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Designing a Batak Toba Local Content Educational Game Prototype: A GDLC-Based User Needs Analysis Approach

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ABSTRACT

Digital-based educational games that incorporate local content have significant potential as interactive and engaging learning media, particularly in introducing local culture to users as well as understanding their own culture and serving as a form of appreciation and strengthening of national identity. Currently available educational game applications, however, are limited to a few particular cultures, with less attention to integrating local elements, particularly those of the Batak Toba culture. This study aims to identify the necessary features, design, and gamification models, as well as the factors influencing the effectiveness of educational games in enhancing understanding of local content, using the Game Development Life Cycle (GDLC) method with the addition of user needs analysis. The user needs analysis was conducted using a survey and Focus Group Discussions (FGD) with prospective user partners at primary schools in Toba. The user needs analysis indicated a need for a mobile application with interactive, user-friendly features. More than 33% chose adventure, with some challenges and trophies, to be played individually or as part of a team. Furthermore, the results of the survey and FGD served as the basis for the pre-production phase, which determined the game type, scenario, gameplay, and challenges. In the production phase, the game interface was designed according to user needs. The final stage of prototype testing indicated that 95% of respondents stated that the prototype depicted Batak cultural content. This research contributes to the implementation of GDLC by integrating user needs analysis into data collection to increase software satisfaction and acceptance. Further research is needed to analyze system testing and the application's impact on students' knowledge of the Batak Toba subject.

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■ INTRODUCTION

The use of technology-based tools, particularly for learning among younger learners, has been extensively explored by researchers (Dong et al., 2024; Faizatunisa & Kuniati, 2024; Kurniawan et al., 2026). Dong et al. (2024), for example, investigated a way to improve the quality of children's learning by integrating technology into the teaching and learning process. They used virtual reality (VR) games to help children with cognitive impairment. The study found that gamification effectively enhanced participants' cognitive development by providing an interactive learning experience. In a different context, Faizatunisa & Kuniati (2024) argued that educational games can be used as learning materials or tools for younger learners, as they may facilitate their exploration of curiosity. In general, integrating educational game technology may promote learning in children.

In discussing children's learning, Piaget (1964) proposed a theory of cognitive development organized by age ranges. The stages are sensorimotor (0-2 years), preoperational (2-7 years), concrete operational (7-11 years), and formal operational (11 years and up) (Piaget, 1964). Each stage of development indicates different characteristics. In this study, the target users are primary school students, and, based on the stage classification, they are categorized as being in the concrete operational stage. Several cognitive developmental operations in this stage include the ability to reason flexibly and in an organized manner, as well as to classify and

order objects. Piaget (1964) also highlighted the importance of children's experiences and their physical environment in their learning. This means that it is essential for educators of learners at this stage to provide them with experience and a concrete, close environment to support their learning.

Several studies suggest that using technology-based tools for learning among young learners is appropriate, as children are in their concrete developmental stage. Dong et al. (2024), for example, experimented with gamified cognitive training for children with cognitive impairment. Employing Piaget's theory of concrete operations, they designed several virtual games for the 15-day training. It was found that the training participants showed improvement in cognition and motor development. This study also suggests that game types should be adjusted to different levels of cognitive development. In the concrete developmental stage, it was recommended to stimulate children's learning through games with clear objectives and rules to achieve them, as these enhance the development of their thinking structure (Dong et al., 2024).

The concrete development stage, as previously mentioned, underscores the importance of relevant materials and the learning environment for children's lives. Research by Føreland & Äärelä-Vihriälä (2024) focused on using Minecraft as learning material for pre-service teachers and on practicing with primary school students in the Sami Indigenous education context (Norway), particularly in learning the Sami language and culture. Minecraft was chosen because it contained materials closely related to the Sami environment. Beyond general topics such as mathematics and geometry, Minecraft also featured environments depicting Sami contexts, including reindeer husbandry, a snow world, and flags. Through the game, players might also gain exposure to the language, either through the game or through the teachers' instruction (Føreland & Äärelä-Vihriälä, 2024). The results of the study indicate that Minecraft, as game content, is relevant to the purpose of learning in the context under study because it aligns with Sami culture and environment, thereby facilitating learning.

Another study by Prasetyo et al. (2023) explored the use of automation in speech recognition using Deltalk. The technology was an English-learning platform for young learners, featuring stories delivered via an automated speech-recognition tool within a game-based model. This research indicated that technology use, particularly for language learning, reflected the potential of digital tools to provide flexible, accessible, and interactive learning experiences (Prasetyo et al., 2023). In a different study, Utami & Ghufron (2024), in a critical review, examined the effectiveness of using Scratch, a free-access coding platform for primary school students. The study showed that the activity was relevant to what children need at this developmental stage, as they could experience seriation and classification, decentering, reversibility, conservation, and the elimination of egocentrism, which are characteristics of the concrete operational stage. All of which help children develop their logic, structured thinking (Utami & Ghufron, 2024), and problem-solving (Babakr et al., 2019).

Based on the discussion above, it is clear that technology helps in stimulating children's cognition. However, it is also necessary to consider children's cognitive load when receiving and processing information to avoid being overwhelmed (Sweller, 2024). Since the technology is designed for children, the design process must also account for individual differences. Sweller's theory of cognitive load (Sweller, 1988), especially intrinsic cognitive load, focuses on leveling the degree of difficulty in a learning process to enable more effective information processing. The studies above had limited discussion of how the games could address the cognitive load on children when receiving and processing information.

Educational game applications have evolved from mere entertainment platforms into effective learning tools, capable of increasing learners' motivation (Oshi et al., 2025), improving engagement and comprehension of specific topics like accounting (Hajimoradkhani et al., 2019), geography (Gu et al., 2025), and even being used for the intercultural adaptation process (Hu, 2025). This research on educational games predominantly highlighted popular or global cultures and common topics.

The preservation of cultural heritage is vital for strengthening national identity and fostering appreciation of local wisdom among younger generations (Cahyono & Iswati, 2017; Baka et al., 2018; Rachmadyanti, 2017). One essential approach to cultural preservation is integrating local content into school curricula. Providing children with knowledge of local traditions and encouraging them to value their culture not only supports heritage preservation but also enhances their learning experiences (Ahyati et al., 2024; Nurdiana & Asmah, 2022)

In the Indonesian context, some research, particularly on the gamification of culture through educational games, generally offers a

promising strategy (Ahyati et al., 2024; Andrean et al., 2025; Ariyana et al., 2022; Pangau et al., 2019; Qonitattsani & Sukardi, 2024). The research by Nurdiana & Asmah (2022) focused on gamifying West Kalimantan's local culture to teach math to young learners. Another study by Ahyati et al. (2024) systematically reviewed the integration of online educational games with local and cultural content at the primary school level. They found that games with local content increased students' engagement and motivation to learn, resulting in improved literacy overall and, in particular, literacy in local culture. In line with the previously mentioned study, Andrean et al. (2025) suggested that games with local content in primary schools are beneficial in that they promote reading motivation, learning outcomes, and students' recognition of their own culture. Besides, learning is more interactive when technology is used (Andrean et al., 2025). Research by Qonitattsani & Sukardi (2024) investigated the use of a game application for learning Bahasa Indonesia. Research by Asiqin et al. (2025) integrated Flores culture into their educational game, while research by Ariyana et al. (2022) developed a cultural batik game from Yogyakarta into their application. However, discussion of educational games, particularly in the Toba region, is limited, even though the area is famous for its rich cultural heritage, including language, traditions, and indigenous values. Limbong et al. (2023) have integrated a game-based writing system for Batak Toba primary school students, but broader discussion of Batak Toba content is scarce.

To address this gap, it is crucial to design an educational game that incorporates local Batak Toba cultural elements. Such integration can improve learners' understanding of their own culture, cultivate appreciation, and reinforce national identity. This study builds on previous initiatives that disseminated local-content storybooks and short films to partner schools in Toba Regency. These initiatives received highly positive responses for offering diverse learning media that retained strong cultural relevance (Pasaribu et al., 2022; Pasaribu et al., 2024).

The Game Development Life Cycle is a predominant method in software development, specifically for game development (Sidik et al., 2024; Krisdiawan & Darsanto, 2019). It covers the entire process of game development from start to finish, with four main stages: (i) initialization, (ii) pre-production, (iii) production, and (iv) testing. Ramadaniati et al. (2025) designed a 2D puzzle educational game to introduce traditional East Kalimantan games using the GDLC method. The Game Development Life Cycle (GDLC) provides an effective way to design and develop games, considering each step at each stage. However, the game cannot automatically add value after completion. Furthermore, Asiqin et al. (2025) developed an educational game for Flores culture using GDLC. This research resulted in a highly effective educational game application to enhance cultural learning among students at SDN 1 Atap Cipaku. Another study by Saputras et al. (2022) developed an educational game that introduces Indonesian culture using the GDLC method. This study yielded a usability score of 83.7% across the overall test, indicating that this educational game application is satisfactory. In this research, however, data collection during the initialization stage of GDLC was limited to observing the culture (for example, Asiqin et al., 2025 and Rachmadyanti, 2017), with minimal interaction with target users, such as user needs analysis.

Based on the previous explanation, it can be seen that research on game applications with local content has been widely conducted. However, research on the use of GDLC to develop game applications for learning local content, such as language, traditions, food, and clothing, is scarce. If the game application is developed using GDLC, the testing results are satisfactory. Hypothetically, the development of educational games with local content will generally adopt the GDLC method, since previous research has indicated effective results and may yield similar results. Therefore, in this study, a prototype educational game will be developed that highlights Batak Toba culture, specifically the Batak Toba language, using the GDLC method. This research also conduct a user needs analysis during the initialization stage of GDLC for the target users, to ensure the results meet the needs, expectations, and contextual requirements of its intended users. It is considered effective for understanding the user's needs, particularly in human-computer interaction (Lopes et al., 2018; Bano & Zowghi, 2015; Castro et al., 2008).

Compared with similar studies in Indonesia (Asiqin, 2025; Saputra et al., 2022), this research, from a pedagogical perspective, sought to incorporate Piaget's concrete operational stage as the theoretical foundation for game design, a point not discussed in either study. This is essential, given the game's target user. Asiqin's research focuses on developing software based on common user needs found in schools, and the assessment is conducted after the game is implemented by calculating N-gain. Saputra et al.'s (2022) research draws on

cultural knowledge from encyclopedias and emphasizes the alpha and beta testing process after implementation to address shortcomings in user needs. This study explicitly prioritizes the application of a user need (Bano & Zowghi, 2015). Analysis is a foundational principle that precedes system implementation and is subsequently reinforced by the administration of User Acceptance Testing (UAT) as a rigorous post-development validation instrument. This approach is designed to ensure that the system yielded by this research demonstrably and comprehensively reflects the genuine needs, expectations, and contextual requirements of its intended user population.

The results of the aforementioned studies have been taken into consideration in designing the educational game in this research. Considering the importance of cultural content as concrete material for learning among children aged 7-11 (primary school students) in Toba Regency, Batak Toba culture was chosen as the game's material. The game has also been designed with targets and rules to support learners' cognitive development in structured thinking by devising strategies to win, thereby managing cognitive load, as suggested by Sweller's (1988) cognitive load theory. In addition, the characteristics of the concrete developmental stage (seriation and classification, decentering, etc.) have been incorporated into planning the game's content, particularly the levels and modes (individual and collaborative). Consequently, this research raised two research questions:

RQ1. Is the implementation of the GLDC method significant for developing a game prototype with local content?

RQ2. Is there a significant relationship between user needs analysis and the result of user testing?

Therefore, the main objective of this study is to determine whether the GDCL method, which uses user needs, is significant for developing game applications with local content and to investigate the relationship between user needs and user testing results.

■ METHOD

Participants

Participants for the requirements gathering and user testing in this research were students from four elementary schools, both public and private, located in Toba Regency. All elementary schools can select one local content lesson, and the four schools chose Batak Toba. This lesson is compulsory for students in grades 4-6. Purposive sampling was used to select respondents who had experienced the teaching of local content at their respective schools. With a total population of 360 students, the sample size was determined using the Slovin method (Sevilla et al., 2007).

Therefore, the minimum sample is 189 respondents.

Participants in the FGD were school teachers, students, and parents from the four elementary schools. The school teachers have a background in teaching Batak Toba as local content lessons, while parents have knowledge of Batak Toba and speak the Batak language. They were considered to have background knowledge in Batak Toba. The school teachers would also validate the materials to be included in the application and the level of difficulty suitable for elementary school students. It is

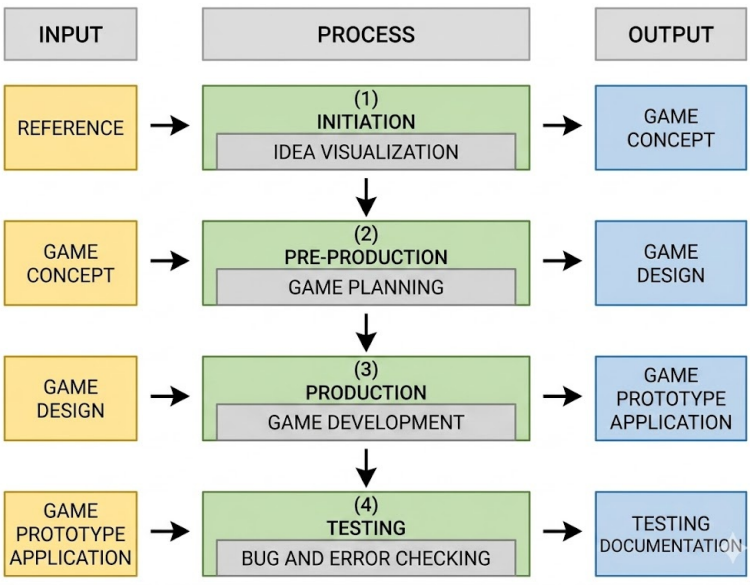

Figure 1. Game Development Life Cycle

necessary to have a local Batak Toba cultural expert to validate the content; therefore, the expert will be involved in the next iteration.

Research Design and Procedure

The problem-solving approach in this study employed a prototype development method informed by the analysis results. The prototype development process refers to the Game Development Life Cycle (GDLC) (Sidik et al., 2024; Krisdiawan & Darsanto, 2019), which has been adapted as follows (Figure 1).

Initialization

The initialization stage consists of needs identification, which is conducted to determine the requirements for the educational game application. This process involved surveys with students from four partner primary schools and focus group discussions (FGDs) to obtain deeper insights into user needs and preferences. There were four primary schools involved in the research process. As explained by the participants, all the schools were located in Toba, with students mostly from Batak Toba backgrounds.

Pre-production

The pre-production stage includes:(a) Game type, which involves identifying the gameplay flow to be designed and implemented in the culture-based educational application. (b) Scenario and character design, which involves defining and designing the application's storylines and characters. (c) Gameplay design, which specifies how the game is created and implemented, enabling users to experience cultural learning through stories, quizzes, puzzles, or other interactive formats. (d) Challenge design defines the challenges users will encounter, such as quizzes, puzzles, or other tasks. (e) Additional elements, which may be incorporated based on user needs identified during the requirements analysis.

Production

The production stage consists of application design, in which the structure of the culture-based educational game is modeled and represented through Use Case Diagrams. Prototype modeling involves developing a prototype in the form of user interface (UI) designs.

Testing

At this stage, the prototype was tested to ensure that the culture-based educational game application functions without errors. If errors were identified during testing, revisions were made to prevent them from interfering with the application's functionality. There are two types of testing targeted for this research: User Acceptance Testing and System Testing. However, system testing has not yet been conducted, as the result is still a static prototype. Further research is needed to investigate system testing.

Instruments

The instruments used were a needs-analysis questionnaire and user testing. The user testing instrument was evaluated using Spearman's correlation to assess the significance of each question. This study employed nine questions for user testing to assess the consistency of the questionnaire items in measuring the same construct. The indicators tested were related to the initial interface, navigation and interaction, the content's relevance to the Batak Toba culture, the visual design with Batak cultural nuances, the clarity of information and the user's learning experience, and the overall feasibility.

Data Analysis

The data were collected manually by visiting the four elementary schools in April-May 2025 (needs analysis) and in September (prototype testing). Participants answered these questions via the Web-based system. The data obtained were manually recorded and statistically analyzed using Microsoft Excel 2016.

■ RESULTS AND DISCUSSION

GDLC Implementation

Initialization

In the initialization stage, the research focused on exploring the application's identification needs. A standardized questionnaire was distributed to stakeholders in the study (students, teachers, and parents) from four primary schools in the Toba area. Through this survey, the team obtained input regarding the needs and preferences of these stakeholders regarding the development of a prototype educational game with local content.

User needs were identified using a structured questionnaire consisting of multiple-choice questions and Likert-scale statements to capture users' needs for the proposed local-content educational game prototype. For each question, respondents could choose from a list of options or provide their own answer. Q1 and Q2 explore the common medium and platform that the users are familiar with. Q3 focuses on the type of game, while Q4 is about the use of color in the prototype. Q5 - Q7 explore the choice of character and local names used. Q8 - 10 focus on the nature of the game, with

challenge, the prize, and the storyline of the game. Q11 assesses the need for background sound or music in the application, and the final question determines the preferred concept of a solo or team player for the game.

Based on the survey, most respondents (88.04%) prefer to play games on their mobile phones via a specific platform. This result indicates that mobile phones have become the primary medium of digital interaction amongst the target users. In addition, the data reveal a strong need for an interactive, user-friendly application. A substantial majority of respondents selected options that reflected their preferences for the proposed game. More than 33% chose adventure as the main theme of the game, with bright colors. In terms of characters, Maruli and Uli are the two top names selected for the main characters. The findings also indicate that the respondents prefer challenges with prizes in the form of trophies. As many as 40.2% prefer background music. Last but not least, the proposed application is preferable in a multiplayer concept.

Following the survey, a focus group discussion (FGD) was designed by inviting representatives of teachers and parents from the partnering school. Through this FGD, deeper insights into potential user needs and preferences were obtained. Some important findings from the FGD concerned the cultural content to be included in the application, such as the Batak Toba script, all ceremonial events celebrated in Batak Toba, and Batak Toba music as background sound. Participants also suggested that a more culturally grounded approach be introduced from the beginning of the game, including using a Batak Toba traditional house as the application icon and personifying a character with a local Batak Toba name. These results are fundamental to the next process, as they reflect the genuine needs, expectations, and contextual requirements of the intended user population. These results also served as the basis for developing the user-centered design game during the pre-production stage.

Pre-production

The application's storyline and scenarios were developed based on the results in the initialization phase. Two games were designed to develop a sense of challenge. Each game's content consisted of different categories. The design of the game types followed Sweller's cognitive load theory (Sweller, 1988), particularly its focus on intrinsic cognitive load. To cater to individual cognitive differences (Sweller, 2024), the two games were designed as both individual- and team-based. The game types were leveled up: the first game consisted of 10 simple closed-ended questions, while the second was more challenging and featured more complex content.

Two games were designed to develop a sense of challenge. Each game's content consisted of different types of categories. In the first game, Cultural Trivia, 4 categories were incorporated: Traditional Food, Tarombo, Traditional Clothing, and Traditional Music. There were 10 questions per category, for a total of 40 questions. In the second game, called Cultural Exploration, the game was set on a journey to several famous places in Toba. A journey map is provided from the starting point to the end point (with a total of 10 places), with the first 4 places are for easy questions (simple vocabulary, word meanings, and other relevant questions), the next 3 places are for medium questions (sentences, sentence structure and other relevant questions) and the the last 3 places are for difficult questions (texts related to Batak script, knowledge related to Batak culture, such as wedding ceremonies, births and deaths, etc., one text for 2 or 3 questions). Each point contains 5 questions, for a total of 50 questions.

The gameplay design was centered on cultural exploration, with 10 places to visit, starting from IT Del - Taman Eden - Toba Caldera - Parapat - Ajibata (take the ferry) - Tomok - Tuktuk - Batuhoda - Tanah Ponggol - Sibeabea. At each place, a notification will appear before answering a question. For example, at point Del: "You will go on an adventure in Toba. There will be 5 questions at each location you visit. If you answer 3 questions correctly, you can move on to the next location. Let's complete this mission and reach Sibeabea as quickly as possible and with the most points." At point Eden: "You will see the beauty of the Garden of Eden, but first, answer the following questions. Good luck." And so on until the final point: Sibeabea. Those who have arrived will receive a trophy. Then, a notification will appear: "Congratulations, you have arrived in Sibea bea and completed this mission.

To create a sense of challenge, one scenario was prepared. At the end point, a challenge was created. If the user accepted the challenge, they would receive an additional reward, such as extra points or a virtual ticket to stay overnight at a hotel in Toba. These scenarios were based on user needs. As part of a crucial cycle in application development in human-computer interaction, user needs analysis is important for understanding the

user's needs. This aligned with previous research that incorporated user needs analysis into the application development process (Lopes et al., 2018).

The Mechanics–Dynamics–Aesthetics (MDA) framework was used for the end-to-end design process, resulting in the prototype of the Toba Batak educational game (Harms et al., 2015; Utami et al., 2022). MDA is a framework that bridges the gap between the player experience and game development. The MDA framework for a game has three interrelated layers: Mechanics, which refers to the rules, components, and systems intentionally designed by the developer; Dynamics, which describes the runtime behaviors and interactions that occur when the player engages with the mechanics; and Aesthetics, which represents the emotional responses and experiential outcomes experienced by the player. Below are details and explanations of each layer:

1. *Mechanics*: designed by rules, components, and systems by the developer. (a) Two game types: Cultural Trivia (40 questions in 4 cultural categories) and Cultural Exploration (a trip to 10 locations in Toba). (b) Level system: easy, medium, difficult questions. (c) Game modes: solo and multiplayer. (d) Reward system: trophies and additional points. (e) Visual elements: Maruli & Uli as characters, traditional Batak houses as icons, Batak background music
2. *Dynamics*: emerge as players interact. (a) Players strategize to answer questions to advance to the next location. (b) Competition in team mode encourages collaboration. (c) Additional challenges at the endpoint (Sibeabea) encourage players to continue playing. (d) Interaction with cultural content stimulates curiosity.
3. *Aesthetics*: measured through UAT (User Acceptance Testing). (a) 95% of respondents stated that the prototype adequately depicts Batak cultural content. (b) 80% voted "strongly agree" on the culturally nuanced Batak visual design. (3) 93% agreed on the overall suitability of the application. (4) Users found the learning experience enjoyable and challenging.

Production

In the production stage, the game prototype was designed by integrating the identification of potential users' needs and preferences. The prototype was designed using the GDLC method.

Figure 2. Interface of Game 1 (Cultural Trivia)

Figure 3. Interface of Game 2. Cultural Exploration

Testing

In the testing stage, the application prototype was tested with potential users from partner schools at IT Del as part of the application trial and evaluation process. Through this activity, feedback was gathered from potential users to inform improvements and quality enhancements. The test results, in the form of a User Acceptance Test (UAT) questionnaire, were designed to evaluate user acceptance of the Batak cultural game prototype. The instrument used a Likert scale with five categories: Strongly Disagree, Disagree, Neutral, Agree, and Strongly Agree.

The next stage was to carry out a Spearman correlation test, as shown in Table 2. The correlation test was conducted on 30 respondents, the minimum required to run the test.

Table 2. Spearman correlation matrix between statements and total score (N = 30)

Variables	S1	S2	S3	S4	S5	S6	S7	S8	S9
S1	-								
S2	0.662**	-							
S3	0.862**	0.610**	-						
S4	0.675**	0.588**	0.722**	-					
S5	0.690**	0.489**	0.793**	0.847**	-				
S6	0.725**	0.579**	0.838**	0.733**	0.838**	-			
S7	0.541**	0.444*	0.684**	0.767**	0.805**	0.838**	-		
S8	0.511**	0.306	0.644**	0.652**	0.692**	0.779**	0.846**	-	
S9	0.438*	0.236	0.576**	0.648**	0.734**	0.761**	0.886**	0.971**	-
Total	0.814**	0.678**	0.898**	0.842**	0.904**	0.926**	0.862**	0.793**	0.768**

**Correlation is significant at the 0.05 level (2-tailed).*
***Correlation is significant at the 0.01 level (2-tailed).*

From the data tested using Spearman's correlation, it can be concluded that the user testing questionnaire shows a significant correlation. The instrument used SPSS 22.0 with the data obtained. All the statements (in column Total) had values greater than 0.05 (for example, Statement 1, with a total value of 0.814,> 0.05), indicating that all the variables have a significant correlation. Based on the results of this research, the user testing instrument was declared significant for use.

The stacked bar chart (Figure 4) presents the results of user testing across nine evaluation statements during prototype testing. Statement 1 focused on the initial interface, where most respondents strongly agreed or agreed, indicating that the interface's first impression is visually appealing. Statements 2 and 3 focused on navigation and interaction, where most respondents found the system, including the navigation pane, easy to use and user-friendly. Statements 4, 5, and 6 addressed the content's relevance to the Batak Toba culture. The responses indicated that users perceive the local content of Toba presented in the prototype as appropriate and aligned with educational goals. Particularly for statement 6, related to the visual design with Batak cultural nuances, users gave one of the strongest positive responses, with 80% selecting "strongly agree," highlighting that the cultural elements are well integrated into the visual design. Similarly, statements 7 and 8 about the clarity of information and the user's learning experience show that users find the information in the prototype clear, concise, and challenging, in the sense of gaining new learning experience in a game format. The last statement is about the overall feasibility. This statement has the highest approval rating, with 93% choosing "Strongly Agree."

Nevertheless, the results also showed a small proportion of non-responses across several questions, which may indicate minor issues with question clarity or user comprehension. For example, in statement 4, even though most respondents selected 'Strongly agree' and 'agree' regarding the relevance of the content to the educational purpose, 7% still disagreed with this statement. This highlights the necessity of improving instructional clarity and aligning local content with the educational purpose set upfront. It is also necessary to further research on ensuring a more intuitive user experience in subsequent iterations.

GDLC-based Game Development with Local Content

The overall outcome of the GDLC implementation for game development with local content indicated that the game development has been successfully implemented. Each stage was conducted rigorously to maintain the validity of the research, from initialization to testing. The successful implementation was reflected in positive perceptions among the majority of respondents, particularly regarding the interface, navigation, interaction, cultural content, visual design, and clarity of information. Moreover, the design of the game types followed Sweller's cognitive load theory (Sweller, 1988), particularly the intrinsic cognitive load. To cater to individual cognitive differences (Sweller, 2024), the two games were designed as both individual and team-based. Nonetheless, further research is needed to investigate how far the local content provided in the application can improve students' knowledge of the Batak Toba subject, as this is the educational purpose and a main concern in the application's development.

User Needs and User Testing

As part of a crucial cycle in application development in human-computer interaction,

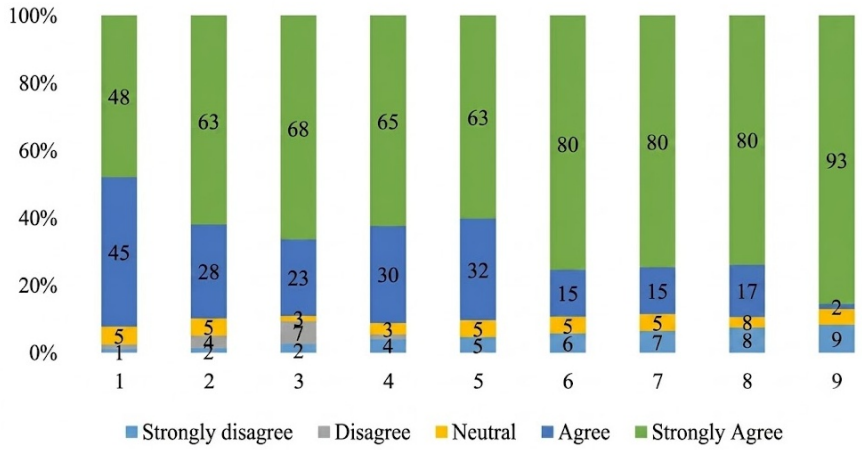

Figure 4. Result of user testing

user needs analysis is important for understanding the user's needs. This research showed that conducting a user needs analysis made application development more effective by identifying users' needs from the initial stages of development. The testing results show that the design meets the satisfactory levels of usability and content appropriateness from the users' perspective. This aligns with previous research that incorporated user needs analysis into the application development process (Lopes et al., 2018; Castro et al., 2008). However, system testing as part of the GDLC has not yet been completed, as the development is still in the prototype phase. Further research on system testing is necessary.

As for user testing, as suggested by Hamzah et al. (2025), it was a significant process in this research through which application validation was strengthened by rating several aspects, including usability, user experience, and content appropriateness, from the users' perspective. As shown in Figure 4, the application's initial interface, system and navigation pane, the relevance of the cultural content, and its feasibility received high scores.

■ CONCLUSION

Based on the research activities conducted throughout this study, several key conclusions emerge. First, the findings reaffirm that educational game applications hold substantial potential as innovative learning media for primary school students (Ahyati et al., 2024; Dafa et al., 2024; Krisdiawan & Darsanto, 2019; Nurdiana & Asmah, 2022; Sidik et al., 2024; Wildan & Rusdiyani, 2023). The proposed interactive features and engaging formats, as a result of UAT testing, make the application a suitable tool for supporting content learning. Second, integrating local cultural content, particularly Batak Toba culture, is effective in providing engaging, relevant, and concrete learning materials that enhance students' understanding and appreciation of their cultural heritage. Third, responses from potential users, based on survey analysis, focus group discussions, and application prototype testing, indicate a strong positive reception of the educational game prototype. This indicates that both its usability and its potential to be well accepted in real classroom settings. Finally, the research activities outlined in the initial plan, which used the GDLC method, have been successfully executed. This suggests the feasibility of the development process and the establishment of a strong foundation for further stages of implementation and system testing.

This research will continue to explore other potential topics relevant to the research theme. One focus for future research will be integrating the application into classroom learning, specifically investigating how far the local content provided in the application can improve students' knowledge of the Batak Toba subject. Further discussion on system testing as part of the GDLC will also be incorporated for future research.

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■ DECLARATION OF GENERATIVE AI USAGE

The authors declare that this manuscript was prepared without the use of generative AI technologies or automated text-producing tools for idea generation. All ideas, narrative structure, arguments, and scientific

explanations were developed solely by the authors.

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