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The impact of mobile ethnomathematics learning based on Sundanese culture on creative thinking and intelligence

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Abstract

This study examines the impact of mobile ethnomathematics learning based on Sundanese culture on the creative thinking and intelligence of elementary school teacher education students. The research involved 123 students and employed a quasi-experimental design with a post-test non-equivalent control group. Four methods of mobile ethnomathematics learning were implemented: open (30 students), guided (32 students), structured (31 students), and expository (30 students). Data were collected using mathematical comprehension tests and non-test questionnaires and analyzed for normality, homogeneity, and mean differences using the Rasch model. The results demonstrate that mobile ethnomathematics learning significantly enhances students' creative thinking and intelligence, with the guided method proving to be the most effective. This approach not only enriches mathematics learning by integrating cultural elements but also fosters engagement and preserves traditional Sundanese cultural values. These findings highlight the potential of culturally integrated mobile learning as a transformative tool in mathematics education.

Keywords
Mobile ethnomathematics, Sundanese culture, creative thinking, creative intelligence, mathematics education, quasi-experimental research, cultural-based learning.

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Introduction

Research in mathematics education increasingly emphasizes the integration of digital technologies, innovative teaching methods, and culturally responsive approaches. Trends such as inquiry-based learning, gamification, and equity in education highlight the need to address diverse student backgrounds and cultural contexts to foster meaningful learning experiences. This shift reflects the critical need for reform in mathematics education, including the synergistic integration of cultural heritage and digital technologies to create a more engaging and inclusive learning environment.

Ethnomathematics, which links mathematical concepts with cultural practices, has emerged as a powerful approach to bridging cultural diversity with formal academic mathematics (D'Ambrosio, 2020). By embedding cultural elements into the learning process, ethnomathematics not only enriches students' understanding of mathematics but also enhances their ability to relate mathematical concepts to real-life contexts. This approach allows students to appreciate the power, beauty, and utility of mathematics in ways that align with their cultural identities (Milton Rosa & Orey, 2010; Begg, 2001). It also supports the development of critical skills such as creative thinking and creative intelligence, which are essential for problem-solving in complex, real-world scenarios.

Mobile learning technologies further amplify the potential of ethnomathematics by enabling flexible, context-rich learning environments. With the rapid growth of wireless and mobile computing technologies, mobile learning has introduced a paradigm shift in education, offering access to learning resources anytime and anywhere. Mobile applications facilitate the integration of local cultural contexts into mathematics education, making the learning process more interactive and engaging (Sharples et al., 2015; Bano et al., 2018). Research indicates that mobile technologies can enhance creative thinking and problem-solving skills by connecting local cultural knowledge with mathematical concepts (Sayibu et al., 2022; Verner et al., 2019).

Despite the growing body of literature on the use of mobile technologies in education, there is a significant gap in studies that explore their application within local cultural contexts, particularly in the context of Sundanese culture. This gap raises the following research question: How does the integration of mobile ethnomathematics learning based on Sundanese cultural elements impact the creative thinking and cognitive development of elementary school teacher education students?

This study, thus, aims to address this question by examining the impact of mobile ethnomathematics learning based on Sundanese culture on the creative thinking and intelligence of elementary school teacher education students. Sundanese culture, rich in traditions and mathematical artifacts, offers a unique opportunity to contextualize mathematics learning through culturally relevant pedagogy. The research would employ four distinct mobile learning methods—guided, open, structured, and expository—guided by constructivist learning theory and culturally relevant pedagogy. These theories inform the choice of methods, ensuring that the cultural context and active learning strategies are central to the learning process. The findings seek to contribute to the growing body of knowledge on culturally responsive mobile learning and its potential to enhance students' creativity and cognitive development in mathematics.

1. Literature Review

1.1 Mobile Learning (M-Learning) in Education

Mobile learning (m-learning) has significantly transformed the educational landscape by utilizing the unique capabilities of mobile devices. These devices, with their input features (touch, voice, keyboard), sensing capabilities (camera, GPS, microphones), and output functions, create dynamic and interactive learning environments that extend beyond traditional classroom settings (Clements & Sarama, 2020; Weber & Lockwood, 2014). These features support the design of personalized learning experiences, allowing students to access and interact with online resources anytime and anywhere, overcoming the traditional constraints of time and space in education (Barreto, 2013; McQuiggan et al., 2015).

Mobile learning tools, such as smartphones and tablets, facilitate various educational activities, from searching documents and reading e-books to recording videos and sharing content (Kukulska-Hulme, 2005; Barreto, 2013). The evolution of mobile-assisted learning, starting in the mid-1990s, initially focused on hardware characteristics (e.g., size, shape, material) but later expanded to include software capabilities, enabling internet access, information retrieval, and participation in interactive activities (Han et al., 2004; Angela, 2012).

Recent studies emphasize the increasing importance of mobile learning in both informal and formal educational settings, with smartphones playing a crucial role in promoting personalized, self-paced learning (Ifeanyi & Chukwuere, 2018; UNESCO, 2011). However, the integration of mobile devices into educational environments requires adequate technological infrastructure and the proper training of educators to use these tools effectively (UNESCO, 2011). This trend is particularly evident in language acquisition, where mobile learning has proven effective in providing flexible, self-directed learning opportunities for students (Alothman et al., 2017; Koehler et al., 2013).

1.2 Ethnomathematics in Mathematics Education

Ethnomathematics, the study of mathematical practices embedded within specific cultural contexts, bridges the gap between abstract mathematical theories and culturally relevant applications. This approach makes mathematics more meaningful and accessible to students by connecting mathematical concepts to everyday cultural practices (Cimen, 2014). It aligns with the theory of constructivism, which suggests that learners construct new knowledge by linking it to their prior experiences and contexts (Piaget, 1973).

In Indonesia, ethnomathematics based on Sundanese culture provide an innovative framework for integrating local cultural heritage into formal mathematics education. By incorporating traditional Sundanese games, patterns in batik designs, and architectural geometries, students are able to connect mathematical concepts to their cultural environment, fostering both cognitive engagement and cultural appreciation (Supriadi, 2019). This approach not only enhances mathematical understanding but also nurtures creativity as students apply abstract concepts in culturally relevant ways.

1.3 The Role of Creative Thinking in Ethnomathematics

Creative thinking is a key component of ethnomathematics, enabling students to engage with mathematical problems through innovative cultural perspectives. In this context, creative thinking involves not only problem-solving but also the ability to adapt and apply mathematical principles in diverse cultural scenarios (M. Rosa et al., 2015). Socio-cognitive development theory emphasizes that learning is deeply influenced by social and cultural contexts, which shape how individuals perceive and solve problems (Vygotsky, 1978). Through ethnomathematics, students are encouraged to employ divergent thinking, generating multiple solutions and perspectives on mathematical problems within their cultural frameworks (Nufus et al., 2024).

1.4 Creative Intelligence in Ethnomathematics

Creative intelligence, as defined by Rowe (2004), includes intuitive, innovative, imaginative, and inspirational dimensions. These types of intelligence play a crucial role in ethnomathematics by promoting flexible problem-solving approaches that draw upon cultural knowledge and mathematical reasoning. For example, imaginative intelligence allows students to re-envision traditional mathematical concepts through cultural expressions, while innovative intelligence facilitates the systematic exploration of mathematical ideas (Munakata et al., 2021).

Incorporating creative intelligence into ethnomathematics allows students to approach mathematical challenges with originality and cultural awareness. This also aligns with the constructivist perspective, emphasizing the role of active, context-driven learning experiences that foster both cognitive and socio-cultural development. By integrating creative intelligence, educators can cultivate an environment that encourages students to think critically, creatively, and culturally when solving mathematical problems.

1.5 Conceptual Framework for Hypothesis Development

The conceptual framework for this study integrates mobile learning, ethnomathematics, and creative thinking, grounded in both constructivist and socio-cognitive theories. Constructivism suggests that learners actively construct knowledge by engaging with culturally relevant content, while socio-cognitive theory emphasizes the importance of social interaction and cultural context in shaping cognitive development. Based on these theories, the study hypothesizes the following:

1. The integration of mobile learning in ethnomathematics education will enhance students' creative thinking skills.
2. Cultural context, particularly through Sundanese ethnomathematics, will facilitate deeper mathematical understanding and engagement.
3. Mobile devices, when used to access culturally relevant mathematical content, will improve students' problem-solving abilities in ethnomathematics.

This framework provides a solid foundation for further exploration of how mobile learning, combined with ethnomathematical practices, can promote creative thinking and improve mathematical learning outcomes.

2. Methods

2.1 Research Design

This study employed a quasi-experimental design with a post-test non-equivalent control group to evaluate the effectiveness of mobile ethnomathematics learning based on Sundanese culture. This design was chosen to measure the impact of four different learning methods—guided, open, structured, and expository—on students' creative thinking and creative intelligence. The quasi-experimental design is appropriate as it allows for comparison between groups without random assignment, which is common in educational settings where randomization may not be feasible (Creswell, 2014). This design also enables the assessment of the effectiveness of different instructional methods in real-world classroom contexts.

The study was guided by constructivist learning theory, which emphasizes the active role of learners in constructing their own understanding through experience and interaction with their environment (Piaget, 1973). According to constructivist principles, students are encouraged to build on their prior knowledge, and learning is more effective when it is contextualized within their cultural and personal experiences. The integration of culturally relevant pedagogy (Ladson-Billings, 1994) further supports the choice of methods. Culturally relevant pedagogy highlights the importance of connecting students' cultural backgrounds to the learning process, fostering engagement, and promoting deeper understanding. By combining these theories, the study aimed to create an environment where learning is both meaningful and inclusive, incorporating local cultural elements into mathematical learning experiences.

The four learning methods—guided, open, structured, and expository—were selected based on their alignment with the active learning strategies inherent in constructivism. Guided learning allows for scaffolding, where students receive support while constructing knowledge, while open learning provides more autonomy and encourages independent exploration. Structured learning offers a more organized approach to learning, which can help students build foundational knowledge, and expository learning focuses on direct instruction, allowing for clear, structured dissemination of content. Each of these methods was designed to engage students in different ways, ensuring a comprehensive exploration of how cultural integration affects creative thinking and intelligence in the context of mobile ethnomathematics.

2.2 Participants

The participants consisted of 123 undergraduate students enrolled in an elementary teacher education program at one of the regional campuses of a state university in Bandung, Indonesia. The sample was divided into four groups based on the learning method used: Guided group: 32 students, Open group: 30 students, Structured group: 31 students**,** and Expository group: 30 students. The students were recruited using a purposive sampling method to ensure diversity in demographics and learning backgrounds. The majority of participants were female (86%), with ages ranging from 17 to 21 years.

2.3 Instruments

Data collection was conducted using the following instruments:

1. Creative Thinking Test: Designed to assess students' fluency, flexibility, and originality in solving mathematical problems, this test included tasks such as creating mathematical formulations inspired by traditional Sundanese games and solving open-ended problems.
2. Creative Intelligence Questionnaire: A 24-item Likert-scale instrument based on the Rasch model, measuring indicators of creative intelligence, including problem-solving, originality, and cultural adaptability.
3. Documentation: Used to capture qualitative data regarding learning processes and student engagement.

The instruments were validated through expert judgment and pilot testing, achieving reliability scores of 0.73 for the creative intelligence questionnaire and 0.98 for the test items, indicating high reliability and consistency.

2.4 Procedure

The study was conducted over [insert duration, e.g., 8 weeks] in a controlled learning environment. The mobile ethnomathematics application, which integrates Sundanese cultural elements such as traditional games (e.g., *congklak*, *engklek*, *endog-endogan*), was used as the primary learning tool. Students were assigned to one of the four learning methods:

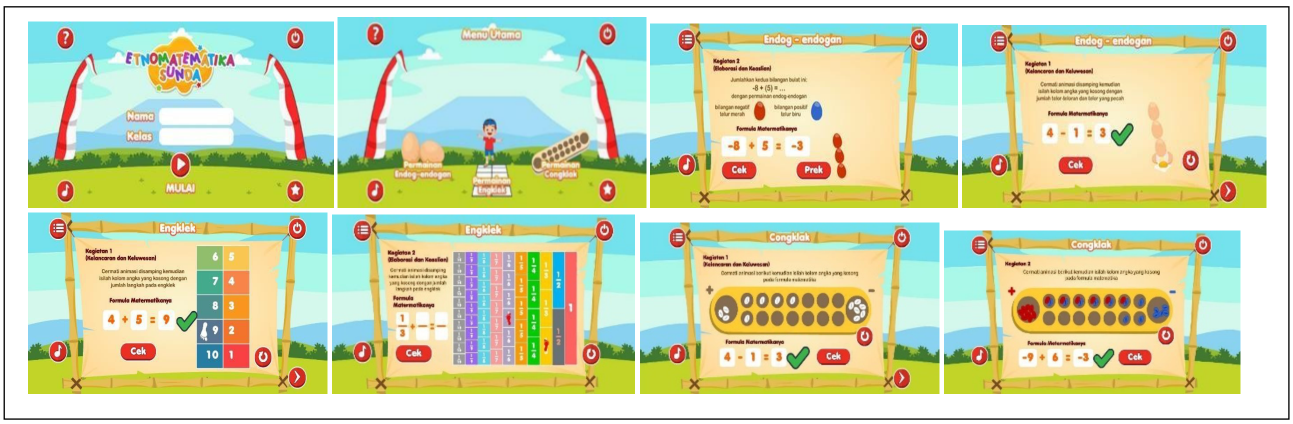
1. Guided Learning: Students received step-by-step guidance from the instructor while using the application.
2. Open Learning**:** Students explored the application independently with minimal guidance.

3. Structured Learning: Students followed a structured sequence of tasks within the application.
4. Expository Learning**:** The instructor demonstrated the application while students observed.

2.5 Data Analysis

Quantitative data from the creative thinking test were analyzed utilizing SPSS version 24.0 to perform normality, homogeneity, and Kruskal-Wallis tests. Post-hoc analysis was conducted to determine significant differences among the four groups. The creative intelligence questionnaire data were analyzed using the Rasch model to evaluate item difficulty and respondent ability. The Rasch analysis provided insights into the alignment of questionnaire items with the constructs of creative intelligence and cultural engagement.

Figure 1*: Application Mobile Sundanese Ethnomathematics Learning*



The Instrument of Mathematical Creative Thinking Test

The mathematical creative thinking test was designed to evaluate students' flexibility and originality in solving mathematical problems. It contextualized mathematical concepts using traditional Sundanese cultural elements. Below are examples of test items:

1. Fractional Calculation with Cultural Adaptation
   - Problem: *Create a fractional calculation formulation based on the addition below:*

$$\frac{1}{2} + \frac{1}{3} = \frac{5}{6}$$

   - Task: *Adapt the formulation into the context of a traditional game of your choice. Explain how the game represents the fractions and calculations.*
   - Objective: *Assess flexibility and smoothness in adapting mathematical concepts to cultural contexts.*

2. Number Pairing with Visual Representation
   - Problem: *Consider the following image of a circle (representing a grain, seed, or ball) as a learning medium. Create two pairs of positive and negative numbers that add up to 6.*

OOOOOOOOOO OOOOOOOOOO

OOOOOOOOOO

(Grain/Seed/Ball)

   - Task: .... + ... = *6. Associate the calculation with the concept of a traditional game or visual representation.*
   - Objective: *Evaluate creativity and flexibility in generating solutions and connecting mathematics to traditional cultural elements.*

.... + ... = 6		Traditional Game Concept/Image

The Ability of Mathematical Creative Intelligence Test Instrument

This instrument evaluated students' mathematical creative intelligence by measuring their activities, feelings, and opinions related to mathematical problem-solving and learning. It used a 4-point Likert scale to capture responses, with options ranging from VF (Very Frequently) = 5, F (Frequently) = 4, R (Rarely) = 2, and N (Never) = 1. Positive statements were scored directly, while negative statements were reverse-coded to ensure consistency in interpretation. The items were designed to assess indicators such as creativity, open-mindedness, risk-taking, problem-solving ability, and engagement with mathematics.

Table 1: *The Ability of Mathematical Creative Intelligence Test Instrument*

No.	Items	Indicator	Valence	No.	Items	Indicator	Valence
1	Introducing changes in math learning	Adaptability	Positive	5	Lazy to explain various ideas	Lack of initiative	Negative
2	Dare to answer questions in front of the class	Confidence	Positive	6	Learning math is boring.	Lack of interest	Negative
3	I am sure I will get a perfect score.	Self-efficacy	Positive	7	Avoiding math assignments	Avoidance behavior	Negative
4	Not focusing on new problems	Lack of focus	Negative	8	Confident in answering every question correctly	Confidence	Positive

No.	Items	Indicator	Valence
9	I am looking for more than one answer.	Divergent thinking	Positive
10	Without counting with numbers, learning math is unique.	Creativity	Positive
11	Try other ideas for creating a mathematical model	Flexibility	Positive
12	I believe in being able to solve problems well.	Self-efficacy	Positive
13	Feeling tired of learning mathematics for a long time	Fatigue	Negative
14	Analyzing answering questions	Analytical thinking	Negative
15	Creating a comfortable math learning situation	Engagement	Positive
16	Experiment with answering questions	Creativity	Positive
17	Asking questions when having difficulty answering the question	Problem-solving	Positive
18	It is enough to have only one idea to answer the question.	Fixed mindset	Negative
19	Satisfied with a strategy for solving problems	Lack of exploration	Negative
20	Feel comfortable with new learning	Adaptability	Positive
21	Creating interesting ideas and different from others	Originality	Positive
22	Fantasizing in mathematics is unique.	Creativity	Positive
23	Dare to take risks in learning	Risk-taking	Positive
24	Refusing to accept original ideas	Rigidity	Negative
25	Argue that defending one's own opinion is not important.	Lack of confidence	Negative
26	Be open-minded in accepting ideas	Open-mindedness	Positive
27	Complementing incomplete ideas	Problem-solving	Positive
28	Comment in math when appointed	Hesitation	Negative
29	Comfortable in the same way as friends	Lack of independence	Negative

No.	Items	Indicator	Valence
30	Argue that important math assignments are completed even though they will be wrong.	Lack of precision	Negative
31	Propose the best solution when there is a math problem	Problem-solving	Positive
32	Provide help to friends when there is a problem	Collaboration	Positive
33	Afraid of being blamed by friends	Fear of failure	Negative
34	Feel comfortable on your own in learning math	Isolation	Negative
35	It is enough to have one source for learning mathematics.	Lack of exploration	Negative
36	Argue that learning math is not important	Disinterest	Negative
37	Refusing to support new ideas	Rigidity	Negative
38	Nervous to answer questions in front of the class	Lack of confidence	Negative
39	Feeling weak when discussing with good friends	Intimidation	Positive
40	Avoid conflicts by arguing with friends who do not like learning math	Conflict resolution	Positive

3. Results

The results of this study demonstrate the effectiveness of mobile ethnomathematics learning methods based on Sundanese culture in enhancing students' creative thinking and creative intelligence. The data were analyzed using SPSS version 24.0 and the Rasch model. The key findings are as follows:

3.1 Comparison of Creative Thinking Scores Across Learning Methods

Table 2: *The Mean Scores of Creative Thinking*

Method	N	Mean	Std. Deviation
Guided	32	8.34	2.08
Open	30	7.28	2.11
Structured	31	6.90	3.43
Expository	30	6.12	2.19

The Kruskal-Wallis test results ($p < 0.05$) showed significant differences among the groups. Post-hoc analysis revealed that the guided method achieved the highest mean score, significantly outperforming the other three methods. This finding suggests that the integration of Sundanese cultural elements in the guided learning method is particularly effective in fostering creative thinking.

3.2 Creative Intelligence Assessment

The Rasch analysis of the creative intelligence questionnaire revealed high reliability (0.98 for items and 0.73 for respondents**).** Students in the guided and open learning groups demonstrated higher levels of creative intelligence**,** particularly in the indicators of flexibility, originality, and problem-solving. These findings suggest that both the guided and open methods effectively enhance students' creative intelligence, with a notable emphasis on the ability to adapt and generate novel solutions to problems.

The structured and expository methods, on the other hand, showed comparatively lower scores in these areas, indicating that they may be less effective in fostering creative intelligence when compared to the guided and open methods.

Figure 2: *Result of Rasch Model 1*

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-------------------------------------------------------------------------------

     SUMMARY OF 111 MEASURED PERSON
-------------------------------------------------------------------------------
|          TOTAL                         MODEL         INFIT        OUTFIT    |
|          SCORE     COUNT     MEASURE   ERROR      MNSQ   ZSTD   MNSQ   ZSTD |
|-----------------------------------------------------------------------------|
| MEAN      93.8      35.0         .20     .28       .99    -.4   1.02    -.3 |
| S.D.       6.8        .0         .54     .01       .61    2.4    .66    2.3 |
| MAX.     115.0      35.0        2.19     .34      3.12    5.8   3.26    5.4 |
| MIN.      76.0      35.0       -1.11     .26       .09   -7.2    .08   -6.2 |
|-----------------------------------------------------------------------------|
| REAL RMSE    .31 TRUE SD     .44  SEPARATION  1.40  PERSON RELIABILITY  .66 |
|MODEL RMSE    .28 TRUE SD     .46  SEPARATION  1.63  PERSON RELIABILITY  .73 ||
| S.E. OF PERSON MEAN = .05                                                   |
-------------------------------------------------------------------------------
PERSON RAW SCORE-TO-MEASURE CORRELATION = 1.00
CRONBACH ALPHA (KR-20) PERSON RAW SCORE "TEST" RELIABILITY = .71

     SUMMARY OF 35 MEASURED ITEM
-------------------------------------------------------------------------------
|          TOTAL                         MODEL         INFIT        OUTFIT    |
|          SCORE     COUNT     MEASURE   ERROR      MNSQ   ZSTD   MNSQ   ZSTD |
|-----------------------------------------------------------------------------|
| MEAN     297.5     111.0         .00     .16      1.01    -.1   1.02    -.1 |
| S.D.      45.6        .0        1.18     .03       .26    1.8    .25    1.6 |
| MAX.     358.0     111.0        1.97     .19      1.76    3.5   1.78    3.6 |
| MIN.     207.0     111.0       -1.79     .13       .56   -5.2    .66   -3.7 |
|-----------------------------------------------------------------------------|
| REAL RMSE    .18 TRUE SD    1.17  SEPARATION  6.68  ITEM   RELIABILITY  .98 |
|MODEL RMSE    .17 TRUE SD    1.17  SEPARATION  7.04  ITEM   RELIABILITY  .98 |
| S.E. OF ITEM MEAN = .20                                                     |
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Figure 3: *Result of Rasch Model 2*

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            PERSON - MAP - ITEM
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    3                  +
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    2                  +
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                   . T|  C8      D4      D6      D8
                     #  |  B8      D3
                       |S A7      C5      D7
    1               ##  +  A6      C4
                   ### S|  A4      A5      D5
              .#######  |
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               ####### M|
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    0           ######  +M
                  .###  |
                  .### S|  C2      C7
                   ###  |  C1
                    .#  |  D1
                     .  |  C3
   -1                # T+  A2      A9      B6
                       |S A1      B1
                     #  |
                       |  B2      D2
                       |  B5      B7
                       |  C6
   -2                  +
                 <less>|<frequ>
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3.3 Qualitative Observations

Qualitative observations documented in this study indicated that traditional games, such as *congklak* and *engklek*, played an important role in enhancing the cultural relevance of the learning experience and motivating students. These activities helped students connect mathematical concepts with Sundanese cultural practices, reinforcing the link between local culture and the learning material.

Moreover, guided learning, in particular, fostered active participation and provided scaffolding that allowed students to make meaningful connections between mathematical concepts and cultural elements. This highlights the effectiveness of integrating cultural practices into mobile ethnomathematics learning methods in supporting students' cognitive development and creative thinking.

Figure 4: *Learning in Class*

4. Discussion

The findings of this study indicate that learning mathematics through ethnomathematics with mobile applications is significantly more effective in fostering creative thinking abilities than traditional expository learning methods. This enhanced effectiveness arises primarily from the flexibility and adaptability of mobile learning environments. Mobile technologies enable students to engage in mathematical activities without being constrained by time and space, creating more opportunities for exploration and meaningful engagement. These findings are consistent with prior studies highlighting the transformative potential of mobile learning environments in enhancing student creativity and cognitive engagement.

Students reported that mobile learning activities enhanced their learning experiences through interactive and contextually relevant tasks. This aligns with research by Fessakis et al. (2018), which demonstrated that cultural integration in mobile platforms can stimulate deeper engagement in mathematics. Furthermore, the integration of Sundanese cultural elements into mathematical tasks not only enriched students' understanding but also made the learning process more enjoyable and relevant. However, several challenges associated with mobile learning, such as information overload, inadequate mobile support, and high costs, remain substantial obstacles to broader implementation. To address these limitations, robust wireless infrastructure and uninterrupted internet access must be prioritized, especially in educational institutions.

4.1 Role of Guided Learning in Mobile Ethnomathematics

Among the four instructional approaches evaluated in this study (guided, open, structured, and expository), the guided learning method emerged as the most effective in enhancing creative thinking and intelligence. This finding underscores the critical role of instructors as facilitators of technology-based learning. Guided learning provides the necessary scaffolding for students, allowing them to connect mathematical concepts with cultural contexts effectively. The method's success is partly attributed to the alignment of its strategies with constructivist principles, which emphasize the importance of interactive and collaborative exploration.

Lecturers' self-efficacy and technological literacy are pivotal in determining the successful integration of mobile ethnomathematics into the curriculum. Research by Farmer and Ramsdale (2016) suggests that instructors who actively guide students through problem-solving processes can foster higher levels of understanding and creativity. In this study, the guided approach involved step-by-step facilitation, ensuring that students remained engaged and focused on their tasks. Moreover, the role of self-efficacy and technology readiness among students cannot be understated, as these factors significantly influence student engagement and learning outcomes in online environments.

4.2 Relevance to Technological and Pandemic-Driven Adaptations

The integration of mobile ethnomathematics into the curriculum offers a flexible and adaptive solution to the challenges posed by disruptions such as the COVID-19 pandemic. During periods of remote learning, mobile applications provided a reliable platform for maintaining instructional continuity while enhancing student engagement through culturally enriched content. These findings are consistent with those of Kellam (2020), who emphasized the adaptability of mobile learning in response to technological advancements and global crises.

The use of guided, open, and structured methods demonstrated superior creative thinking scores compared to expository learning, reaffirming the value of active, student-centered instructional approaches. Mobile learning environments also enable educators to address diverse student needs by providing flexible access to materials and collaborative learning opportunities regardless of location. By leveraging mobile technologies, educational institutions can ensure that mathematical learning remains inclusive and equitable, even during unforeseen disruptions.

4.3 Educational Benefits of Ethnomathematics Learning

Ethnomathematics learning via mobile applications provides several key educational benefits, as substantiated by this study and corroborated by prior research:

1. Cognitive Benefits: Ethnomathematics contextualizes mathematical concepts within cultural frameworks, helping students overcome cognitive barriers often associated with abstract mathematics. This approach enhances problem-solving abilities and creative thinking, making mathematics more accessible and meaningful. For instance, incorporating traditional Sundanese games into mathematical tasks facilitated deeper understanding and stimulated innovative thinking.
2. Cultural Awareness: Ethnomathematics enriches students' understanding of their cultural heritage, fostering a sense of identity and multicultural awareness. These outcomes align with the findings of François and Kerkhove (2010), who noted that cultural integration in education promotes openness and appreciation for diversity.
3. Motivational Effects**:** Integrating cultural elements into mathematics learning stimulates curiosity and motivation. Students engaged with ethnomathematics are more likely to exhibit positive attitudes toward mathematics, as noted by Supriadi (2019) in the context of Sundanese culture.
4. Identity Formation**:** Ethnomathematics helps students connect mathematical concepts with their cultural identities, positioning mathematics as a relevant and

empowering discipline. This connection fosters a deeper appreciation for the role of mathematics in everyday life and cultural preservation.

4.4 Emotional and Social Dimensions in Ethnomathematics

While the cognitive benefits of ethnomathematics are well-established, this study also highlights the need for further exploration of its emotional and social dimensions. Learning environments enriched with cultural elements can evoke a sense of belonging and emotional resonance among students, fostering engagement and persistence. François and Kerkhove (2010) emphasized the importance of affective processes in learning, noting that emotions play a critical role in shaping attitudes and behaviors.

Moreover, Gay (2018) suggests that culturally responsive teaching must prioritize the development of interpersonal skills and cross-cultural dialogue, enabling students to navigate diverse educational contexts effectively. Emotional and social considerations are particularly relevant in collaborative learning settings, where peer interactions can amplify engagement and creativity. This aspect warrants further investigation to optimize the design of ethnomathematics learning environments.

4.5 Constructivist Approach in Ethnomathematics Learning

Ethnomathematics is deeply rooted in constructivist theories of learning, which posit that knowledge is actively constructed through inquiry and interaction with cultural contexts. This study confirms that culturally contextualized learning environments foster collaboration and collective knowledge building, as highlighted by Eglash (1997) and Skovsmose (2022). For example, the incorporation of traditional Sundanese games into mathematical tasks provided students with an opportunity to construct their understanding through culturally meaningful activities.

Social constructivism further underscores the importance of dialogue and community in learning processes. By engaging in cultural dialogues, students develop both cognitive and social competencies necessary for addressing real-world problems. This approach aligns with Ligorio (2010), who argues that culturally enriched learning environments prepare students to contribute to societal transformation.*5.6 Implications for Future Research and Practice*

This study's findings underscore the transformative potential of mobile ethnomathematics as a tool for culturally responsive education. However, several areas warrant further investigation:

1. Integration of Emotional and Social Dimensions: Future research should explore how cultural contexts influence students' emotional engagement and social interactions in learning environments. Such studies can inform the design of more holistic and inclusive educational practices.
2. Scalability Across Diverse Contexts**:** The scalability of mobile ethnomathematics learning should be examined to ensure its applicability across different cultural and institutional settings. This includes evaluating the feasibility of implementing similar approaches in non-Indonesian cultural contexts.
3. Educator Training**:** Teacher training programs must prioritize the development of competencies necessary for facilitating culturally responsive mobile learning. This includes fostering technological literacy, cultural awareness, and the ability to design engaging contextually relevant tasks.

5. Conclusion

This study concludes that ethnomathematics learning through mobile applications significantly enhances students' creative thinking abilities and creative intelligence. Among the four methods evaluated—guided, open, structured, and expository—the guided method demonstrated the highest effectiveness. This indicates that active lecturer facilitation plays a critical role in helping students connect mathematical concepts with cultural elements, thereby fostering creativity and deeper engagement.

Mobile ethnomathematics learning not only makes mathematics more enjoyable but also preserves and promotes original cultural ideas, such as those rooted in Sundanese traditions. By integrating cultural heritage into mathematics education, this approach supports the development of critical cognitive skills, cultural identity, and a greater appreciation for diversity.

The findings highlight the transformative potential of mobile ethnomathematics learning as a tool for culturally responsive education. It offers flexibility and adaptability, making it a valuable approach for addressing challenges in formal education, especially in the context of technological advancements and potential future disruptions such as pandemics.

5.1 Suggestions

Based on the findings, the following suggestions are made for future research and practice in ethnomathematics education:

1. Broader Implementation**:** It is recommended to expand the use of mobile ethnomathematics learning in a variety of educational settings, particularly in rural or culturally diverse areas, where it can foster both mathematical understanding and cultural appreciation. Pilot programs in different geographical contexts could provide insights into the adaptability and effectiveness of the approach.
2. Long-Term Impact Assessment**:** Future research should examine the long-term effects of mobile ethnomathematics learning on students' academic performance, motivation, and cultural identity. Longitudinal studies could provide valuable data on how sustained engagement with this approach influences learning outcomes over time.
3. Cultural Integration Refinement: While the integration of Sundanese cultural elements was beneficial, further exploration is needed to refine the inclusion of diverse cultural practices across different regions. Developing a more comprehensive cultural framework within mobile learning platforms could enrich the learning experience for students from various cultural backgrounds.
4. Educator Training and Professional Development: Effective implementation of mobile ethnomathematics learning requires training educators in both the technical aspects of mobile learning and the pedagogical strategies needed to integrate cultural elements. Teacher professional development programs focused on culturally responsive teaching methods could ensure that educators are equipped to maximize the impact of this approach.
5. Technological Advancements**:** Given the rapid pace of technological change, future studies should explore how emerging technologies (e.g., augmented reality, gamification) can enhance the mobile ethnomathematics learning experience, making it even more engaging and immersive for students.

6. Limitations

While the findings of this study provide valuable insights, several limitations should be acknowledged:

1. Sample Size and Generalizability**:** The study involved a relatively small sample size from a specific context, which may limit the generalizability of the findings. Future research should involve larger and more diverse samples to ensure that the results are representative of a broader population.
2. Short-Term Nature of the Study: The study focused on short-term effects, and as such, it does not provide information on the long-term sustainability of the learning outcomes. A longitudinal approach would help determine whether the enhancements in creative thinking and intelligence are maintained over time.
3. Cultural Bias**:** While the integration of Sundanese cultural elements was central to the study, the findings may not be applicable to other cultural contexts without modification. Future research should explore the adaptability of mobile ethnomathematics learning in different cultural settings to ensure that the method is universally applicable.
4. Technological Limitations**:** The study was conducted using mobile applications that may not be accessible to all students, particularly those in regions with limited access to technology. Future studies should consider the role of digital equity in the implementation of mobile ethnomathematics learning and explore ways to overcome technological barriers.
5. Control of External Variables**:** While the study controlled for several factors, external variables such as students' prior knowledge of mathematics or personal interest in cultural learning may have influenced the outcomes. Further research could explore the influence of these factors on the effectiveness of mobile ethnomathematics learning.

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