plentiful, and relevant to the daily lives of both teachers and students, facilitating the translation of community service innovations into practical applications. In response to the complexity of these issues, this community service program does not position teachers as passive recipients of educational materials, but rather as the primary agents of change. Plans for problem-solving and expected social change (expected social engineering) were designed through structured training (participatory workshops, demonstrations, independent practice, and mentoring) to break down the rigidity of teachers' teaching methods.

The social engineering initiative designed for this community service project is to build an environmentally friendly learning ecosystem based on local coastal wisdom through a self-directed teacher learning community. Through this program, mangrove leaf biomass waste is transformed into natural dye to create Banten Batik motifs while exploring the underlying geometric concepts. It is hoped that this intervention will not only address the pedagogical challenges faced by teachers and the learning difficulties experienced by students at SDN Siring but also transform coastal waste into a sustainable learning resource and foster the teachers' community's autonomy in preserving local culture and the coastal ecosystem of the Sunda Strait in a sustainable manner.

METHODS

This community service activity employs a participatory mentoring approach that positions teachers as both partners and co-creators of change, from the initial planning stage through to the program's sustainability. This approach is designed using models of participatory planning and community organising, in which a team of faculty members and school representatives work together to identify problems, formulate learning needs, and design solutions based on local wisdom. This participatory approach is combined with participatory workshops, hands-on activities, and in-class implementation support, as the combination of concept presentation, demonstrations, independent practice, reflection, and evaluation has been shown to provide a more meaningful learning experience than lecture-based training (Darling-Hammond et al., 2017). The entire series of activities was conducted at SDN Siring, Anyar Village, Serang Regency, Banten, involving 12 elementary school teachers and 40 lower-grade students (grades 2, 3, and 4).

To provide a systematic overview of the program's implementation process from start to finish, the stages of mentoring and social engineering are illustrated in the flowchart in Figure 1 below:

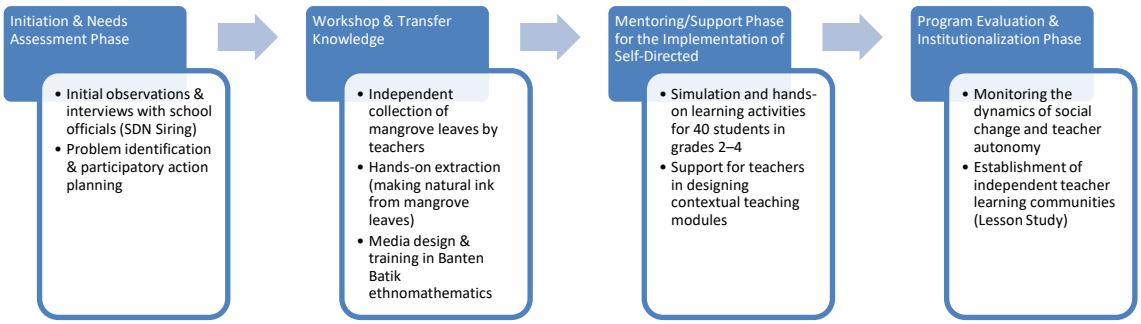


Figure 1. Flowchart of the Stages of Facilitation and Social Engineering

1. Initiation & Needs Assessment Phase (Participatory Planning)

This phase began with a participatory planning session involving the principal and the faculty council of SDN Siring in July 2026. Through Focus Group Discussions (FGD) and in-depth interviews, the community service team, together with the teachers, identified the real issues at the school, ranging from the low utilisation of environmental resources to students' limited understanding of geometric concepts. During this phase, teachers were actively involved in formulating the type of intervention best suited to the characteristics of a coastal school, ensuring that the program was truly rooted in the partners' actual needs.

2. Workshop & Skills Transfer Phase (Hands-on Extraction & Media Design)

This phase was designed to prevent dependency between the teachers and the faculty team. Well in advance of the main workshop, teachers at SDN Siring were directly involved in collecting mangrove leaves and twigs, which are abundant along the coast of the Sunda Strait/Anyar, as biomass. Accompanied by the community service team, the teachers independently carried out hands-on extraction practices, from washing, chopping, and boiling the mangrove leaves with a natural fixative, to filtering the mixture to produce ready-to-use batik dye. This direct involvement ensured that the teachers mastered all techniques for processing coastal waste autonomously.

Once the dye supply was ready, the activity continued with a core workshop on the concepts of ethnomathematics, plane geometry, the characteristics of Banten batik motifs, and techniques for integrating them into the classroom. The community service team demonstrated how to use batik fabric with geometric motifs as a teaching medium. Subsequently, the 12 teachers independently practised colouring Banten batik motifs using the mangrove leaf dye they had extracted themselves. This activity equipped the teachers with technical skills and the ability to identify basic geometric concepts (squares, rectangles, triangles, rhombuses, parallelograms, and circles) (Rosa et al., 2021).

3. Mentoring/Support Phase for the Implementation of Independent Learning Classes

The next phase involved the direct implementation of learning activities for 40 students in grades 2, 3, and 4, who were divided into 10 groups. The community service team directly supported partner teachers as they facilitated students' use of Student Worksheets (LKS). Students explored geometric shapes and symmetry through "learning by doing" activities while colouring batik with mangrove ink (Sudrajat et al., 2023). After completing the colouring, students presented their work. This support helped foster the teachers' independence in managing ethnomathematics-based classes without full intervention from the faculty team.

4. Program Evaluation & Institutionalisation Phase (Institutionalisation)

The monitoring and evaluation of social change dynamics were conducted comprehensively using three instruments: (1) participatory observation to track changes in the enthusiasm and skills of teachers and students during activities; (2) semi-structured interviews to measure improvements in teachers' pedagogical understanding and students' cognitive responses; and (3) analysis of documentation and worksheet results. Data were analysed using qualitative descriptive methods. As part of the program's institutionalisation, the evaluation results were used to establish a school-based learning community for teachers, ensuring that the tradition of creating educational materials from mangrove waste and teaching ethnomath continues independently and sustainably after the community service program concludes.

RESULTS AND DISCUSSION

Implementation of Geometry Learning Workshop Based on Banten Batik Ethnomathematics

The community service activity began with a workshop on geometry learning based on Banten Batik ethnomathematics, attended by 12 teachers from SDN Siring, Anyar Village, Serang Regency. The workshop began with a presentation on ethnomathematics concepts, the

implementation of Banten Batik motifs in geometry instruction, and the use of natural dye from mangrove leaves as an environmentally based learning medium. After the presentation, participants took part in a demonstration and hands-on activity colouring Banten Batik motifs that incorporated various geometric concepts, such as squares, rectangles, triangles, rhombuses, parallelograms, circles, and octagons.



Figure 2. Workshop on Geometry Learning Based on the Ethnomathematics of Banten Batik

Throughout the activity, the teachers showed great enthusiasm. All participants actively took part in the batik-making practice, discussed the geometric concepts found in batik motifs, and shared their experiences with implementing contextual learning in the classroom. The mentoring process had its challenges. During the Batik-making practice, teachers faced challenges such as controlling the ink to prevent spills and determining the colour areas within the motifs, while the team guided each group. This activity demonstrated that a hands-on learning approach can enhance participant engagement because participants not only receive theoretical material but also gain direct experience in using learning media based on local culture. This finding aligns with Experiential Learning theory, which emphasises that direct experience is the foundation for the formation of new knowledge (Budiarti et al., 2022). Furthermore, practice-based training has proven to be more effective in enhancing teachers' professional competencies than training that is purely theoretical.

Improving Teachers' Understanding of Geometric Concepts

The observation results showed that teachers were able to identify various geometric concepts found in Banten batik motifs. During the reflection session, teachers mentioned various two-dimensional shapes they had successfully identified, including rectangles, rhombuses, triangles, octagons, squares, parallelograms, circles, and kites. Although there were still some errors, such as referring to an ellipse as a cube, in general, the teachers were able to connect the batik motifs to the geometric concepts taught in elementary school. These errors are important to note because they indicate that the teachers have not yet fully mastered the distinction between two-dimensional and three-dimensional shapes. The team responded by facilitating a dialogue, asking teachers to point out and explain the characteristics of the shapes, then comparing them to real objects until the teachers discovered the differences on their own.



Figure 3. Batik-Making Workshop Featuring Geometric Motifs

These findings indicate that Banten Batik motifs can serve as a concrete medium in geometry instruction because they make it easier to visualise abstract concepts. These results align with a study (Subekhi et al., 2021) that revealed that Lebak Banten batik motifs contain various geometric concepts, such as squares, rectangles, triangles, circles, symmetry, and graphs, that are relevant to mathematics education. Similarly, Roesdiana et al. (2024), through a systematic literature review, concluded that batik motifs are among the most widely used cultural contexts in implementing ethnomathematics in geometry instruction, thereby enhancing students' understanding of mathematical concepts.

Teachers' Responses to The Training

Based on the interview results, all teachers responded positively to the training activities. The teachers stated that these activities provided new experiences, broadened their understanding of culture-based mathematics instruction, and created an enjoyable learning atmosphere. Several teachers noted that batik-making activities reduced boredom, improved concentration, increased patience, and inspired more creative mathematics instruction.



Figure 4. Group Photo of Teachers and Examples of Banten Batik Created Using Mangrove Ink

These results indicate that the workshop not only improved the teachers' pedagogical skills but also boosted their motivation and self-confidence in developing innovative teaching methods. These findings support the research results (Desimone & Garet, 2015), which state that teacher professional development is more effective when it involves collaborative activities, hands-on practice, reflection, and problem-solving related to classroom instruction.

Implementation of The Learning Activity With Students

The next stage was implementing the learning activity with 40 students in grades 2, 3, and 4 through an activity in which they coloured Banten batik motifs using natural dye extracted from mangrove leaves. The students worked in groups using Student Worksheets (LKS) that contained activity instructions and questions regarding the concepts of two-dimensional shapes.

Observations showed that the students were very enthusiastic about participating in the learning activity. During the colouring process, students actively discussed the geometric shapes found in the batik patterns. In interviews, second-grade students identified rectangles and squares; third-grade students identified triangles, squares, and rectangles; and fourth-grade students began to connect geometric shapes with the concepts of area and perimeter after guidance from the community service team.



Figure 5. Guiding Students in Colouring Geometric Batik Patterns

These findings indicate that using Banten Batik as a teaching medium provides a concrete learning experience, helping students visually identify geometric shapes. The colouring activity also makes students more active compared to conventional learning because they learn through direct experience (learning by doing). These results support the theory (Kolb, 1984) that real-world experiences form the basis for the development of new knowledge. Furthermore, research by Supriadi (2019) that shows that ethnomathematics-based learning is able to connect school mathematics with community culture, thereby making learning more meaningful and easier for students to understand.

The Use of Mangrove Leaves as a Learning Medium

One key innovation in this community service project is the use of natural ink derived from mangrove leaf extract. The use of this local material offers two benefits at once: it serves as a learning medium for geometry based on ethnomathematics and as an educational tool for coastal environmental conservation. Teachers noted that using materials from the surrounding environment provides new experiences and can foster students' appreciation for Banten Batik culture and the mangrove ecosystem.

The main ink ingredient is readily available in Anyar Village. The school is located near the coast, which is home to many mangrove trees, and the teachers are already familiar with these plants. Supporting materials, such as textile dyes, can be obtained from fabric dye stores. Fabric and bamboo brushes can be sourced from Banten Batik artisans. The ink-making process consists of collecting mangrove leaves and stems, chopping the mangrove leaves, boiling them for 20–30 minutes, straining, and storing the ink. The difficulty level is moderate because the colour depends on the fixing agent and the proportions used, and the results are not always consistent from one batch to the next. The colour retention after sun-drying and rinsing results in vibrant hues.

The tools used during the activity were a digital scale, a beaker, scissors, an induction stove, a stopwatch, a strainer, a thermometer, and a blender. These tools are readily available, so that teachers can make the ink on their own. This activity also does not require digital devices, making the method suitable for schools with limited facilities. With easily obtainable materials and a straightforward process, mangrove ink has the potential to be developed as a regular learning medium in schools. To realise this potential, teachers need repeated practice and standardised mixing ratios.



Figure 6. The Process of Making Ink from Mangrove Extract

This approach demonstrates that mathematics learning is not only oriented toward conceptual mastery but can also be integrated with environmental education and the preservation of local culture. The integration of culture, the environment, and mathematics is a key characteristic of contextual learning that supports the achievement of the goals of Education for Sustainable Development (ESD), as recommended by Böhmer (2023). Environment-based

learning has also been shown to increase students' awareness of the sustainability of natural resources in their surroundings (Fauville et al., 2019). Despite these positive outcomes, this study has a limitation: students' cognitive improvements in geometry were evaluated through qualitative classroom observations and interviews rather than standardised pre- and post-test instruments. Future community service initiatives should incorporate quantitative assessments to measure learning gains more rigorously.

Discussion

Overall, the community service activity successfully enhanced teachers' competencies in designing ethnomathematics lessons on Banten batik geometry while also providing students with meaningful learning experiences. This success was evident in the teachers' ability to identify geometric elements in batik motifs, their increased enthusiasm during the workshop, and their positive responses to the implementation of locally-based learning materials. These findings reinforce the results of Darling-Hammond et al. (2017), which state that teacher training emphasising hands-on practice, reflection, and collaboration has a greater impact on improving the quality of learning than conventional training. The initial assessment showed that no teachers were utilising the local culture or surroundings, and the school had only one smart TV. The materials used (the batik fabric and ink) are tangible and do not rely on digital devices, so they can be used immediately in the school setting without additional facilities. This addresses the issue of students who are not yet very familiar with two-dimensional shapes by providing real objects they can see and touch.

For students, the activity of batik-making using mangrove leaf ink makes geometry learning more concrete, enjoyable, and contextual. This hands-on learning experience makes it easier for students to recognise two-dimensional shapes and connect them to real-world objects around them. These results reinforce the findings of Rosa & Orey (2011) that ethnomathematics is an effective approach for connecting school mathematics with community culture, thereby enhancing the meaningfulness of learning. In contrast, using Banten batik as a learning medium supports the findings of Subekhi et al. (2021), who showed that Banten batik motifs contain various geometric concepts that can serve as a resource for learning mathematics.

In addition to having an impact on pedagogical aspects, this activity also raises awareness about the preservation of Banten batik culture and the use of mangrove resources as an environment-based learning medium. Thus, this community service program not only contributes to improving the quality of mathematics education but also supports the preservation of local culture and sustainable environmental education, as recommended in the framework (Böhmer, 2023). The improvement in understanding was determined through observations and interviews, rather than through pre- and post-activity assessments. Therefore, the students' proficiency in geometric shapes cannot yet be quantified as a measurable improvement. This limitation serves as the basis for future activities to include pre- and post-assessment instruments.

Furthermore, the core novelty of this community service project lies in its dual-transformative model, bridging cultural ethnomathematics with ecological waste valorisation. While existing literature extensively documents ethnomathematical explorations in cultural artefacts such as batik (Roesdiana et al., 2024; Subekhi et al., 2021) or environmental education in general settings, limited initiatives explicitly integrate coastal biomass remediation into primary mathematics instruction. By transforming discarded mangrove leaves into organic batik dye, this program operationalises the principles of Education for Sustainable Development (ESD), as advocated by Böhmer (2023), and moves beyond conventional classroom boundaries. This interdisciplinary perspective resonates with the framework of 'ecological mathematics,' which advocates for embedding ecological awareness directly into mathematical inquiry, repositioning nature not merely as a backdrop but as an active component of numerical and spatial reasoning (Kumar, 2024).

This approach aligns with contemporary educational frameworks emphasising place-based education, where local ecological challenges become rich contextual learning environments (Putman & Rose, 2023; Gruenewald, 2003). Moreover, empowering teachers to process local

materials independently addresses a critical gap identified by Darling-Hammond et al. (2017) and Desimone & Garet (2015), confirming that sustainable pedagogical transformation requires hands-on, community-embedded professional development rather than passive theoretical training. Consequently, this study contributes a scalable, interdisciplinary framework that unites cultural preservation, environmental stewardship, and spatial reasoning in primary education.

CONCLUSION

This community service program has successfully achieved its strategic objectives in transforming the paradigm and professional competence of teachers in coastal areas. Through a participatory mentoring approach, the program successfully shifted teachers' roles from text-bound instructors reliant on conventional methods to independent, creative learning facilitators grounded in local ecological wisdom and coastal culture. The integration of Banten Batik ethnomathematics and the utilisation of mangrove leaf biomass waste proved effective in equipping educators to design contextual, interactive, and meaningful mathematics learning experiences for students.

As a tangible form of program continuity and a broader multiplier effect, the sustainability of this community service does not remain isolated at the partner school level; rather, it is institutionalised through systematic integration with the Teachers' Working Group network at the Anyar District level. Through this professional forum, the training model for utilising mangrove waste and designing ethnomathematics-based teaching modules is disseminated periodically to other primary school clusters across the coastal region. This strategic step is expected to foster an autonomous pedagogical innovation ecosystem, reinforce local cultural preservation, and sustainably address coastal environmental challenges on a broader regional scale.

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