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Local Culture-Based Ethnomathematics for Strengthening STEAM Literacy in Transdisciplinary Mathematics Education

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Abstract

This study aims to describe the implementation of local culture-based ethnomathematics in strengthening STEAM literacy within transdisciplinary mathematics learning. A qualitative descriptive approach was employed through thematic analysis of 14 student projects developed by postgraduate students in the Mathematics Education Program at Universitas Negeri Makassar during the 2025/2026 academic year. Data were collected through document analysis of student project reports focusing on local culture, geometry, arts, digital technology, and STEAM-based learning. Data analysis was conducted through coding, categorization, theme synthesis, and interpretation. The findings reveal that local culture provides an effective context for STEAM-based transdisciplinary learning by connecting mathematical, scientific, artistic, and technological concepts with students' real-life experiences. The project themes were predominantly related to local Sulawesi cultural elements, including *Tongkonan* traditional houses, *Lipa' Sabbe* motifs, traditional weaving, *Sayyang Pattudu*, and natural patterns based on symmetry and fractals. STEAM integration was reflected in the use of GeoGebra and Canva for concept visualization, digital design, and mathematical exploration. The transdisciplinary projects also supported the

development of numeracy, scientific, digital, visual, and cultural literacy, as well as 21st-century skills. The study concludes that integrating local culture, transdisciplinary learning, and digital technology has strong potential as an innovative mathematics learning model for supporting the implementation of the *Merdeka Curriculum*. These findings contribute to mathematics education by demonstrating how ethnomathematics can strengthen STEAM literacy while preserving local cultural values in technology-enhanced learning environments.

Keywords: Ethnomathematics; Local Culture; Mathematics Education; STEAM Literacy; Transdisciplinary Learning

INTRODUCTION

The challenges of globalization in the 21st century have brought significant consequences to the field of education, where students are no longer adequately prepared by basic literacy and numeracy skills alone (Ismiyati, 2026). The rapid advancement of information technology, automation, and digital transformation requires learners to master 21st-century competencies, particularly the 4C skills: critical thinking, creativity, communication, and collaboration (Ismiyati, Tohamba, et al., 2025; Rosa & Orey, 2021a). In this context, education is expected to produce problem solvers, innovators, and logical thinkers who are capable of processing complex information from multiple digital sources to support effective decision-making (Rosa & Orey, 2021a). Despite mathematics often being regarded as the "Queen of Science," empirical evidence indicates that Indonesian students' mathematical literacy and numeracy skills remain relatively low (Ismiyati, 2026). Findings from the Programme for International Student Assessment (PISA) consistently place Indonesia among the lower-performing countries, with achievement trends showing limited improvement (Asni et al., 2026; Sartika et al., 2025; Zahra et al., 2025). This condition is further exacerbated by conventional instructional practices that emphasize memorization of formulas and procedural algorithms, causing mathematics to be perceived as abstract, monotonous, and disconnected from students' everyday experiences (Anniza et al., 2026; Ismiyati, 2026; Sartika et al., 2025).

As a response to these educational challenges, the STEAM (Science, Technology, Engineering, Arts, and Mathematics) approach has emerged as a holistic educational paradigm that integrates multiple disciplines into meaningful learning experiences (Rosa & Orey, 2021a). Rather than teaching science and mathematics as isolated subjects, STEAM

positions them as interconnected tools for understanding real-world problems through creativity, innovation, and artistic expression (Adawiah et al., 2025). Previous studies have demonstrated that STEAM-based learning effectively enhances students' engagement, learning motivation, critical thinking, and problem-solving abilities through active and contextual learning experiences (Ismiyati, Permatasari, et al., 2025; Kazimova et al., 2025).

In the Indonesian educational context, the integration of local culture into classroom instruction has become increasingly important in making learning more meaningful and relevant to students' lives (Asni et al., 2026). Culturally responsive teaching enables learners to see their identities and cultural backgrounds reflected in the learning process, thereby strengthening their sense of belonging and motivation to learn (Kazimova et al., 2025). Indonesia's rich cultural heritage, including traditional architecture, woven fabrics, folk performances, and local games, provides authentic contexts for exploring abstract mathematical concepts in concrete and meaningful ways (Adawiah et al., 2025; Asni et al., 2026).

One educational approach that bridges mathematics and culture is ethnomathematics, which refers to the study of how cultural groups develop mathematical ideas, procedures, and practices to interpret and organize their environments (Orey & Rosa, 2021). Ethnomathematics recognizes diverse ways of knowing and demonstrates that mathematical practices are universal in nature but uniquely expressed through cultural symbols, patterns, and artifacts (Orey & Rosa, 2021; Rosa, Milton Orey, 2026). Through this perspective, mathematics is no longer viewed as a culturally neutral Western product, but rather as a social and cultural construction embedded within everyday community practices (Rosa, Milton Orey, 2026).

Furthermore, contemporary educational developments demand a shift from silo-based learning toward transdisciplinary approaches that integrate knowledge across disciplines to address complex real-world problems (Ismiyati, 2025a; Krause, 2025). In mathematics education, transdisciplinary learning enables students to understand the interconnectedness of mathematical reasoning, scientific principles, technological innovation, and artistic expression within a unified learning framework Ismiyati, 2025). Such an approach is particularly relevant for preparing future educators who are expected to implement innovative and contextual learning aligned with current educational reforms (Krause, 2025).

Although numerous studies have examined STEAM education and ethnomathematics separately, limited research has explicitly explored the implementation of Sulawesi local culture-based ethnomathematics within a transdisciplinary STEAM literacy framework, particularly in higher education settings for prospective mathematics teachers (Asni et al., 2026; Ismiyati, 2025b; Ismiyati, Permatasari, et al., 2025). Existing ethnomathematics studies predominantly focus on descriptive explorations of cultural artifacts without integrating modern digital technologies and comprehensive STEAM literacy analysis (Asni et al., 2026; Krause, 2025). Consequently, there is a pressing need to investigate how prospective teachers interpret and implement cross-disciplinary integration as preparation for future implementation of the Merdeka Curriculum. Therefore, this study aims to describe the implementation of local culture-based ethnomathematics in strengthening STEAM literacy through transdisciplinary mathematics learning. Through thematic analysis of 14 postgraduate student projects, this study seeks to provide concrete insights into how Sulawesi cultural artifacts, such as Tongkonan traditional houses and Lipa' Sabbe weaving motifs, are integrated with digital technology and geometric analysis to foster 21st-century competencies and support the development of the Pancasila Student Profile.

METHODS

This study employed a qualitative descriptive approach to explore the implementation of local culture-based ethnomathematics in transdisciplinary mathematics learning aimed at strengthening STEAM literacy. The study utilized thematic analysis to identify and interpret themes emerging from student projects developed by postgraduate students in the Mathematics Education Program at Universitas Negeri Makassar during the 2025/2026 academic year.

The data sources consisted of 14 student project reports focusing on local culture, ethnomathematics, geometry, digital arts, and educational technology. The projects explored various cultural and mathematical themes, including Tongkonan traditional houses, Torajan weaving, Lipa' Sabbe motifs, Sayyang Pattudu cultural performances, fractal geometry, as well as energy and motion visualization using GeoGebra and Canva.

Data were collected through document analysis of the student project reports. The primary research instrument was the researcher, supported by a thematic analysis

framework designed to examine elements of local culture, STEAM integration, digital technology utilization, and the forms of literacy developed within the projects.

The data analysis procedures followed the thematic analysis stages proposed by Virginia Braun and Victoria Clarke, including data familiarization, initial coding, theme searching, theme reviewing, theme defining, and report writing. To ensure the trustworthiness of the data, the study employed prolonged engagement, theoretical triangulation, and peer checking to validate the consistency between data interpretation and the research focus.

RESULTS

The analysis of the 14 student projects revealed a strong interconnection between local culture, ethnomathematics, transdisciplinary learning, and the strengthening of STEAM literacy. The analyzed projects demonstrated students' tendency to integrate concepts from mathematics, science, arts, and technology through the context of Sulawesi local culture and natural phenomena surrounding learners. The analysis process was conducted through data coding, category classification, and theme synthesis to identify dominant patterns emerging from the student project reports.

Based on the coding results, several major themes were identified, including local culture as a learning resource, STEAM integration, digital technology utilization, visual ethnomathematics, and the enhancement of 21st-century literacy skills. The thematic coding results of the student projects are presented in Table 1.

Table 1. Thematic Coding Results of Student Project Analysis

No	Project Theme	Initial Codes	Category	Main Theme	Dominant STEAM Elements	Digital Technology	Developed Literacy
1	Traditional Houses of South Sulawesi	cultural geometry, local architecture, visual modeling	Cultural ethnomathematics	Local Culture as Learning Resource	Mathematics, Arts, Technology	GeoGebra	Numeracy, cultural, digital literacy
2	Traditional Torajan Weaving	geometric patterns, symmetry, cultural motifs	Mathematical cultural patterns	Visual Ethnomathematics	Mathematics, Arts	GeoGebra, Canva	Visual and numeracy literacy
3	Sayyang Pattudu	motion, balance,	Integration of culture and	Science–Culture Integration	Science, Mathematics	Digital media	Scientific and cultural

No	Project Theme	Initial Codes	Category	Main Theme	Dominant STEAM Elements	Digital Technology	Developed Literacy
		cultural patterns	science		, Arts		literacy
4	Lipa' Sabbe Motifs	symmetry, fractal patterns, aesthetics	Cultural geometry	Geometry and Aesthetics	Mathematics, Arts, Technology	GeoGebra	Numeracy and aesthetic literacy
5	Poster Gamification	digital posters, creativity, visualization	Visual literacy	STEAM Gamification	Arts, Technology	Canva	Visual and digital literacy
6	Energy and Motion	graphs, energy, concept visualization	Contextual STEAM	Science in Everyday Life	Science, Mathematics, Technology	GeoGebra, Canva	Scientific and numeracy literacy
7	Fractal Geometry	natural patterns, digital art, simulation	Digital fractals	Mathematics and Nature	Mathematics, Technology, Arts	Computer software	Digital and numeracy literacy
8	Tongkonan Traditional House	proportion, solid geometry, symmetry	Cultural geometry	Ethnomathematical Architecture	Mathematics, Arts	GeoGebra	Numeracy and cultural literacy
9	Leaf and Flower Symmetry	natural patterns, fractals, symmetry	Biomathematics	Nature-Based STEAM	Science, Mathematics, Arts	GeoGebra, Canva	Scientific and visual literacy
10	Digital Art Visualization	design, visual patterns, creativity	Digital arts	Art and Technology Integration	Arts, Technology	Canva	Creativity and digital literacy
11	Project-Based Learning	collaboration, problem solving	Transdisciplinary learning	Project-Based STEAM	Engineering, Mathematics	Digital media	Collaborative and numeracy literacy
12	Exploration of Cultural Geometry	spatial forms, geometric patterns	Contextual ethnomathematics	Contextual Geometry	Mathematics, Arts	GeoGebra	Numeracy and cultural literacy
13	Digital STEAM Literacy	educational technology	Digital literacy	Technology in STEAM	Technology, Science	Canva, GeoGebra	Digital and scientific literacy
14	Natural Phenomena and Mathematics	natural patterns, scientific observation	Contextual science	Mathematics in Nature	Science, Mathematics	GeoGebra	Scientific and numeracy literacy

Based on the coding results presented in Table 1, several major research themes were identified, as presented in Table 2.

Table 2. Synthesis of Major Themes from Student Project Analysis

No	Major Theme	Findings Indicators	Project Representation
1	Local Culture as a Learning Resource	Utilization of local culture as a context for mathematics and science learning	Tongkonan, Lipa' Sabbe, Torajan weaving, Sayyang Pattudu
2	STEAM Integration in Learning	Integration of Science, Technology, Engineering, Arts, and Mathematics elements within projects	Energy and motion visualization, poster design, geometric exploration
3	Visual Ethnomathematics	Exploration of geometry, symmetry, proportion, and fractal concepts in culture and nature	Traditional textile motifs, traditional house patterns, leaf and flower patterns
4	Digital Technology Utilization	Use of digital applications for visualization, design, and learning simulation	GeoGebra, Canva, digital media
5	Strengthening STEAM Literacy	Development of numeracy, scientific, digital, visual, and cultural literacy	Pattern analysis, project design, mathematical visualization
6	Transdisciplinary Learning	Integration of multiple disciplines within a unified learning context	Culture-, art-, technology-, and nature-based projects
7	Development of 21st-Century Competencies	Enhancement of creativity, critical thinking, collaboration, and communication	Project-based learning and digital exploration

Based on the synthesis of major themes presented in Table 2, the student projects were predominantly characterized by the use of local culture as a contextual foundation for STEAM-based transdisciplinary learning. In addition, digital technologies such as GeoGebra and Canva emerged as the primary media for supporting the visualization of mathematical and scientific concepts in more concrete, interactive, and engaging ways. The findings further indicate that the student projects were not solely oriented toward the mastery of mathematical concepts, but also emphasized the development of numeracy, scientific, digital, visual, and cultural literacy, alongside the enhancement of 21st-century competencies through contextual and project-based learning approaches. These competencies included creativity, critical thinking, collaboration, and communication, which were consistently reflected throughout the project implementation process. Overall, the findings suggest that the integration of ethnomathematics, local culture, and digital technology holds significant potential as an innovative instructional model for supporting the implementation of transdisciplinary learning in mathematics education.

DISCUSSION

The findings indicate that the implementation of local culture-based ethnomathematics within transdisciplinary learning was able to create mathematics learning experiences that were more contextual, creative, and meaningful. The study revealed a strong integration among local culture, STEAM elements, and the utilization of digital technology within the student projects. The analyzed projects were not solely oriented toward mastering mathematical concepts, but also contributed to the development of critical thinking, creativity, collaboration, communication, as well as digital and cultural literacy as essential components of 21st-century competencies. In this discussion section, the researchers further examine several key aspects emerging from the findings, including the dominance of local culture in transdisciplinary learning, the integration of STEAM elements within student projects, the use of digital technology for concept visualization, and the implications of local culture-based transdisciplinary learning for the development of innovative mathematics instruction aligned with the implementation of the Merdeka Curriculum.

Dominance of Local Culture in Transdisciplinary Learning

The findings revealed that local culture emerged as the most dominant theme in the students' transdisciplinary learning projects. This dominance was reflected in the large number of projects incorporating Sulawesi cultural elements, such as Tongkonan traditional houses, Lipa' Sabbe motifs, traditional Torajan weaving, Sayyang Pattudu performances, and various natural patterns associated with mathematical and scientific concepts. These findings indicate that students tended to position local culture as a learning context closely connected to learners' everyday lives, enabling abstract concepts in mathematics and science to be understood in more concrete and meaningful ways. This finding is consistent with previous studies highlighting the effectiveness of integrating cultural elements such as Lipa' Sabbe silk fabrics and Pinisi boats in strengthening numeracy literacy through active and contextual learning experiences (Asni et al., 2026).

Local culture became highly dominant because of its strong connection to students' social experiences and surrounding environments. Cultural contexts were perceived as capable of fostering learning experiences that are more contextual, humanistic, and relevant to daily life. In mathematics learning, local culture provides rich mathematical representations that can be explored, including geometric forms, symmetry patterns,

proportions, transformations, and fractal patterns. Through integration with digital technologies such as GeoGebra and Canva, the exploration of these cultural motifs not only strengthened students' spatial understanding but also enhanced their digital literacy and creativity (Adawiah et al., 2025; Ismiyati, Permatasari, et al., 2025). Through this approach, mathematics is no longer viewed as an abstract discipline detached from reality, but rather as an integral part of community cultural practices.

The dominance of local culture within the student projects also reflects the implementation of an ethnomathematical approach in transdisciplinary learning. Ethnomathematics views mathematical concepts as developing and evolving through cultural practices within society. In the context of this study, students integrated cultural elements into mathematics learning through the exploration of traditional architectural structures, woven textile patterns, cultural motifs, and natural phenomena. For example, the Tongkonan exploration project highlighted concepts of solid geometry, symmetry, and proportion embedded in traditional Torajan architecture, while the Lipa' Sabbe motif project explored symmetry and fractal patterns found in traditional Bugis textiles. This process represents a form of translation between local knowledge systems (emic perspectives) and academic knowledge systems (etic perspectives), allowing both systems of knowledge to coexist dialogically without diminishing their intrinsic values (Rosa, Milton Orey, 2026; Rosa & Orey, 2021b). These findings demonstrate that local culture can serve as a rich and contextual source for mathematics learning. Nevertheless, the implementation of ethnomathematics-based transdisciplinary learning still requires sensitivity toward challenges arising from the rigidity of formal curriculum standards, which may limit opportunities for accommodating diverse local epistemologies (Oviedo-berrocal et al., 2026).

Integration of STEAM Elements in Student Projects

The analysis revealed that all student projects integrated the elements of Science, Technology, Engineering, Arts, and Mathematics (STEAM) within the transdisciplinary learning process. This integration was reflected in the interconnectedness among mathematical concepts, scientific phenomena, digital technology utilization, visual design, and problem-solving processes developed throughout the projects. The students not only focused on mastering mathematical concepts, but also connected them with cultural

contexts, environmental phenomena, and visual creativity, resulting in more holistic and contextual learning experiences.

The science element was evident in projects exploring energy and motion phenomena, natural patterns, plant structures, and the regularity of biological and physical phenomena in everyday life. Projects involving the visualization of energy and motion using GeoGebra and Canva demonstrated how physics concepts, such as energy transformation, object motion, and distance–time relationships, were represented through mathematical and digital visualization. In addition, projects exploring symmetry and fractal patterns in leaves and flowers illustrated the integration of scientific concepts through the observation of natural patterns and biological structures. These findings suggest that STEAM-based learning helps learners understand scientific phenomena more concretely through contextual and visual approaches.

The technology element appeared prominently through the use of digital applications such as GeoGebra, Canva, and other visual media. GeoGebra was utilized to interactively visualize geometric concepts, symmetry patterns, graphs, and fractals, while Canva was used to design posters, visual presentations, and scientific communication media. The use of digital technology enabled students to transform abstract concepts into more accessible visual representations. Furthermore, the integration of technology also contributed to strengthening students' digital literacy and their competencies in utilizing technology-based learning media.

The engineering element was reflected in the processes of model design, project visualization, and the development of project-based learning products. Students engaged in design processes, structural reconstruction, and modeling of cultural objects and natural phenomena using systematic approaches. For instance, projects related to Tongkonan traditional houses and cultural geometry exploration involved the analysis of solid geometry, proportions, and visual structures, which were subsequently represented through digital models. These findings indicate that the engineering component within STEAM extends beyond technological construction to include the ability to creatively design solutions and learning models.

The arts element became one of the key components that strengthened aesthetics and creativity within the student projects. Artistic aspects were reflected in the exploration of cultural motifs, digital poster design, fractal pattern visualization, and artistic

representations of mathematical and scientific concepts. The poster-based gamification project demonstrated how visual design could function as an engaging and interactive medium for mathematical communication. Similarly, the exploration of Lipa' Sabbe motifs and traditional weaving patterns illustrated the connection between cultural visual aesthetics and geometric as well as mathematical concepts. These findings emphasize the important role of the arts in fostering creative, communicative, and meaningful learning experiences.

Meanwhile, mathematics served as the primary foundation across all student projects. The mathematical concepts most frequently identified included geometry, symmetry, transformation, measurement, graphs, proportions, and fractal patterns. Students explored various mathematical representations embedded within local culture and natural phenomena as part of ethnomathematical implementation. This demonstrates that mathematics was not positioned as an isolated discipline, but rather integrated with science, technology, arts, and culture within a unified learning experience.

Overall, the integration of STEAM elements within the student projects indicates that local culture-based transdisciplinary learning can create learning experiences that are more contextual, creative, and relevant to the demands of 21st-century education. This approach not only supports the mastery of academic concepts but also strengthens students' critical thinking, creativity, collaboration, communication, and digital literacy skills. These findings align with previous studies suggesting that transdisciplinary learning enables students to perceive deep connections among mathematical reasoning, scientific principles, and artistic expression as a holistic worldview (Ismiyati, 2025a) . Furthermore, the integration of local cultural elements such as traditional houses and handicrafts has been empirically shown to enhance students' motivation and numeracy literacy through active and applied learning experiences (Asni et al., 2026; Sartika et al., 2025). Nevertheless, the effectiveness of this approach largely depends on educators' willingness to move beyond conventional teaching methods and explicitly communicate interdisciplinary connections so that students do not develop fragmented understandings (Krause, 2025). In addition, its implementation should remain sensitive to challenges posed by rigid formal curriculum standards, which may still limit opportunities for accommodating diverse local epistemologies and indigenous knowledge systems (Oviedo-berrocal et al., 2026).

Utilization of Digital Technology in Concept Visualization

The findings revealed that the utilization of digital technology became one of the essential components in students' transdisciplinary learning projects. Technology was used not merely as a supporting instructional medium, but also as a tool for facilitating the visualization of abstract concepts, mathematical exploration, and the presentation of project outcomes in more interactive and creative ways. Based on the analysis results, the applications most frequently used by students were GeoGebra and Canva. GeoGebra was primarily utilized to visualize geometric concepts, symmetry, graphs, transformations, and fractal patterns, while Canva was employed to design digital posters, visual presentations, and scientific communication media. These findings are consistent with previous studies suggesting that interactive and user-friendly digital platforms can enhance students' active participation and facilitate their understanding of complex mathematical concepts (Ismiyati, Permatasari, et al., 2025).

The use of GeoGebra appeared particularly dominant in projects related to cultural geometry exploration and natural phenomena. In the Lipa' Sabbe motif project, GeoGebra was used to visualize symmetry patterns and fractal structures embedded in traditional Bugis textile motifs. Similarly, in the Tongkonan traditional house project, the application was utilized to represent solid geometry, proportions, and geometric structures of traditional architecture in more concrete forms. Digital visualization enabled students to better understand the relationship between mathematical concepts and cultural objects in contextual ways . Furthermore, the application facilitated digital experimentation, allowing students to manipulate geometric forms visually and directly test mathematical principles (Adawiah et al., 2025). Nevertheless, educators must ensure that such visual explorations remain directed toward understanding formal mathematical properties so that visualization activities do not merely result in superficial procedural understanding (Hernandez-Zavaleta et al., 2026).

In addition to GeoGebra, Canva also became a widely used platform for developing students' visual creativity in learning activities. Canva was employed in poster-based gamification projects and in the visualization of energy and motion concepts to create learning media that were communicative, engaging, and aesthetically appealing. Through creative visual design, students not only communicated mathematical and scientific information but also developed visual communication skills and digital literacy.

These findings indicate that digital technology plays a significant role in supporting more interactive and student-centered learning environments. The integration of artistic elements through technology further enabled students to interpret real-life phenomena from multiple perspectives while balancing rationality and imagination in problem-solving processes (Ismiyati, 2025a).

The utilization of digital technology in the student projects also demonstrated the strengthening of digital literacy as part of 21st-century competencies. Students used technology not only as a presentation tool, but also as a medium for exploration, analysis, and visual representation of concepts. In the context of mathematics learning, digital technology helped transform abstract concepts into more concrete representations through simulations, interactive graphs, and visual models. This finding aligns with the view that digital tools support the development of 4C competencies critical thinking, collaboration, creativity, and communication which are increasingly crucial in the era of globalization (Adawiah et al., 2025; Ismiyati, 2026).

Overall, the utilization of digital technology in the student projects functioned not only as a learning support tool but also as a medium for integrating mathematics, science, arts, and culture within STEAM-based transdisciplinary learning. The integration of digital technology contributed to the creation of learning experiences that were more contextual, interactive, creative, and relevant to the demands of 21st-century education.

Implications of Local Culture-Based Transdisciplinary Learning

The findings indicate that local culture-based transdisciplinary learning has significant implications for the development of mathematics instruction that is more contextual, creative, and meaningful. The integration of local culture into learning projects enabled students to understand mathematical and scientific concepts through authentic experiences closely connected to their daily lives. Local culture functioned not only as a medium for cultural preservation but also as a learning resource capable of bridging abstract concepts with concrete real-life phenomena (Sape & Syamsuddin, 2025; Serepinah & Nurhasanah, 2023). These findings suggest that ethnomathematics-based learning can support students in developing deeper conceptual understanding through familiar cultural contexts (Nursyahidah et al., 2025).

Another implication of this study can be observed in the strengthening of transdisciplinary approaches within mathematics education. The student projects

demonstrated that the integration of mathematics, science, arts, and technology created more holistic learning experiences compared to fragmented and discipline-centered instruction. Through transdisciplinary approaches, students not only learned mathematical concepts but also developed critical thinking, creativity, collaboration, and communication skills while solving contextual problems (Afifah et al., 2025; Kartikaningtyas et al., 2025). These findings indicate that STEAM-based transdisciplinary learning effectively supports the development of 21st-century competencies required in the digital era.

The use of digital technologies such as GeoGebra and Canva also provided positive implications for the enhancement of students' digital literacy and mathematical visualization abilities. Digital technologies enabled students to model abstract concepts into more concrete and interactive forms through simulations, graphs, and visual designs. The integration of technology with cultural contexts supported the contextual development of abstract concept visualization, digital literacy, and numeracy literacy (Nursyahidah et al., 2025; Sunzuma & Umbara, 2025). Furthermore, the utilization of technology in learning demonstrates that educational processes are no longer limited to conventional content delivery, but have evolved into opportunities for independent exploration and creative knowledge construction. Therefore, the integration of digital technology into transdisciplinary learning represents an important strategy for supporting innovative education in the 21st century.

The findings of this study also have important implications for the implementation of the Merdeka Curriculum and the strengthening of the Pancasila Student Profile. The student projects reflected the development of critical reasoning, creativity, collaboration, and global diversity awareness through the exploration of local culture and project-based learning activities. This approach aligns with the characteristics of the Merdeka Curriculum, which emphasizes contextual, flexible, and student-centered learning (Anwar & Ramadhani, 2025). By utilizing local culture as a learning context, students not only acquire academic knowledge but also develop cultural awareness and strengthen their local identity amid the challenges of globalization.

Overall, local culture-based transdisciplinary learning has strong potential to become an innovative instructional model that is highly relevant to contemporary educational needs. The integration of local culture, STEAM, and digital technology not

only strengthens students' academic understanding but also supports the holistic development of character, creativity, and 21st-century literacy skills.

CONCLUSION

The findings of this study demonstrate that local culture is highly effective as a contextual foundation for STEAM-based transdisciplinary learning because it connects mathematical, scientific, artistic, and technological concepts with students' real-life experiences. Various elements of local culture, such as Tongkonan traditional houses, Lipa' Sabbe motifs, traditional weaving, Sayyang Pattudu performances, and natural patterns, contain mathematical representations in the form of geometry, symmetry, proportions, and fractal patterns that can serve as meaningful and contextual learning resources. The integration of local culture into learning activities strengthens the ethnomathematical approach, which positions culture as an integral part of mathematical knowledge construction while simultaneously supporting the preservation of local cultural heritage through education.

In addition, the transdisciplinary learning projects developed by the students were shown to enhance various forms of 21st-century literacy, particularly numeracy, scientific, digital, visual, and cultural literacy. Through the integration of STEAM elements, students not only developed academic understanding but also strengthened their critical thinking, creativity, collaboration, and communication skills in solving contextual problems. The project-based approach further encouraged more active, reflective, and student-centered learning experiences, making instruction more relevant to the demands of 21st-century education.

The utilization of digital technologies such as GeoGebra and Canva also played a significant role in supporting concept visualization and fostering students' creativity. Digital technology enabled abstract concepts to be transformed into more concrete, interactive, and engaging visual representations, thereby facilitating mathematical and scientific exploration. Beyond strengthening conceptual understanding, the use of technology also contributed to the development of digital literacy and visual communication skills within STEAM-based transdisciplinary learning.

The implications of this study suggest that local culture can be more broadly utilized as a learning resource in mathematics and STEAM education across various

educational levels. Teachers and educators are encouraged to develop project-based learning that integrates ethnomathematics, digital technology, and local cultural contexts in order to create learning experiences that are more contextual, creative, and meaningful. Future studies are recommended to implement local culture-based transdisciplinary learning directly in schools through experimental or developmental research designs, as well as to integrate emerging technologies such as artificial intelligence, augmented reality, and other interactive media into ethnomathematics-based STEAM learning.

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