



Artificial Intelligence Assisted Ethnomathematics in Gedog Batik Indonesia: Integrating a Social Media-Supported STEM Project for Pre-Service Elementary Teachers

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Abstract: This study explores ethnomathematical structures embedded in Gedog batik in Indonesia and examines the role of artificial intelligence (AI) in integrating these structures into STEM projects for pre-service elementary teachers and in fostering public engagement through social media. The objectives are to identify mathematical concepts in batik motifs and production processes, analyze the contribution of AI in ethnomathematical analysis, and evaluate the pedagogical and social impacts of this integration. A qualitative ethnographic approach was employed, involving six batik artisans and eighteen pre-service teachers. Data were collected through interviews, participant observation, focus group discussions, and social media interaction analysis, and analyzed using thematic, narrative, and AI-assisted digital pattern techniques. The findings show that Gedog batik embodies systematic mathematical concepts, including number, measurement, coordinate systems, geometry, transformations, and patterns, reflected in both motifs and production activities. AI enhanced analytical precision and revealed implicit mathematical reasoning used by artisans. The integration into STEM projects resulted in contextualized, pedagogically coherent learning models, thereby improving teacher competence. Social media dissemination generated positive public responses. This study contributes an AI-assisted ethnomathematics-STEM framework that supports contextual mathematics learning, teacher education innovation, and cultural sustainability.

Keywords: artificial intelligence in education; ethnomathematics; gedog batik; pre-service elementary teachers; social media in education; stem project-based learning

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INTRODUCTION

The advancement of mathematics education in the twenty-first century requires learning approaches that extend beyond the acquisition of formal concepts to encompass the ability to connect mathematical ideas with real-world contexts, cultural practices, and technological developments (Kim & Md-Ali, 2017; Su & Guo, 2023). This perspective is consistent with the framework of contextualized mathematics learning and the promotion of STEM (Science, Technology, Engineering, and Mathematics) competencies, which prioritize interdisciplinary integration, authentic problem solving, creativity, and digital literacy (Averin et al., 2020; Bada, 2022; Winarni et al., 2025). Within multicultural societies such as Indonesia, embedding local cultural contexts into mathematics instruction through ethnomathematics constitutes a strategic pathway to enhance learning relevance while simultaneously reinforcing cultural identity and supporting the long-term sustainability of cultural heritage.

Ethnomathematics conceptualizes mathematics as a culturally situated system of knowledge that is constructed, enacted, and transmitted through patterned social practices, material artifacts, and locally developed epistemologies (Batiibwe, 2024). Empirical investigations have consistently demonstrated that cultural productions, including batik, weaving traditions, and vernacular architecture, instantiate formal mathematical structures such as metric reasoning, spatial relationships, numerical regularities, and transformational processes (Ishartono & Ningtyas, 2021; Mauluah & Marsigit, 2019; Nurcahyo et al., 2024; Wati et al., 2021). However, scholarship in the Indonesian context has predominantly privileged semiotic and visual analyses of motifs and symbolic representations, with limited attention to production processes as sites of situated mathematical activity characterized by procedural regularities, operational constraints, and iterative decision-making (Alibali et al., 2013; Fadiana et al., 2021; Schwartz et al., 2025). This imbalance constrains the theoretical and pedagogical articulation of local cultural practices as mathematically generative systems. Consequently, the potential of indigenous cultural knowledge to be operationalized as a systematic, curriculum-aligned, and pedagogically scalable resource within formal mathematics education remains largely under-theorized and empirically underdeveloped.

In this context, Gedog batik from Tuban, Indonesia, occupies a strategic and timely position and warrants examination as a potential learning resource. As one of the oldest batik traditions in East Java, it originated in the inland areas of Tuban and continues to be produced through traditional methods. Its distinctiveness lies in the comprehensiveness of its production process, which encompasses cotton spinning, hand weaving using conventional looms, and batik patterning and dyeing with natural pigments. The term "Gedog" derives from the characteristic "dog-dog" sound emitted by the loom during operation, reflecting the close interrelationship among cultural artifacts, indigenous technology, and the everyday practices of the artisan community (Rahmawati, 2018; Maulida & Agustin, 2020; Rahmawati & Guntur, 2018). This lengthy and labor-intensive process, grounded in intergenerational knowledge transmission, positions Gedog batik not merely as an aesthetic product but as an embodiment of a sophisticated local knowledge system, involving systematic activities such as counting, measuring, spatial positioning, pattern construction, and proportional reasoning. Accordingly, Gedog batik demonstrates substantial potential as an authentic and contextual learning resource, as it integrates mathematical concepts within real-world practices and the socio-historical experiences of the Tuban community (Wati et al., 2021).

The urgency of adopting Gedog batik as an educational resource is further reinforced by ongoing challenges to cultural preservation amid modernization and the industrialization of batik production (Khasanah et al., 2025; Maulida & Agustin, 2020). Younger generations, including school students and pre-service teachers, are increasingly detached from traditional manufacturing processes and tend to perceive batik solely as a finished commodity rather than as a culturally embedded practice (Shaharuddin et al., 2021; Wesnina et al., 2025). Without systematic integration into formal educational settings, the local knowledge associated with the techniques, motifs, and underlying mathematical principles of Gedog batik is at risk of gradual erosion or disappearance (Maulida & Agustin, 2020; Satriyani & Segara, 2023; Sholikhah et al., 2020). Therefore, positioning Gedog batik as a context for mathematics and STEM education functions not only as an instructional innovation but also as a deliberate effort to sustain and transmit cultural knowledge across generations.

Recent advances in AI have created significant opportunities for educational research, particularly in the systematic analysis of visual and qualitative data. Techniques such as pattern recognition, image segmentation, and natural language processing enable researchers to identify mathematical structures in a more objective, consistent, and measurable manner (Sakshi & Kukreja, 2023; Sarker, 2022). These technologies enable the efficient processing of complex visual patterns and textual information, thereby enhancing analytical accuracy and reducing subjectivity in interpretation. Within mathematics education, AI has increasingly been utilized to support concept mapping, diagnose student misconceptions, and develop adaptive and personalized learning media (Liu et al., 2025; Strielkowski et al., 2025). Nevertheless, AI facilitates the integration of multimodal data sources, enabling a more comprehensive understanding of learning processes and knowledge construction. It also supports the visualization of abstract mathematical concepts, making them more accessible for learners. Despite these advancements, the application of AI as an analytical instrument in ethnomathematics research remains relatively limited. This gap is particularly evident in studies exploring Indonesian local cultural contexts and teacher education, where the potential of AI to systematically uncover culturally embedded mathematical knowledge has not been fully realized.

Project-based STEM learning is increasingly recognized as an effective approach for preparing students and prospective teachers to address the demands of the twenty-first century by integrating science, technology, engineering, and mathematics in authentic problem-solving tasks (Cahyono et al., 2024; Martínez-Borreguero et al., 2022). However, STEM implementation in educational settings has predominantly relied on modern technologies and laboratory-based experiments and has rarely incorporated traditional cultural practices as meaningful learning contexts. Moreover, empirical studies examining the dissemination and public reception of culture-based STEM learning designs via social media remain scarce, despite the growing role of digital platforms as spaces for participation and educational communication. These conditions indicate a research gap in three major areas. First, in-depth and systematic investigations of ethnomathematics embedded in cultural production processes remain limited. Second, few studies have integrated AI as an analytical tool in ethnomathematics research. Third, there is a lack of research exploring how ethnomathematical findings can be transformed into STEM project designs for prospective elementary school teachers while simultaneously examining public responses to their dissemination via social media. To address these gaps, the present study explores ethnomathematical concepts embedded in the motifs and production processes of Gedog batik from Tuban, Indonesia, using AI-based analysis; integrates these findings into the design of a STEM learning project for prospective elementary school teachers; and examines public responses to the project as disseminated through social media. Gedog batik was selected for its status as a form of traditional cultural heritage with a strong local identity and for its incorporation of structured, consistent mathematical activities into artisans' daily practices.

This study is expected to contribute both theoretically and practically. From a theoretical perspective, it extends ethnomathematics research by positioning cultural production processes as primary sources of mathematical structures and by demonstrating AI's role in enhancing analytical rigor and systematization. Practically, it proposes a model of culturally grounded STEM learning for elementary teacher education and

highlights the potential of social media as a digital learning ecosystem that facilitates knowledge dissemination, public engagement, and the reinforcement of local cultural values within formal education. This study addresses the following Research Questions (RQ):

- RQ (1). What specific mathematical concepts are embedded within the motifs and production processes of Gedog batik?
- RQ (2). How can AI methodologies be systematically applied to identify, classify, and map ethnomathematical concepts in Gedog batik?
- RQ (3). To what extent, and through what instructional design strategies, can the outcomes of AI-assisted ethnomathematics analysis be integrated into STEM-based project-based learning for pre-service elementary teachers?
- RQ (4). How is the dissemination of the ethnomathematics-based STEM project on Gedog batik perceived and responded to by the public through social media platforms?

METHODS

This qualitative study investigates mathematical concepts embedded in local cultural practices by applying AI within a STEM project framework supported by social media. An ethnographic approach was adopted to enable an in-depth examination of community experiences and perspectives regarding the use of mathematical ideas in everyday activities, particularly those associated with cultural production. The primary participants comprised traditional practitioners and community members directly engaged in the production of Gedog batik in Tuban Regency, Indonesia. Six key informants were purposively selected based on their expertise and involvement in the tradition: two traditional leaders, two senior weavers, and two community figures managing batik-related enterprises. The informants were aged 40-75 years and generally had primary-level educational backgrounds, with a small number having completed higher education.

In addition to the cultural informants, 18 pre-service elementary teachers enrolled in the Elementary School Teacher Education program at PGRI Ronggolawe University participated in the study. These students contributed to cultural documentation, AI-assisted data processing, and the development of ethnomathematics-based instructional models. The collaboration between community members and students facilitated a reciprocal learning environment, generating empirically grounded data while fostering innovative linkages between cultural knowledge and contemporary mathematics education.

The study was conducted in Tuban Regency, Indonesia, specifically in the villages of Gaji, Jarorejo, Margorejo, and Kedungrejo. These sites were selected due to their status as major centers of Gedog batik production, where batik-making constitutes a predominant home-based industry. Artisanal activities in these communities are highly interdependent, as residents typically specialize in different stages of the production process. Data were collected using semi-structured interview protocols, focus group discussion (FGD) records, and participant observation guidelines. In-depth interviews were employed to elicit participants' subjective interpretations and experiences concerning the application of mathematical concepts in cultural practices. FGDs were conducted to capture collective viewpoints and social interactions related to the meaning and function of mathematics in local contexts. Participant observation enabled direct documentation of mathematical reasoning as enacted in routine artisanal activities.

Data were analyzed using an integrative qualitative approach combining thematic and narrative analysis supported by AI-assisted social media analytics. The analysis began with data transcription, coding, and categorization to identify key patterns of mathematical practices within cultural activities. Thematic analysis was used to generate core themes, while narrative analysis examined participants' meaning-making processes. AI-based analysis complemented these techniques by identifying interaction patterns and knowledge construction in STEM activities supported by social media. To ensure data validity, this study employed triangulation techniques, including method and data triangulation. Data triangulation was conducted by comparing information across different participants (community members and pre-service teachers) and research sites, while method triangulation integrated interviews, FGDs, observations, and social media data. Credibility was strengthened through member checking and peer debriefing to confirm the consistency and accuracy of interpretations. These strategies ensured that the findings are trustworthy and reflect the participants' experiences comprehensively.

RESULT AND DISCUSSION

Batik is a UNESCO intangible heritage. Various ethnomathematical studies on batik in Indonesia are numerous, including those on classical Yogyakarta batik, coastal batik, Cirebon batik, Solo batik, Gedog batik, and others. Of the many ethnomathematical studies on batik, the majority discuss batik motifs; rare research examines the ethnomathematical aspects of batik-making, especially Gedog batik. Gedog Tuban batik is an ancient batik made in the interior of Tuban City, East Java, Indonesia. The name Gedog is taken from the manufacturing process, which begins with spinning cotton into thread and weaving it into cloth with a manual

tool. The tool makes a "dog dog" sound. From this sound, the name Gedog is taken. The process of making Gedog Tuban batik takes a long time, from spinning cotton into thread to weaving, batik, and dyeing with natural materials. The entire process of making Gedog batik is done traditionally with a canting. Based on the results of observations, documentation, and interviews in the Gedog batik artisan community. Mathematical activities are presented in Table 1.

Table 1. Mathematical Aspect in Batik Making Activities

Mathematical Aspects	Batik Making Activities
Counting Aspect	The production of hand-drawn batik requires systematic quantitative reasoning, particularly in estimating the amount of wax required and the number of colors to be applied throughout the dyeing stages. Furthermore, the determination of the number of dots or lines composing a motif is closely linked to the characteristics of the canting used. As the principal drawing instrument in batik production, canting tools are manufactured with varying numbers of spouts, commonly ranging from one to seven, which directly affect the density, precision, and structural complexity of the resulting patterns.
Locating aspect	In the preliminary stage of pattern development on paper, artisans employ a Cartesian coordinate framework to facilitate construction and preserve symmetry. This representation serves as an effective tool for regulating the alignment, symmetry, and proportional relationships among batik design elements.
Measurement aspects	In determining the dimensions of the fabric to be decorated, batik artisans commonly rely on reference marks on walls, floors, or wooden surfaces as informal measuring aids. They also employ finger units, typically using two fingers, to estimate the width of the uncolored border along the fabric edges. In addition, line thickness is measured to select an appropriate canting radius. Canting tools vary not only in the number of spouts but also in tip diameter, which is adjusted according to specific functional requirements in the batik-making process.
Design aspects	Several geometric batik motifs are structured around fundamental patterns, including rhombuses, sets of parallel lines oriented at approximately 45° , squares partitioned into four congruent triangles by their diagonals, and circular forms arranged to produce elliptical configurations. Beyond the construction of these basic patterns, the development of geometric motifs inherently involves geometric transformations such as translation, reflection, rotation, and dilation. These processes are performed implicitly as part of artisans' routine practices, often without explicit awareness of the underlying mathematical principles. Consequently, geometric transformations constitute a pervasive mathematical foundation in the design and production of batik motifs.
Playing Aspects	The determination of motif placement and color arrangement follows specific compositional rules to generate coherent variations, such as mirrored, opposing, or alternating configurations. Through this systematic structuring, geometric batik motifs can be organized into visually balanced and aesthetically refined compositions.

In batik production, artisans use a specialized instrument known as a canting, a metal tool that contains and dispenses molten wax through a narrow spout. Structurally, the canting consists of three main components: the *nyamplung*, a copper reservoir for holding the wax; the *cucuk*, which functions as the outlet through which hot wax flows; and a handle, typically made of bamboo or wood, which facilitates controlled manipulation during the drawing process. Based on the number of spouts (*cucuk*), canting tools are commonly classified into several types. The *canting cecekan* has a single tip, while the *canting laron* or *loron* has two tips (*loro* in Javanese). The *canting telon* has three tips (*telu*), typically arranged to form an isosceles triangle, whereas the *canting prapatan* has four tips (*papat*) forming a square pattern. The *canting liman* has five tips (*limo*), arranged as a square with a central point. In addition, the *canting byok* features more than seven or an odd number of tips, while the *canting renteng* or *galaran* consists of four or six tips arranged in a straight line, each design reflecting specific functional and aesthetic purposes in batik production. The names of the types of canting above are very closely related to the names of numbers in Javanese (*siji*, *loro*, *telu*, *papat*, *limo*). In addition, mathematical concepts

are also found in Gedog batik motifs. Based on observations and interviews with batik makers, the motifs and process of making Gedog batik contain geometric and measurement content. The geometric content found includes the concepts of points, lines, angles, plane figures, similarity, congruence, and geometric transformations. Kijing Miring is one of the Gedog batik motifs. The Kijing Miring motif includes the mathematical concepts of straight and parallel lines, rhombus figures, and congruence, as shown in [Figure 1](#). Apart from the kijing miring motif, the pumpkin flower motif also contains mathematical concepts, including triangular plane shapes, symmetry, and reflection, as shown in [Figure 2](#).



Figure 1. Gedog Batik with Kijing Miring Motif



Figure 2. Gedog Batik with Waluh Flower Motif

AI facilitated the ethnomathematical investigation of Gedog batik in this study for visual analysis and qualitative data processing. Students used an AI-based application to detect and visualize mathematical structures embedded in batik motifs, including repetitive patterns, symmetry, similarity, and geometric transformations (i.e., translation, reflection, rotation, and dilation). These features enabled the systematic mapping of identified concepts and their alignment with elementary school mathematics curricula. In addition, AI-supported natural language processing was employed to organize and analyze observational and interview data collected from artisans to identify mathematical activities such as counting, measuring, spatial positioning, and pattern design. Rather than substituting for the role of the researcher, the integration of AI enhanced analytical efficiency, accuracy, and representational clarity, thereby strengthening the transformation of local cultural knowledge into contextualized, structured, and pedagogically relevant mathematical learning resources for STEM education at the elementary level. The results of the AI-assisted ethnomathematics exploration of Gedog batik are presented in [Table 2](#).

Table 2. The results of the AI-assisted ethnomathematics exploration of Gedog batik

Elements of Gedog Batik	Identified Mathematical Concepts	AI-Assisted Analysis Methods	Exploration Results and Main Findings
Oblique Gravestone Motif	Straight lines, parallel lines, rhombuses, acute–obtuse angles, congruence, translation	Digital image analysis and geometric pattern detection	AI identified a rhombus-shaped basic unit with angular slopes. The motif unit undergoes repeated horizontal and vertical translations, maintaining congruent size and shape.

Elements of Gedog Batik	Identified Mathematical Concepts	AI-Assisted Analysis Methods	Exploration Results and Main Findings
Pumpkin Flower Motif	Triangles, lines of symmetry, reflections, limited rotations	Pattern segmentation and symmetry analysis	AI detects repeating triangular structures with vertical and horizontal axes of symmetry. Reflection transformations are used to create visually balanced pairs of motifs.
Gringsing Gedog Motif	Parallel lines, grid, translation, sliding symmetry	Linear pattern detection and <i>pattern clustering</i>	AI classifies the motif as a lattice structure with periodic repetition of parallel lines through horizontal and vertical translations.
Ganggeng Gedog Motif	Simple curves, elementary fractals, repeating shapes	Contour detection and analysis of organic shapes	AI maps curved shapes resembling aquatic plants as repeating simple curves with limited scale variation.
Kluweh Flower Motif	Circle, ellipse, radial symmetry, repeating patterns, proportions	Shape detection and radial symmetry analysis	AI identified a basic structure resembling radially arranged circular and elliptical slices. The motif units exhibit regular repetition and consistent relative proportions among elements, with rotational symmetry as the main principle of the motif's composition.
Jemprak Bird Motif	Geometric transformations (reflection and translation), similarity, position coordinates	Object segmentation and digital position mapping	AI detected repeating bird shapes of relatively similar size, arranged through horizontal translation and bilateral reflection. The motif's position was analyzed in a two-dimensional coordinate system to reveal the regularity of spacing between objects and the balance of the visual composition.
Tamarind Motif	Branch patterns, curved lines, angles, simple fractal repetition	Contour analysis and branching structure	AI maps the structure of a motif resembling a plant branch, with repeated curved shapes at different scales. This pattern is classified as an elementary fractal, with relatively stable branching angles and proportional spacing between elements.
Arrangement of motif elements on the fabric surface	Cartesian coordinate system, distance, position regularity	Digital coordinate mapping	AI maps the positions of points and lines in a motif into a two-dimensional coordinate system, showing the regularity of element spacing and the consistency of the motif's position within each row and column.
Determining the thickness of batik lines	Diameter, radius, size ratio	Visual analysis of the results of canting strokes	AI relates variations in the canting tip size to line thickness and classifies the proportional relationship between the tool size and the resulting motif line.
Types of canting (cecekan, loron, telon, prapatan, liman, byok)	Whole numbers, number patterns, flat shapes	Numerical feature-based classification	AI groups canting based on the number of tips (1, 2, 3, 4, 5, >7) and associates them with geometric representations (dot, triangle, square, square with a central point) and the Javanese number system.
Determining the position and color of the motif	Alternating patterns, rotational symmetry, simple combinatorics	Analysis of color composition and motif position	AI detects opposing, alternating, and 180° rotation patterns in motif arrangements to maintain visual balance.

AI-supported analysis indicates that both the motifs and the production procedures of Gedog batik incorporate a wide range of systematically structured mathematical concepts, including plane geometry, geometric transformations, repetitive patterning, similarity, measurement, and numerical representation, as manifested in the use of traditional tools such as the canting. The integration of AI techniques enables more objective and systematic detection of visual patterns, symmetry, and spatial regularities, thereby strengthening the empirical evidence from field observations and interviews with artisans. Moreover, the combined application of image analysis and natural language processing enables the identification and mapping of implicit mathematical practices embedded in batik production, such as non-standard measurement strategies, material estimation, and coordinate-based pattern design. These findings suggest that ethnomathematics in Gedog batik is not merely an abstract theoretical construct but is concretely enacted through stable and culturally situated production activities, highlighting its considerable potential to be developed into a contextualized learning resource.

Within the elementary education innovation course, pre-service elementary teachers were tasked with developing a STEM-based learning project grounded in the traditional production process of Gedog batik. The objective of this assignment was to cultivate students' capacity to integrate scientific, technological, engineering, and mathematical concepts into contextual instructional designs embedded in local cultural practices. The participants were initially organized into six groups, each assigned a distinct STEM project theme related to Tuban Gedog batik. The groups conducted literature reviews and limited field observations and subsequently developed tangible products for their respective project tasks. A summary of the project assignments and the products generated by each group is presented in [Table 3](#).

Table 3. The Project Assignments and The Products Generated by Each Group

Group	Project Assignment	Activity Description	Product
1	Cultural Analysis and Gedog Batik Process	Studying the history of Tuban Gedog batik, identifying the stages of Gedog batik production, inventorying the types of motifs, compiling a description of the potential of Gedog batik as a learning resource for elementary schools.	Descriptive report Infographic of the Gedog batik process
2	STEM Learning: Mathematical elements in the Gedog batik motif	Analyzing the ethnomathematic elements of the Gedog batik motif, compiling elementary school mathematics learning activities based on the ethnomathematics of the Gedog batik motif.	Mathematics concept map Gedog batik ethnomathematics Example of contextual questions Mathematics Student Worksheet
3	STEM Learning: Scientific Elements of Gedog Batik in Coloring and Material Experiments	Explaining the properties of gedog cloth fiber, types of natural dyes, color diffusion process, designing simple experiments for elementary school, compiling safe practical procedures	Experimental module Science Student Worksheet Observation sheet
4	STEM Learning: Technology and Engineering Design (Work process and tools) for making Gedog batik	Analyzing the function of batik tools, designing student project workflows, designing learning solutions (tool limitations, safety, learning time), designing mini elementary school batik products	Project flowchart Simple tool design Teacher's guide
5	Learning Design (Pedagogy)	Developing learning objectives, project-based learning-STEM syntax, learning scenarios, compiling integrated student worksheets	Complete teaching module Student Worksheet project
6	STEM project evaluation design	Designing product assessment instruments and rubrics, process assessment instruments and rubrics, STEM comprehension tests	Evaluation instrument package

Students were subsequently required to develop a learning project plan for elementary education that comprised clearly defined learning objectives, a STEM concept map, sequential stages of project implementation, and the specification of the expected final product. Within this design, students articulated scientific concepts related to the physical properties of textile fibers and dye absorption processes, technological concepts associated with the utilization of traditional batik tools, engineering concepts reflected in motif design and procedural aspects of batik production, and mathematical concepts encompassing plane geometry, symmetry, patterning, measurement, and motif repetition. In addition, they developed student worksheets, instruments to assess both process and learning outcomes, and strategies for teacher facilitation and mentoring throughout project implementation.

The assignment results indicated that the majority of students were capable of producing systematic, practically feasible project designs suitable for elementary school contexts. These designs extended beyond batik production activities to include phases of conceptual exploration, simple dyeing experiments, collaborative group discussions, and student presentations. Several participants further incorporated reflective components and reinforced local cultural values into their instructional designs. Through this process, students reported gaining a more profound understanding of the contextualized application of the STEM approach and recognized that mathematical learning can be meaningfully and organically embedded in cultural practices such as Gedog batik. Overall, designing a STEM project grounded in Tuban Gedog batik substantially contributed to the development of prospective teachers' pedagogical competencies, particularly in creating innovative, context-sensitive, and cross-disciplinary instructional models. The assignment also enhanced students' awareness of the pedagogical value of local wisdom as a learning resource, while simultaneously equipping them with experience in designing instruction aligned with elementary learners' needs and the requirements of twenty-first-century curricula.

Beyond project design, students were also instructed to transform their project outputs into educational content supported by AI technologies. Two primary dissemination platforms, Facebook and Instagram, were selected due to their widespread use among the population of Tuban Regency. Through this activity, students not only refined their ability to identify science, technology, engineering, and mathematics concepts embedded in local cultural practices, but also strengthened their digital literacy and capacity to communicate educational content to broader audiences. Community responses to each group's social media publications were subsequently documented through online interactions. These responses varied considerably, ranging from expressions of appreciation and sharing of personal experiences to constructive suggestions that further enriched the learning design. An analysis of these interactions yielded supplementary empirical evidence indicating that AI-supported ethnomathematics initiatives implemented through STEM-oriented projects possess substantial potential to attract public interest when presented in creative, digitally mediated formats, as shown in Table 4.

Table 4. Project Assignment and Response Summary in Social Media

Project Assignment	Platform	Number of Likes	Number of Comments	Number of Shares	Response Summary
Cultural Analysis and Gedog Batik Process	Instagram	216	22	24	Netizens expressed their appreciation for the efforts to document local culture and the detailed process of making Gedog batik. Many comments found the content informative, revealing insights into the traditional stages of batik-making, and crucial for preserving Tuban's cultural heritage. Some users expressed pride in the local culture and encouraged the continued publication of similar content.
STEM Learning: Mathematical elements in the Gedog batik motif	Facebook	188	19	19	Positive comments regarding the connection between batik motifs and mathematical concepts dominated responses. Netizens considered this approach creative, "not boring," and relevant for elementary school students. Several comments shared experiences teaching children about patterns and symmetry and suggested increasing the number of example problems and worksheets.

Project Assignment	Platform	Number of Likes	Number of Comments	Number of Shares	Response Summary
STEM Learning: Scientific Elements of Gedog Batik in Coloring and Material Experiments	Facebook	203	18	20	Netizens expressed interest in the natural-dye experiment and the color-diffusion process. Comments noted the content's educational and practical application for science learning. Some users added information about local dye plants and questioned the safety of the materials for students.
STEM Learning: Technology and Engineering Design (Work process and tools) for making Gedog batik	Instagram	193	20	21	Responses highlighted the uniqueness of traditional tools and the batik-making workflow. Netizens appreciated the flowchart visualization and simple tool designs for students. Several comments noted that this approach helped students understand engineering concretely through local culture.
Learning Design	Facebook	199	23	25	Responses focused on the quality of the lesson design. Netizens (especially teachers) commented that the project-based learning-STEM syntax and integrated Student Worksheets were realistic and easy to implement. Suggestions were made for adapting to classroom time constraints and school conditions.
STEM project evaluation design	Facebook	195	19	21	Netizens appreciated the existence of the process and product assessment rubric, as it was rarely discussed publicly. Several comments noted that the instrument helped teachers assess students' creativity and group work and suggested simplifying the assessment format.

The dissemination of the Gedog batik-based STEM projects through Instagram and Facebook revealed a stable pattern of public engagement across all assigned projects, as evidenced by substantial levels of likes, comments, and content sharing. User feedback was largely positive, highlighting the clarity of the presentation, its alignment with elementary school learning contexts, and its contribution to the preservation of local cultural heritage. Posts that integrated mathematical, scientific, technological, engineering, pedagogical, and assessment components were regarded not only as informative but also as authentic illustrations of contextualized instructional practices applicable to classroom settings. Collectively, these results suggest that social media platforms constitute an effective channel for communicating ethnomathematics-oriented STEM learning initiatives and for extending educational influence beyond academic communities to the broader public.

Further analysis of user comments indicates that social media interactions operate as a participatory learning space in which community members act not merely as passive recipients of information but as active contributors who share experiential insights, indigenous knowledge, and pedagogical perspectives (Dawley, 2009; Wang & Kumar, 2026). Such interactions foster processes of collaborative knowledge construction among students, teachers, and the wider community. Consequently, STEM projects supported by AI and social networking platforms not only enhance the pedagogical competence of prospective teachers but also illustrate the potential of social media to function as a digital learning ecosystem that facilitates the integration of local cultural resources within STEM education (Tarigan et al., 2024; Pramesti et al., 2022; Sumarni & Kadarwati, 2020). These findings underscore the significance of a glocalization-oriented framework for bridging technology-driven educational innovation with locally grounded socio-cultural realities. The findings indicate that Gedog batik embodies a coherent, systematic mathematical structure, evident not only in its motifs but also throughout

its production processes. Activities such as estimating material requirements, determining fabric dimensions, selecting canting types based on the number of spouts, and organizing motif arrangements exemplify the practical application of numerical reasoning, measurement, coordinate systems, and geometric principles. These results substantiate that batik craftsmanship constitutes a form of contextualized mathematical practice that emerges organically in everyday life, rather than being confined to decorative visual representations on textiles (Abdullah et al., 2024; Mauluah & Marsigit, 2019; Wesnina et al., 2025).

The application of artificial intelligence (AI) further strengthens the identification and systematic mapping of ethnomathematical elements embedded in cultural practices. Image-processing techniques enable the accurate recognition of repetitive patterns, symmetry, similarity, and geometric transformations, allowing complex visual structures in batik motifs to be analyzed in a more structured and measurable way. In parallel, natural language processing supports the classification and interpretation of implicit mathematical activities embedded in artisans' narratives, such as counting, measuring, and spatial reasoning. This integration of visual and textual analysis provides a more comprehensive understanding of how mathematical concepts are constructed and enacted within cultural contexts. Moreover, AI enhances analytical efficiency by processing large and diverse datasets that would be difficult to analyze manually. It also contributes to the consistency and reproducibility of findings, thereby strengthening the validity of qualitative research. In this respect, AI functions as a complementary analytical tool that enhances the precision and transparency of data interpretation while preserving the central role of researchers' qualitative judgment in ethnographic inquiry (Adhitya & Supriyadi, 2024; Cheah, 2025; Payadnya et al., 2024).

The incorporation of ethnomathematics exploration outcomes into student-designed STEM-oriented learning projects demonstrates that local cultural practices can be effectively recontextualized as structured and formal educational resources. Through this approach, students were able to bridge abstract mathematical concepts with authentic real-world applications rooted in local wisdom. They successfully integrated scientific, technological, engineering, and mathematical elements through activities such as batik production, natural dye experimentation, and the design of simple motifs and tools. These activities not only enhanced conceptual understanding but also promoted problem-solving, creativity, and interdisciplinary thinking. Furthermore, the project-based nature of the learning design encouraged active student engagement and collaboration, which are essential components of meaningful STEM learning. The integration of cultural contexts also strengthened students' appreciation of local heritage while making learning more relevant to their lived experiences. This evidence suggests that culturally situated, project-based learning environments foster deeper and more meaningful STEM learning experiences for prospective elementary school teachers. Such approaches also contribute to the development of pedagogical competence in designing innovative and context-sensitive instruction (Maqruf et al., 2025; Morrison et al., 2021; Nava & Park, 2021; Retno et al., 2025).

Public engagement with project-related content disseminated via social media further illustrates that ethnomathematics-based learning initiatives can extend beyond conventional classroom boundaries. Predominantly positive community interactions indicate that social media platforms may serve as participatory learning environments while simultaneously reinforcing local cultural values. These outcomes align with the principle of educational glocalization, which leverages global digital technologies to sustain and enhance local contexts and identities (Manara & Weber, 2023). Nevertheless, the present study is confined to the cultural setting of Gedog batik in Tuban, Indonesia, and involves a limited cohort of participants. Future investigations should include elementary school students as primary subjects and adopt mixed-methods approaches to obtain a more comprehensive assessment of learning outcomes.

In summary, this study demonstrates that integrating AI-supported ethnomathematics exploration into STEM-based projects and social media dissemination is not merely an instructional alternative but a strategically relevant approach to addressing the limitations of decontextualized mathematics learning. By systematically transforming culturally embedded knowledge into structured and analyzable learning resources, this approach strengthens the conceptual relevance and applicability of mathematics in real-world contexts. The use of AI contributes to greater analytical rigor and consistency in identifying ethnomathematical elements, while STEM-based projects operationalize these findings into coherent pedagogical practices. Moreover, the active involvement of pre-service teachers indicates that such integration is effective in developing context-sensitive pedagogical competence rather than solely content mastery. The inclusion of social media as a dissemination platform further extends the pedagogical scope by enabling broader participation and public validation of learning outputs. Therefore, this study provides empirical support for positioning AI-assisted ethnomathematics as a scalable and culturally responsive framework for mathematics education, particularly within teacher education contexts, while simultaneously reinforcing the sustainability of local cultural knowledge.

CONCLUSION

This study demonstrates that Gedog batik embodies a coherent and systematic set of mathematical concepts, not only in its motifs but also throughout its production processes, including counting, measurement, spatial reasoning, geometric transformations, and pattern structuring. These findings confirm that

ethnomathematics in cultural practices operates as a concrete and functional knowledge system rather than merely symbolic representation. The integration of AI proved instrumental in enhancing the identification, classification, and visualization of these mathematical structures, enabling a more systematic and transparent analysis of both visual and qualitative data. Furthermore, the transformation of these findings into STEM-based project designs indicates that ethnomathematical knowledge can be effectively recontextualized into structured and pedagogically relevant learning models. Pre-service teachers demonstrated the ability to develop interdisciplinary, contextual, and implementable instructional designs aligned with elementary education needs. The dissemination of project outputs through social media also revealed strong public engagement and positive responses, highlighting the potential of digital platforms as participatory learning spaces that connect academic knowledge with wider communities. Importantly, implementing this approach has several significant impacts. Pedagogically, it strengthens prospective teachers' competence in designing contextual and culturally responsive STEM learning. Conceptually, it enhances students' understanding of mathematics as meaningful and applicable in real-life contexts. Socially, it increases public awareness and appreciation of local cultural heritage. At a broader level, this approach supports the sustainability of indigenous knowledge by integrating it into formal education and digital ecosystems. Overall, this study affirms that AI-assisted ethnomathematics integrated within STEM project-based learning and supported by social media constitutes a feasible, impactful, and scalable framework for advancing mathematics education while simultaneously promoting cultural preservation.

REFERENCES

- Abdullah, A. A., Richardo, R., & Mubarok, M. N. (2024). Ethnomodeling on Activities of Giriloyo Hand-Written Batik Craftsmen. *Evolutionary Studies in Imaginative Culture*.
- Adhitya, Y., & Supriyadi, E. (2024). Ethnomathematics in Javanese and Sundanese Batik: An AI-Assisted Comparative Analysis. *Union: Jurnal Ilmiah Pendidikan Matematika*, 12(3), 472–482.
- Alibali, M. W., Nathan, M. J., Church, R. B., Wolfgram, M. S., Kim, S., & Knuth, E. J. (2013). Teachers' Gestures and Speech in Mathematics Lessons: Forging Common Ground by Resolving Trouble Spots. *ZDM - International Journal on Mathematics Education*, 45(3), 425–440.
- Averin, S., Murodhodjaeva, N., Romanova, M., Serebrennikova, Y., & Koptelov, A. V. (2020). Continuity in Education in the Implementation of the STEM Education for the Children of Preschool and Elementary School Age Modular Program. In *SHS Web of Conferences* (Vol. 79, p. 01002). EDP Sciences.
- Bada, A. A. (2022). Effectiveness of Brain-Based Teaching Strategy on Students' Achievement and Score Levels in Heat Energy. *Journal of Innovation in Educational and Cultural Research*, 3(1), 20–29.
- Batiibwe, M. S. K. (2024). The Role of Ethnomathematics in Mathematics Education: A Literature Review. *Asian Journal for Mathematics Education*, 3(4), 383–405.
- Cahyono, A. N., Arifudin, R., Aditya, R. I., Maulana, B. S., & Lavicza, Z. (2025). An Exploratory Study on STEM Education Through Math Trails With Digital Technology to Promote Mathematical Literacy. *STEM Education*, 5(1), 41–52.
- Cheah, C. W. (2025). AI-Augmented Netnography: Ethical and Methodological Frameworks for Responsible Digital Research. *International Journal of Qualitative Methods*, 24, 1–11.
- Dawley, L. (2009). Social Network Knowledge Construction: Emerging Virtual World Pedagogy. *On the Horizon: The International Journal of Learning Futures*, 17(2), 109–121.
- Fadiana, M., Amin, S. M., Lukito, A., Yuliastuti, R., & Apriono, D. (2021). Pattern Generalization Strategy From Concrete Operational Students. *Journal of Physics: Conference Series*, 1776(1), 012019.
- Ishartono, N., & Ningtyas, D. A. (2021). Exploring Mathematical Concepts in Batik Sidoluhur Solo. *International Journal on Emerging Mathematics Education*, 5(2), 151.
- Khasanah, B. A., Prahmana, R. C. I., Adiputra, S., & Arnal-Palacián, M. (2025). The Beauty of Mathematics in Indonesian Culture: An Impactful and Meaningful Context in Number Patterns Learning. *Journal of Research and Advances in Mathematics Education*, 10(2), 68–80.
- Kim, K. M., & Md-Ali, R. (2017). GeoGebra: Towards Realizing 21st Century Learning in Mathematics Education. *Malaysian Journal of Learning and Instruction*, 93–115.
- Liu, J., Sun, D., Sun, J., Wang, J., & Yu, P. L. H. (2025). Designing a Generative AI Enabled Learning Environment for Mathematics Word Problem Solving in Primary Schools: Learning Performance, Attitudes and Interaction. *Computers and Education: Artificial Intelligence*, 9, 100438.

- Manara, R., & Weber, M. (2023). Cultural Identity in the Digital Age: Navigating Globalization in Local Communities. *Journal of Humanities and Social Sciences (JHASS)*, 5(3), 114–120.
- Maqruf, A., Herman, T., Nurlaelah, E., Suwarma, I. R., & Tang, W. K. W. (2025). Exploring the Research Trends of Mathematics in STEM Education: A Systematic Review Using Bibliometric Analysis. *STEM Education*, 5(6), 1153–1171.
- Martínez-Borreguero, G., Naranjo-Correa, F. L., & Mateos-Núñez, M. (2022). Cognitive and Emotional Development of STEM Skills in Primary School Teacher Training Through Practical Work. *Education Sciences*, 12(7), 1-21.
- Maulida, D. R., & Agustin, S. A. (2020). Perancangan Buku Visual Batik Gedog sebagai Media Pelestarian Motif Batik Tuban. *Jurnal Sains dan Seni ITS*, 9(1).
- Mauluah, L., & Marsigit. (2019). Ethnomathematics for Elementary Student: Exploration the Learning Resources at Kraton Yogyakarta. *International Journal of Scientific and Technology Research*, 8(7), 776–780.
- Morrison, J., Frost, J., Gotch, C., McDuffie, A. R., Austin, B., & French, B. (2021). Teachers' Role in Students' Learning at a Project-Based STEM High School: Implications for Teacher Education. *International Journal of Science and Mathematics Education*, 19(6), 1103–1123.
- Nava, I., & Park, J. (2021). Pre-Service STEM Teachers and Their Enactment of Community-STEM Project Based Learning (C-STEM-PBL). *Journal of Higher Education Theory and Practice*, 21(9), 217–237.
- Nurchahyo, A., Ishartono, N., Pratiwi, A. Y. C., & Waluyo, M. (2024). Exploration of Mathematical Concepts in Batik Truntum Surakarta. *Infinity Journal*, 13(2), 457–475.
- Payadnya, I. P. A. A., Putri, G. A. M. A., Suwija, I. K., Saelee, S., & Jayantika, I. G. A. N. T. (2024). Cultural Integration in AI-Enhanced Mathematics Education: Insights From Southeast Asian Educators. *Journal for Multicultural Education*, 19(1), 58–72.
- Pramesti, D., Probosari, R. M., & Indriyanti, N. Y. (2022). Effectiveness of Project Based Learning Low Carbon STEM and Discovery Learning to Improve Creative Thinking Skills. *Journal of Innovation in Educational and Cultural Research*, 3(3), 444–456.
- Rahmawati, J. (2018). *Pengetahuan pada Tenun Gedog Tuban* [Doctoral dissertation, Institut Seni Indonesia Surakarta].
- Rahmawati, J., & Guntur, G. (2018). Keberadaan Masyarakat Kerek sebagai Penghasil Kain Tenun Gedog Tuban. *Ornamen*, 15(2), 181–194.
- Retno, R. S., Purnomo, P., Hidayat, A., & Mashfufah, A. (2025). Conceptual Framework Design for STEM-Integrated Project-Based Learning (PjBL-STEM) for Elementary Schools. *Asian Education and Development Studies*, 14(3), 579–604.
- Sakshi, & Kukreja, V. (2023). Image Segmentation Techniques: Statistical, Comprehensive, Semi-Automated Analysis and an Application Perspective Analysis of Mathematical Expressions. *Archives of Computational Methods in Engineering*, 30(1), 457–495.
- Sarker, I. H. (2022). AI-Based Modeling: Techniques, Applications and Research Issues Towards Automation, Intelligent and Smart Systems. *SN Computer Science*, 3(2), 158.
- Satriyani, D. R. P., & Segara, N. B. (2023). Relevansi Nilai-Nilai Kearifan Lokal pada Batik Gedog untuk Menumbuhkan Profil Pelajar Pancasila pada Pendidikan IPS di Kabupaten Tuban. *SOSEARCH: Social Science Educational Research*, 3(1), 33–46.
- Schwartz, G., Herbst, P., Chazan, D., & Buchbinder, O. (2025). Mathematics Teacher Educators' Navigational Expertise When Designing Multimodal Representations of Practice: A Semiotic Analysis. *Journal of Mathematics Teacher Education*, 28(2), 341–368.
- Shaharuddin, S. I. S., Shamsuddin, M. S., Drahman, M. H., Hasan, Z., Asri, N. A. M., Nordin, A. A., & Shaffiar, N. M. (2021). A Review on the Malaysian and Indonesian Batik Production, Challenges, and Innovations in the 21st Century. *SAGE Open*, 11(3).
- Sholikhah, I., Purnomo, R., Abas, S., Winanto, A. R., & Hamidah, C. (2020). Industri Kreatif pada Batik Tulis Tenun Gedog: Kondisi. *Jurnal Ekonomi, Manajemen dan Akuntansi*, 4(2), 198–211.
- Strielkowski, W., Grebennikova, V., Lisovskiy, A., Rakhimova, G., & Vasileva, T. (2025). AI-Driven Adaptive Learning for Sustainable Educational Transformation. *Sustainable Development*, 33(2), 1921–1947.

- Su, Q., & Guo, S. (2023). STEM-Based Principles and Strategies to Cultivate Students' Social and Emotional Learning. *STEM Education Review*, 1(6).
- Sumarni, W., & Kadarwati, S. (2020). Ethno-STEM Project-Based Learning: Its Impact to Critical and Creative Thinking Skills. *Jurnal Pendidikan IPA Indonesia*, 9(1), 11–21.
- Tarigan, W. P. L., Paidi, P., Wiyarsi, A., Suhartini, S., & Fajri, S. (2024). Integrating Scratch With Project-Based Learning to Cultivate Students' Academic Performance. *Journal of Innovation in Educational and Cultural Research*, 5(4), 723–735.
- Wang, R., & Kumar, S. (2026). Protected Tourism Areas as Pedagogical Arenas: A Resource–Knowledge–Subjectivity Framework for Analysing Educational Practices. *European Journal of Education*, 61(1), e70403.
- Wati, L. L., Mutamainah, A., Setianingsih, L., & Fadiana, M. J. (2021). Eksplorasi Etnomatematika pada Batik Gedog. *Jurnal Riset Pembelajaran Matematika*, 3(1), 27–34.
- Wesnina, W., Prabawati, M., & Noerharyono, M. (2025). Integrating Traditional and Contemporary in Digital Techniques: The Analysis of Indonesian Batik Motifs Evolution. *Cogent Arts & Humanities*, 12(1).
- Winarni, S., Kamid, Marzal, J., & Asrial. (2025). Numeracy Skill Development in Prospective Mathematics Teachers: Challenges and Opportunities in Real-World Contexts. *Journal on Mathematics Education*, 16(1), 91–110.