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# Template matching-based mobile learning application for effective lampung script writing practice

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**ABSTRACT**

Preserving the traditional Lampung script is crucial for maintaining local cultural identity amid globalization. This study develops an interactive mobile learning application to engage students in studying the Lampung script. The application aids in learning characters and writing methods through features like pronunciation audio, practice questions, and writing exercises. Using the template matching method, the writing exercise feature provides accurate feedback, helping students identify and correct mistakes. Research involved eighth-grade junior high students and local language teachers as informants. Application testing utilized Blackbox Testing to evaluate functionality and template matching accuracy, yielding satisfactory results in handwriting recognition. User feedback indicated positive reception: 95% of students found the application interactive, 90% deemed it interesting, and 100% reported it supported their learning of the Lampung script. Furthermore, 98% expressed interest in using the application in school activities. This mobile application effectively enhances student interest and motivation to learn the traditional Lampung script, contributing to the preservation of local culture through education.



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## 1. INTRODUCTION

The preservation and teaching of traditional scripts to younger generations are essential steps in maintaining cultural identity and local heritage. In the era of globalization, which increasingly threatens the existence of local cultures, traditional script education plays a significant role in fostering pride in local identity among younger generations. An understanding of regional culture, including traditional scripts, is key to nurturing pride in one's identity (Fadli & Afwan, 2024).

Preserving traditional scripts also reinforces national values and multiculturalism. In a diverse society, teaching local scripts can enhance awareness of cultural diversity and the importance of mutual respect across cultures (Supriyadi et al., 2023). Integrating traditional script learning into the educational curriculum allows young people to gain a deeper understanding of their own identities and of the importance of collaboration and tolerance in a multicultural society.

Efforts to preserve traditional scripts are closely tied to preventing the loss of local wisdom. Artistic and cultural development initiatives are part of government and artist-led efforts to protect cultural heritage (Bulan, 2019). Teaching the Lampung script not only helps the younger generation learn reading and writing skills but also enables them to understand the values and philosophies embedded in the culture. This aligns with research showing that culture-based education can enhance a sense of ownership and responsibility for preserving cultural heritage (Rahmawati et al., 2021). Through local script instruction, communities—especially young people—can better understand and appreciate their culture, fostering general literacy (Baeti et al., 2021). Therefore,

Lampung script education can be integrated as part of a broader educational program aimed at improving educational quality and literacy in the region.

Learning traditional scripts, particularly the Lampung script, faces several challenges. One major challenge is students' low interest and motivation in studying the script. This is often linked to a lack of understanding of the Lampung script's importance in cultural and local identity contexts. Student motivation is significantly influenced by varied teaching methods, such as using games and rewarding high-performing students (Yussof et al., 2021). Without engaging teaching approaches, students tend to lose interest in learning traditional scripts.

Moreover, learning difficulties present a substantial barrier to Lampung script instruction. Learning difficulties may arise when students struggle to meet the demands of instruction, often due to a mismatch between student abilities and the instructional material (Munirah, 2018). In learning the Lampung script, the complexity of the script's forms and its differences from more commonly used writing systems, such as the Latin alphabet, can increase the level of difficulty for students. Thus, it is crucial for educators to conduct early diagnoses of students' learning difficulties to apply appropriate interventions (Defriyanto & Dermawan, 2018).

Another factor affecting Lampung script learning is the limited resources and instructional media available. The use of engaging media, such as technology-based applications, can increase students' motivation to learn (Nama et al., 2019). However, there are currently few applications designed specifically for Lampung script learning, reducing accessibility and interactivity in the learning process. Therefore, innovation in developing relevant and engaging instructional media is needed to attract the interest of younger generations (Nama et al., 2019).

Advances in technology and digital media have significantly impacted traditional language and script education. One major impact is the increase in accessibility and ease of the learning process (Damayanti & Nuzuli, 2023). With e-learning and digital platforms, students can now access learning materials anytime and anywhere. E-learning has become a trend in education, offering greater flexibility and interactivity in teaching (Apriadi & Afiarini, 2023). This is especially important for traditional script learning, which often falls outside the formal curriculum.

Furthermore, technology enables the development of more engaging and interactive instructional media. Rapid advances in educational technology have introduced various new tools and media that facilitate the learning process (Maritsa et al., 2021). The use of mobile applications or educational games can spark students' interest in studying traditional scripts, helping them master the script in a more engaging and enjoyable way. Interactive and enjoyable learning methods have been proven to improve student learning outcomes and can be designed more dynamically through educational games and visually appealing media for younger generations (Sholeh et al., 2023).

Developing educational games can be an effective solution to increase interest in learning the Lampung script, particularly among younger generations. Educational games offer an interactive and enjoyable approach that captures students' attention and boosts their engagement in the learning process. Educational games are designed to teach concepts in an enjoyable manner, thereby encouraging students' motivation and interest in learning (Borman & Purwanto, 2019). Through game elements, students can learn the Lampung script in a more captivating and less monotonous way.

Additionally, educational games can incorporate various learning methods tailored to students' learning styles. For instance, games that use visual, auditory, and kinesthetic approaches can provide a more holistic understanding of the Lampung script. Using educational games that support diverse learning styles enhances students' enjoyment and interest in learning (Borman & Erma, 2018). Thus, educational games specifically designed for Lampung script instruction can offer a more effective and enjoyable learning experience.

Educational games also have the advantage of facilitating independent learning. With mobile device access, students can study the Lampung script anytime and anywhere. Educational games function as interactive learning media, encouraging students to learn independently and more actively (Nurchim & Purwanto, 2023). With this approach, students are not limited to classroom learning but can also continue learning outside the classroom in an enjoyable way.

This study was conducted to develop a mobile-based educational game for traditional Lampung script learning. The instruction focuses on practicing Lampung script writing, with rapid feedback provided through the template matching method.

Template matching is a technique used in image processing and pattern recognition. This technique scans the image to locate the area that best matches the template based on a certain degree of similarity (Lanjewar et al., 2023; Zhu et al., 2019). Its purpose is to identify the most similar area in the input image by comparing it to the template. Template matching has been widely applied across various fields, such as facial recognition, object detection, and medical applications (Alhalalmeh et al., 2023).

One interesting application of template matching is in digit recognition. This method compares input digit images with stored digit templates in a database by calculating the matching points between the input image and the template, enabling effective digit recognition (Kusuma & Darmanto, 2016). Therefore, template matching can be applied in developing applications that assist students in learning digit recognition.

With technological advancements, template matching has also become useful for detecting circular-shaped objects. Research by Li and Li utilized a circular template to detect and count overlapping circular objects, with potential applications in industries such as manufacturing and materials processing (Li & Li, 2012). This illustrates the versatility of template matching in various tasks, including quantitative analysis.

Template matching can also be effectively applied to the recognition and learning of traditional scripts, including the Lampung script, by using image processing techniques to detect characters from captured images, such as handwritten characters. Through this method, the system can identify characters written by students, providing feedback on their accuracy or areas for improvement. Thus, template matching can be integrated into interactive learning applications, such as mobile applications.

Template matching offers several advantages over other methods for script learning, particularly within educational game contexts. Unlike methods like K-Nearest Neighbor (K-NN), which require more complex training processes and larger datasets (Istiqphara et al., 2023), template matching can be used directly with existing templates, making it a more efficient choice for educational games that demand quick responses. The ease of implementation is also a significant advantage. Template matching is relatively simple, easy to integrate into applications, and does not require deep knowledge of complex machine learning algorithms.

Technology-based learning has been widely shown to be as effective as, and in some cases even more effective than, conventional teaching methods led by human instructors (Zhao, 2013). One pertinent study by Imron focused on developing instructional materials for teaching the Lampung script to elementary students. This research underscores the importance of introducing the Lampung script into local curricula to enhance students' communication skills and foster a deeper appreciation of their cultural heritage. Supported by technology, such as digital learning applications, students are able to more easily engage with and master the Lampung script (Imron, 2021).

Another study examined the use of template matching in the recognition of Javanese characters. This approach involves comparing a template image with test images following preprocessing and segmentation stages. The findings indicated that template matching is an effective pattern-recognition method, particularly suited for traditional script recognition, allowing students to more accurately identify and reproduce characters (Katili et al., 2018).

Further, incorporating technology into educational practices has shown benefits in increasing student engagement, improving learning outcomes, and providing more personalized and immediate feedback (Alhalalmeh et al., 2023). One example is the educational game Azbuka, developed by Duh et al., which helps children learn to write Cyrillic letters. The study demonstrated that game-based learning enhances traditional writing skills through an interactive, enjoyable experience (Duh et al., 2016).

Collectively, these studies highlight the effectiveness of integrating educational games with pattern-matching techniques for letter recognition, including for traditional scripts like the Lampung script. By employing technology and thoughtfully designed game elements, students can engage in a more dynamic, interactive, and enjoyable learning experience.

## 2. RESEARCH METHOD

This study employs a Research and Development (R&D) approach, utilizing the Waterfall model for structured and systematic software development. The Waterfall model was selected due to its clear, step-by-step framework, which includes requirements analysis, design, implementation,

testing, and maintenance. The primary objective of this research is to develop an Android-based educational game aimed at assisting eighth-grade junior high school students in learning the Lampung script. The game development involves the use of Java programming language and SQLite as a local database to store necessary learning data within the game.

The research subjects are eighth-grade students from a junior high school in Lampung Province, chosen as this age group is typically introduced to regional scripts as part of their curriculum. Additionally, the school's language teachers are included as key informants, providing insights into teaching methods and feedback on integrating technology into script learning. Data collection was conducted through interviews and classroom observations. Interviews with language teachers were used to identify challenges in teaching the Lampung script and their expectations for game-based learning media. Observations of classroom sessions provided insights into how the Lampung script is taught and the obstacles students face.

The developed educational game includes three main features: Lampung script materials, writing practice, and multiple-choice quizzes. The script materials feature displays images of characters, pronunciation guides, and audio to help students master correct pronunciation. The writing practice feature, which uses a template matching method, allows students to practice writing Lampung characters, with the system comparing their input to predefined templates to check accuracy. The final feature, multiple-choice quizzes, is designed to assess students' understanding after they study and practice the characters.

The development process follows the stages of the Waterfall model, beginning with requirements analysis to identify user needs, including desired features from both students and teachers. Next, system design encompasses user interface layouts, gameplay structure, and data structures to support learning. The implementation phase involves programming the game in Java according to the design specifications. Upon completion, testing ensures that the game functions properly, followed by maintenance or improvements based on user feedback.

Testing in this study comprises three main types. Functional testing uses Blackbox Testing to ensure each feature operates according to specifications, such as sound playback, script validation, and quiz functionality. Black-box testing disregards the internal workings of a system, concentrating only on the outputs produced in response to specific inputs and execution scenarios. In this approach, the code is treated as a large black box, with the tester having no access to the system's internal details. The tester identifies the inputs provided to the black box and evaluates the outcomes observed during execution (Naik & Tripathy, 2008). In this way, all functions in the application can be ensured to run well according to the desired criteria, so that the reliability of the application can be guaranteed. Accuracy testing for template matching was conducted using five test samples for each of the 20 Lampung characters, totaling 100 data samples, to evaluate the system's ability to recognize student input and provide accurate feedback. User acceptance testing involved teachers and students, who evaluated the game's interactivity, appeal, and effectiveness in enhancing the learning process.

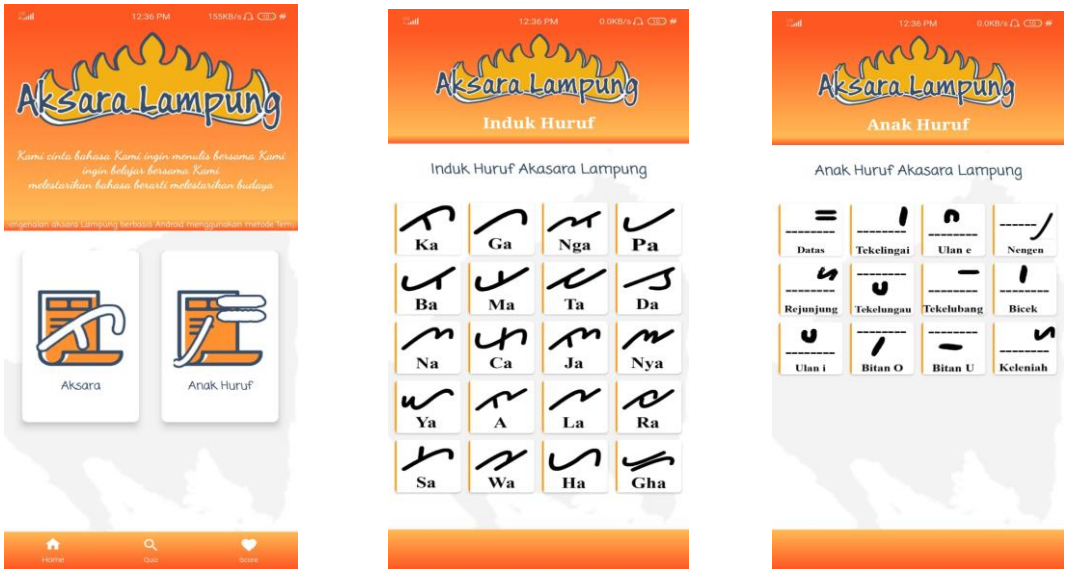
Data collected from interviews and observations were analyzed qualitatively to identify key themes regarding the application of technology in teaching the Lampung script. Functional testing and template matching accuracy results were analyzed quantitatively to assess technical aspects of the game. User acceptance was evaluated using a Likert scale to gauge satisfaction and the game's effectiveness from the perspectives of both students and teachers.

## 3. RESULTS AND DISCUSSIONS

This Lampung traditional script learning application is designed to assist students in learning the characters and sub-characters of the Lampung script through several interactive features such as script materials, quizzes, and writing exercises. Below is an explanation of the interaction flow between the user and the application system: a) Launching the Application, the process begins when the user presses the "Start Application" button. The system then displays a splash screen as the initial display before moving to the next page; b) Displaying the Main Menu, after the splash screen, the system takes the user to the main menu page, where various feature options are available. The user can select one of the menu options to proceed; c) Selecting the Lampung Script Menu, if the user selects the Lampung Script menu, the system displays a list of Lampung characters. When the user selects a character, the application shows detailed information about the selected character, including an audio guide for pronunciation; d) Selecting the Sub-Characters Menu, if the user selects the Sub-Character menu, the system displays a list of Lampung sub-

characters. Each time the user selects a sub-character, the system displays detailed information along with the audio pronunciation; e) Selecting the Quiz Menu, when the user selects the Quiz menu, the system begins a practice session by displaying questions related to the Lampung script. The user will answer a series of questions, with the total number exceeding ten questions. Once all the questions are answered, the system will display the results of the practice session; f) Selecting the Writing Practice Menu, in this menu, the user is given a canvas and example writing as a guide to practice writing Lampung characters. After the user finishes writing, the system displays the results of the writing exercise; g) Selecting the History Menu, the History menu allows the system to display the user's past quiz and writing practice results. This feature enables users to monitor their learning progress; h) Selecting the Exit Menu, if the user selects the Exit menu, the system closes the application, and the learning process concludes.

The interaction flow of the application provides a structured, engaging way for students to learn and practice the Lampung script. The design of the application aims to combine educational content with interactive features that enhance the learning experience. The features such as quizzes, writing practice, and history tracking ensure that students receive timely feedback and can track their progress effectively, which is essential for effective learning.



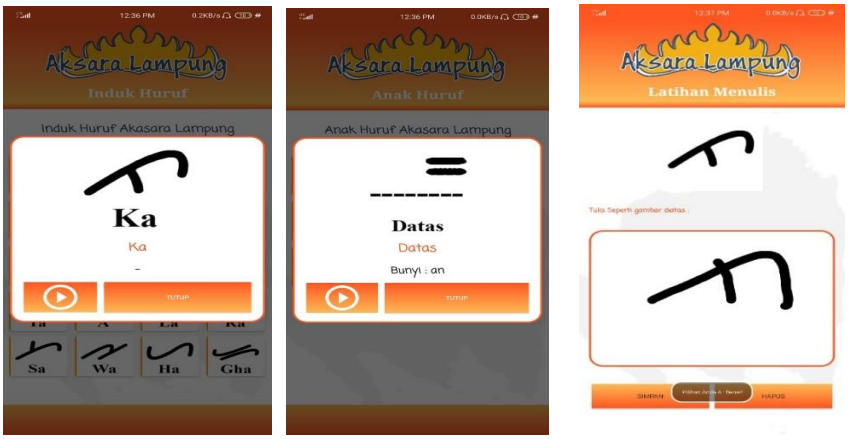

(a) (b) (c)

**Figure 1.** (a) Main Menu; (b) Lampung Script Menu; (c) Sub-character Menu

The application integrates audio recordings to present the sounds of both the main characters and sub-characters of the Lampung script, which are featured in the Lampung script learning module. The audio files are sourced from recordings created by a collaborator of the author, with direct guidance from a Lampung language teacher at SMP Negeri 2 Kotagajah. This ensures that the spelling and pronunciation used in the application align with accurate and clear linguistic standards.

The primary objective of incorporating audio is to aid users in hearing and understanding the correct pronunciation of each character and sub-character in the Lampung script. The audio files are stored in the raw folder in .m4a format, with a total of 32 files—comprising 20 for the main characters and 12 for the sub-characters.

By incorporating these audio elements, the application enhances the learning experience by facilitating better recognition and pronunciation of the Lampung script, offering students a more comprehensive and engaging educational tool.




(a) (b)

**Figure 2.** (a) Audio implementation; (b) Writing practice

The system design for recognizing the Lampung script through the template matching method involves several key steps: a) Input Process, the user's handwritten input is converted into a 3D bitmap image and stored in the application directory. This step ensures that the image is ready for further processing; b) Grayscale Process, the image is then transformed into grayscale by averaging the values of the three color components (red, green, and blue) for each pixel. The resulting image will be in shades of gray, which simplifies the subsequent image processing steps; c) Binarization Process, the grayscale image is converted into a binary image (black-and-white) using thresholding. Pixels with a value less than 128 are set to 0 (black), while pixels greater than 128 are set to 1 (white). This step helps in distinguishing the character from the background, making it easier for the system to process; d) Template Matching Process, in this stage, the system calculates the difference between the input image and the available template images from the training data to find the best match. Template matching is used to compare the user's handwriting against predefined templates and identify the closest match.

These processes ensure that the character recognition system works accurately and efficiently using the template matching method. For each Lampung script character, five template images are used as training data for the matching process. These templates are created by manually writing the characters within the application and saving them as image files. The following table shows the template images used in the process.

**Table 1.** Character template images

| Letter | Template 1 | Template 2 | Template 3 | Template 4 | Template 5 |
|---|---|---|---|---|---|
| KA |  |  |  |  |  |
| GA |  |  |  |  |  |
| NGA |  |  |  |  |  |
| PA |  |  |  |  |  |
| BA |  |  |  |  |  |
| MA |  |  |  |  |  |
| TA |  |  |  |  |  |
| DA |  |  |  |  |  |
| NA |  |  |  |  |  |

| Letter | Template 1 | Template 2 | Template 3 | Template 4 | Template 5 |
|---|---|---|---|---|---|
| CA |  |  |  |  |  |
| JA |  |  |  |  |  |
| NYA |  |  |  |  |  |
| YA |  |  |  |  |  |
| A |  |  |  |  |  |
| LA |  |  |  |  |  |
| RA |  |  |  |  |  |
| SA |  |  |  |  |  |
| WA |  |  |  |  |  |
| HA |  |  |  |  |  |
| GHA |  |  |  |  |  |

The questions used in the Quiz feature were provided by a Lampung language teacher from SMP Negeri 2 Kotagajah. The application includes a total of 20 practice questions, which are displayed randomly to enhance the learning experience. This randomized approach ensures that each session offers a unique set of questions, helping users to engage more deeply with the material and gain a comprehensive understanding of the Lampung script. The table below lists the specific questions included in the application.

**Table 2.** Quiz questions

| Image | Question | Multiple Choices | Correct Answer |
|---|---|---|---|
|  | What does the letter above read? | - Ka<br>- A<br>- Ba<br>- Ra | Ka |
|  | What does the letter above read? | - Ca<br>- Ma<br>- Ga<br>- Kha | Ga |
|  | What does the letter above read? | - Ka<br>- A<br>- La<br>- Nga | Nga |
|  | What does the letter above read? | - La<br>- Pa<br>- Sa<br>- Nya | Pa |
|  | What does the letter above read? | - Ga<br>- Ma<br>- Ta<br>- Gha | Ba |
|  | What does the letter above read? | - Ra<br>- Ma<br>- Da<br>- Ta | Ma |

| Image | Question | Multiple Choices | Correct Answer |
|---|---|---|---|
|  | What does the letter above read? | - Sa<br>- Ma<br>- Ba<br>- Ta | Ta |
|  | What does the letter above read? | - Wa<br>- Ja<br>- Ba<br>- Nya | Da |
|  | What does the letter above read? | - A<br>- Na<br>- Ba<br>- Ca | Na |
|  | What does the letter above read? | - Ta<br>- Ya<br>- Ca<br>- La | Ca |
|  | What does the letter above read? | - Ja<br>- Nya<br>- Ya<br>- A | Ja |
|  | What does the letter above read? | - Pa<br>- Ma<br>- Nya<br>- Ka | Nya |
|  | What does the letter above read? | - Ya<br>- Sa<br>- Wa<br>- Gha | Ya |
|  | What does the letter above read? | - Ka<br>- A<br>- Ba<br>- Kha | A |
|  | What does the letter above read? | - Ka<br>- Ma<br>- La<br>- Kha | La |
|  | What does the letter above read? | - Ra<br>- Ma<br>- Ba<br>- Kha | Ra |
|  | What does the letter above read? | - Ka<br>- Ma<br>- A<br>- Sa | Sa |
|  | What does the letter above read? | - Ka<br>- Ma<br>- Ba<br>- Wa | Wa |
|  | What does the letter above read? | - Ha<br>- Ma<br>- Ba<br>- Kha | Ha |
|  | What does the letter above read? | - Ka<br>- Ma<br>- Ba<br>- Gha | Gha |

Functional testing was conducted using the Blackbox Testing method, yielding positive results as all features performed as expected. Following this, the accuracy of the template matching method within the writing practice feature was tested.

Steps for Template Matching Accuracy Calculation: a) Input Preprocessing: Both the input image and template (reference image) were processed into a uniform format, such as grayscale and binary conversion, b) Difference Measurement (Similarity Matching): Each pixel in the input image was compared to the corresponding pixel in the template, Differences were calculated for each pixel, with matches (identical values) counted; c) Total Matches: The number of matching pixels between the input image and the template was recorded; d) Accuracy Calculation: Accuracy

was determined by comparing the number of matching pixels to the total pixels in the image, using the following formula: Accuracy = (Σmatches / Σtotalpixels) * 100%, Where: Σmatches = Total matching pixels between input and template, Σtotalpixels = Total number of pixels in the template; d) Threshold: An 80% match threshold was set as the accuracy standard for correct identification.

The accuracy test results confirmed that 5 training data samples for each Lampung character functioned effectively as writing templates, eliminating the need for additional templates.

User testing involved 20 students and 1 teacher, with evaluations on interactivity, appeal, and the educational value of the game conducted through a questionnaire. A Likert scale measured user satisfaction. Feedback from the teacher indicated that the game was sufficiently interactive, engaging, and suitable for Lampung language instruction in school. The student feedback yielded the following results: 95% agreed the game was interactive, 90% found it engaging, and 100% felt it helped in learning traditional Lampung script. Additionally, 98% of students expressed interest in using the game as a learning tool for traditional Lampung script at school.

This study demonstrates that digital technology-based learning applications hold significant potential for preserving regional languages, specifically the Lampung script, through engaging, interactive approaches appealing to younger generations. This aligns with prior findings, which suggest digital technology can be an effective medium for reintroducing regional languages and scripts to the younger demographic (Desiyanto, 2023; Hairah et al., 2023; Munawaroh et al., 2022; Pattawari et al., 2023).

Additionally, this study found that interactive elements in games, such as audiovisual aids and quizzes, offer a more comprehensive learning experience. Implementing audio as pronunciation guidance for the Lampung script proved beneficial for users in mastering proper pronunciation. This finding is consistent with previous research showing that audiovisual integration in language learning can enhance user comprehension and engagement (Ernanida & Yusra, 2019; Naser, 2022).

Interactivity is further supported by the inclusion of multiple-choice questions and writing exercises that provide automatic feedback on user responses. Testing results indicated that students benefited from immediate feedback provided by the application, reinforcing previous studies that underscore the importance of system-user feedback in computer-based learning (Liao et al., 2024).

The template matching method employed in this application demonstrated promising results for recognizing Lampung script handwriting with high accuracy, in line with prior studies on pattern or script recognition (Katili et al., 2018; Lanjewar et al., 2023). Template matching is widely used in pattern recognition research due to its effectiveness in pixel matching between input and templates, even with variable handwriting (Dutta et al., 2012; Riadi et al., 2021).

This research underscores that template matching provides fast and accurate feedback, helping users identify writing errors, aligning with previous studies highlighting template matching's reliability in educational media, particularly in applications requiring real-time feedback (Alhalalmeh et al., 2023).

The findings also support the view that interactive learning media can enhance student motivation and engagement. This is corroborated by numerous studies indicating that interactive educational media can motivate students to be more actively involved in learning in an enjoyable way (Aini & Wijaya, 2022; Nurchim & Purwanto, 2023).

## 4. CONCLUSION

In efforts to preserve and teach the Lampung script to younger generations, using template matching within an educational game has proven effective. This method not only boosts student interest and motivation but also provides quick and interactive feedback in the learning process of writing the script. With a fun and interactive approach, this educational game aids students in gaining a deeper understanding of the Lampung script. The government has integrated Lampung script learning into the curriculum of schools in Lampung Province, to teach the script as part of language and culture learning. By offering a digital platform, the application makes the Lampung script more accessible to a broader audience, including younger generations and those who may not have access to formal education or traditional resources.

This research shows that integrating technology, especially in mobile applications, allows for easier and more flexible access for students to learn traditional scripts. By combining visual

elements, audio, and quizzes, the educational game enhances student engagement, reinforces their understanding of the script, and supports the preservation of local culture.

Testing results indicated that both students and teachers responded positively to the interactivity and appeal of the game. Therefore, further development of this application can serve as a strategic step in ensuring that the Lampung script remains relevant and is taught in an engaging way for future generations.

This study has several limitations. First, testing was conducted only with eighth-grade students at one school, so the results may not represent different levels of understanding across schools or age groups. Second, although template matching was effective for recognizing Lampung script, it has limitations in sensitivity to more complex handwriting variations, which could affect recognition accuracy. Third, the application does not include tiered or personalized learning features that could adapt to individual student abilities, which could enhance learning effectiveness. Lastly, this study does not address long-term sustainability aspects, such as potential declines in student interest with prolonged use. These limitations present opportunities for further research in developing more effective and inclusive traditional script learning media.

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