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ORIGINAL

Designing an android-based learning media for javanese script: a study on student's conceptual understanding and literacy skills

Diseño de un medio de aprendizaje basado en android para escritura javanesa: un estudio sobre la comprensión conceptual y las habilidades de alfabetización de los estudiantes

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ABSTRACT

Introduction: javanese script is a traditional writing system with a rich history and philosophy, and it is one of the most endangered forms of cultural heritage. This study aims to determine the effect of understanding the concept of the Javanese script on the literacy skills of students interested in Android-based learning media.
Methods: this study uses a mixed-methods approach with quantitative and qualitative analysis stages. A sample of 286 students was selected using purposive random sampling. Quantitative data were obtained by administering student questionnaires, while qualitative data were obtained through observation, interviews and documentation. Quantitative data were analyzed using SEM-PLS. Qualitative data analysis was conducted using triangulation of data and sources.
Results: the results of the path coefficient calculation show an effect of 0,341, with a t-count of 6,646, and a p-value of 0,000. Understanding the concept of Javanese script influences interest in Android-based media. The path coefficient obtained from the calculation was 0,486, with a t-count of 8,250, and a p-value of 0,000. The results show the influence of children's literacy skills on interest in Android-based media.
Conclusions: javaScript learning media based on Android can increase interest in and understanding of the concept of JavaScript. Further research is recommended, with a wider and more diverse sample of participants from different schools and backgrounds, to make the results more generalizable.

Keywords: Android-Based Learning; Media; English Script; Literacy Skills; Educational Technology; Student Learning.

RESUMEN

Introducción: la escritura javanesa es un sistema de escritura tradicional rico en historia y filosofía y uno de los patrimonios culturales en peligro de extinción. Este estudio tiene como objetivo determinar el efecto de comprender el concepto de escritura javanesa y las habilidades de alfabetización de los estudiantes interesados en los medios de aprendizaje basados en Android.

Metodo: este estudio utiliza un método Mixto con etapas de análisis cuantitativo y cualitativo. La muestra fue de 286 mediante muestreo aleatorio intencional. Los datos cuantitativos se obtuvieron mediante el llenado de cuestionarios de los estudiantes y los cualitativos mediante observación, entrevistas y documentación. El análisis cuantitativo de los datos se realizó mediante análisis SEM-PLS. El análisis cualitativo de datos se realiza mediante triangulación de datos y fuentes.
Resultados: los resultados del cálculo del coeficiente de trayectoria muestran el efecto de 0,341, con t-count 6,646, y p-value 0,000. Existe una influencia de la comprensión del concepto de escritura javanesa en el interés por los medios basados en Android. Coeficiente de trayectoria obtenido a partir del cálculo de 0,486 con t-count 8,250, y p-value 0,000. Los resultados obtenidos por la influencia de las habilidades de alfabetización de los niños en el interés por los medios basados en Android.
Conclusiones: los medios de aprendizaje de Java Script basados en Android pueden aumentar el interés y la comprensión del concepto de Java Script. se recomienda realizar más investigaciones para realizar investigaciones con una muestra más amplia y diversa, tanto del nivel escolar como de los antecedentes de los estudiantes, de modo que los resultados sean más generales.

Palabras clave: Aprendizaje Basado en Android; Escritura en Inglés Mediático; Habilidades de Alfabetización; Tecnología Educativa; Aprendizaje de los Estudiantes.

INTRODUCTION

In the digital age, learning has undergone significant changes, with technology becoming the main medium for delivering knowledge, as well as an auxiliary tool. Integrating technology into education creates opportunities to improve the quality of learning, particularly with regard to the relevance, accessibility and personalisation of the learning experience.[1,2] However, alongside these advances, there are major challenges in preserving local cultural heritage, including the Javanese Hanacaraka script, which is an important part of the Javanese people's cultural identity. Although it is included in the formal curriculum, students' interest in and ability to read and write the script has decreased due to conventional, repetitive learning methods that are less engaging for the digital generation.

Previous studies have shown that students find learning the script boring and difficult because the approach tends to be rote with minimal interaction.[3,4] Contemporary pedagogical literature emphasises that technology-based learning, particularly interactive digital media and mobile app-based learning, can improve student motivation, participation and learning outcomes.[5,7] Gamification,[8] simulation and approaches based on automatic feedback have been shown to be effective in learning complex visual-linguistic skills such as traditional scripts, calligraphy and non-Latin alphabets.[9,10] Therefore, interactive and gamified mobile learning is theoretically and empirically justified as an effective pedagogical solution for revitalising Javanese script learning.[11,12]

However, a critical review of Java Script applications shows that most focus on technical aspects of software development rather than pedagogical, theory-based learning design or empirical evaluation of their impact on students' literacy skills. These limitations arise from the absence of a user-centred design approach and the lack of integration of cognitive theories, such as dual coding, constructivist learning and scaffolding. There is also a lack of experimental research that tests the effectiveness of applications in measurably improving the ability to read and write Javanese script. Additionally, the evaluation of existing applications is generally more descriptive, failing to employ quantitative or mixed-methods research designs to assess motivational, cognitive and performative aspects of learning.

This study addresses these gaps by developing an Android-based Java Script learning application that integrates interactivity, gamification and cognitive theory-based learning.[13] It also evaluates the application empirically using a pre-test, post-test, control group design. This study not only focuses on the design process, but also tests the effectiveness of the application in terms of student motivation, conceptual understanding, and literacy skills. Thus, this study differs from previous studies in terms of research methodology, media design, pedagogical approach and evaluation model. [14,15]

The urgency of this study lies in the need to preserve cultural heritage through learning approaches relevant to the digital generation. As well as contributing to the innovation of Java script learning media, this study provides added value in the form of an empirical evaluation model that can be replicated by other researchers and educational institutions wishing to develop technology-based learning media for traditional scripts or other visual linguistic materials. Gap analysis there is currently no research that simultaneously develops and evaluates the effectiveness of Android-based Java script learning applications which integrate gamification design, a cognitive learning theoretical basis and the empirical testing of students' literacy skills through a controlled experimental design.

In line with the identified problems and research gaps, this study aims to develop an interactive, Android-based Java script learning application that applies gamification elements in accordance with modern pedagogical principles. Alongside product development, the study will test the application's effectiveness in enhancing student motivation and evaluate its impact on understanding, reading and writing Javanese script using an empirical approach. Furthermore, the study will produce a mobile learning implementation model that is relevant to the characteristics of the digital generation and contributes to the preservation of regional languages and scripts through a technology-based educational approach.

METHOD

Research Design

This study employs a mixed-methods approach, combining complementary quantitative and qualitative analyses to gain a more comprehensive understanding of the effectiveness of Android-based learning media in improving understanding of Javanese script and literacy, and in fostering student interest.[16,17] The study was designed using a correlational-predictive approach in accordance with the Structural Equation Modelling-Partial Least Squares (SEM-PLS) analysis, which was used to test the relationships between the variables. Therefore, while this study is not experimental, it aims to predict the relationship between constructs based on participants' responses to using the application.

Participants and sampling

The sample consisted of 286 Year 4 students from public and private elementary schools in Central Java. The sampling technique used was purposive, not purposive random (an oxymoronic term). This technique was chosen to ensure balanced representation of public and private schools, as well as balanced representation of participants' access to Android-based devices.

Table 1. Characteristics of the study participants

Demographic Variables	Categories	Frequency	Percentage
Age	9-11 years old	286	100 %
Gender	Male / Female	177	63 %
Types Of Schools	State / Private	103	37 %
Previous experience using Java Script media	Yes / No	112	40 %

Research instruments

The main instrument for collecting quantitative data uses a Likert scale questionnaire with a 1–5 response option. This was developed based on four latent constructs: understanding the concept of Javanese script; literacy skills; love and attitude towards local culture; and interest in Android-based learning. The instrument underwent a reliability test and achieved a Cronbach's alpha value of 0,70 for the entire construct, indicating a high level of internal consistency. Additionally, construct validity was analysed using Confirmatory Factor Analysis (CFA), with results showing that all indicators met the loading factor criterion of ≥0,50 and the Average Variance Extracted (AVE) criterion of ≥0,50, thus declaring the construct valid. The complete questionnaire is included in the appendix as additional research material.

Development of Android-Based Learning Media

This study examined the development of Android-based learning media as an independent variable, referencing Mayer's Multimedia Learning Theory and the principle of gamification (rewards, levels, avatars and points) to enhance student motivation. The application contains Javanese script material, as well as reading and writing exercises, interactive quizzes and multilevel challenges. Main features include icon-based navigation, audio and animation-enhanced modules, live feedback and a progress tracker. Cultural elements such as batik, wayang and gamelan are also incorporated into the interface. The application was developed using Android Studio (Kotlin) and Figma for interface design. The development process was carried out in stages through iterative design, with teachers and students involved in the alpha and beta testing stages. Screenshot documentation is included as an appendix to the study.

Research procedure

The four-week study consisted of three main stages. The first stage was an orientation and pre-assessment session, during which participants were introduced to the application and completed an initial questionnaire. The second stage involved the use of learning media, which was carried out three times per week for 30-45 minutes in a structured manner at school, with additional tasks accessible from home. The final stage involved post-assessment and the collection of qualitative data through follow-up questionnaires, observations, interviews and documentation. Qualitative data were analysed using triangulation of sources and methods to

ensure the validity and consistency of the findings.

Research Ethics

This study received ethical clearance from an authorised institutional ethics committee. Participation was fully voluntary, and informed consent was obtained from both students and their parents before data collection began. All research procedures were carried out in accordance with ethical guidelines to ensure confidentiality, anonymity and the responsible handling of participant data.

RESULTS

Data analysis showed that the five indicators of understanding the concept of Java script have an outer loading value between 0,848 and 0,893. As all values are above 0,7, the construct is valid. The average value of 0,760 exceeds 0,5, confirming that the construct of understanding the concept of Javanese script is valid. For the variables measuring children's literacy ability, the five indicators have an outer loading value between 0,706 and 0,788; all indicators meet the validity criteria with a loading factor above 0,7. The average value of 0,574 exceeds 0,5, confirming the validity of the construct of children's literacy ability. Meanwhile, the variable 'interest in Android-based media' consists of six indicators with outer loading values ranging from 0,730 to 0,831; all of these values are greater than 0,7, meaning that the construct is valid. The Ave value of 0,731, which is higher than 0,5, indicates that the construct of interest in Android-based media is valid. The value of the outer loading on each indicator can be seen in the path diagram below.

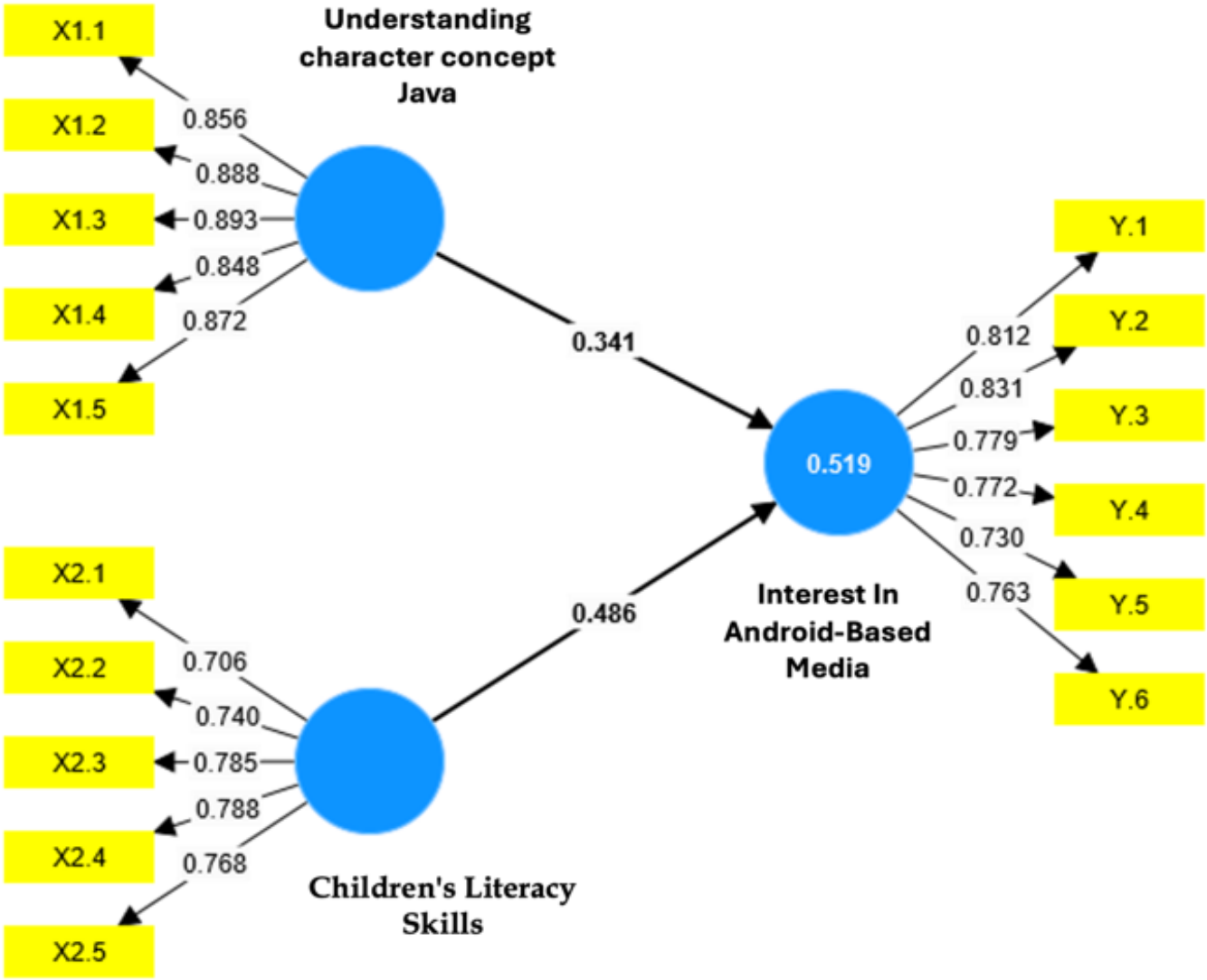

Figure 1. Outer Loading
Source: *Research results 2025*

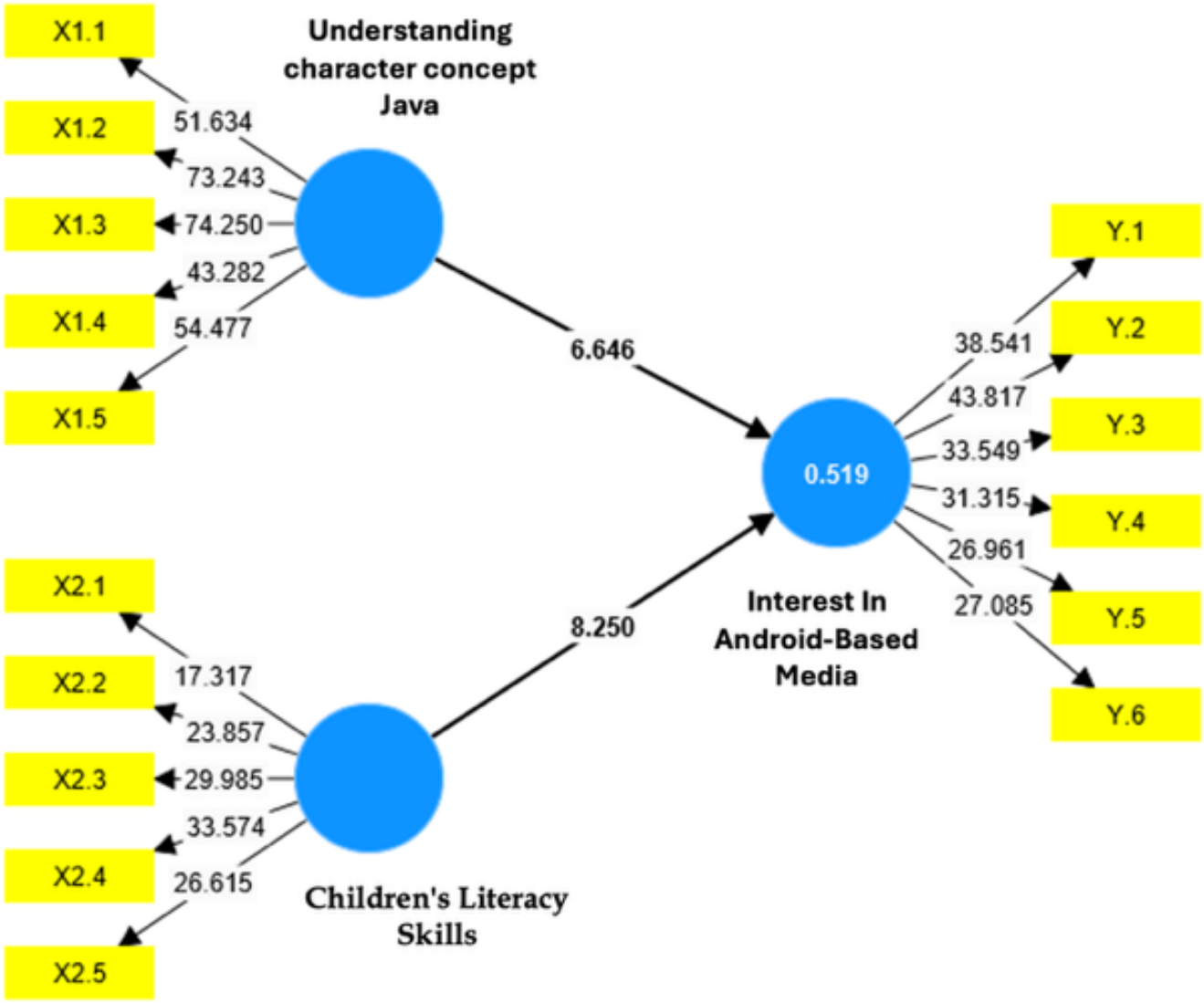

Figure 2. Inner Model
Source: Research results 2025

Having gone through the various stages of the previous analysis, the next step is to test the research hypothesis. This involves looking at the results of the SmartPLS calculations, which produce the path coefficient value, the t-count and the p-value, which are used as the basis for hypothesis testing. The t-statistic value is then used to determine whether the relationship between the variables is significant according to the established criteria.

Table 1. Hypothesis Testing

Hypothesis	*Path Coefficients*	t-count	p-*value*	Results
Children's literacy skills - > interest in android-based media	0,341	6,646	0,000	H1 supported
Understanding the concept of Javanese script - > interest in android-based media	0,486	8,250	0,000	H2 supported

The calculation of the path coefficient revealed an effect of 0,341, with a t-count of 6,646 and a p-value of 0,000. As the path coefficient is positive, the direction of influence is directly proportional: the better a child's literacy skills, the greater their interest in Android-based media. The t-value of 6,646 is greater than the critical value of 1,96, and the p-value of 0,000 is less than the significance level of 0,05, meaning that H1 is supported. The path coefficient obtained from the calculation was 0,486, with a t-count of 8,250 and a p-value of 0,000. This positive path coefficient indicates that a good understanding of the concept of Javanese script

increases interest in Android-based media. The t-value of 8,250 is greater than 1,96 and the p-value of 0,000 is less than 0,05, so H2 is supported. In conclusion, there is a significant effect of understanding the concept of Javanese script on interest in Android-based media.

Based on interviews with four students, it was found that Javanese script is introduced in the third year of primary school and taught gradually until the sixth year, with material in the fourth year focusing on clothing. However, the students claimed that they found it difficult to learn the Javanese script, especially because the shapes of the letters are considered similar, making them difficult to memorise. This has an impact on their ability to read Javanese script. The learning strategies used by students are generally limited to memorising the form of the script and using pepak as a reading guide. They are not directed towards a deeper understanding of the differences in the form of the script. Learning media are limited to LKS and pepaks, making learning monotonous and boring. Consequently, some students stated that they disliked learning Javanese script because they found it difficult.

Additionally, it was found that all students were interested in using mobile phones, primarily for entertainment purposes such as watching YouTube videos and playing games. However, some students use mobile phones to help with their homework, searching for information on the internet. This shows that mobile phones can serve not only as a means of entertainment, but also as a means of learning. When asked about the possibility of learning Java script using Android-based media, all the students were happy and interested because the media is similar to the games they often play on their mobile phones.

Interviews with three teachers revealed that students are generally less enthusiastic about learning the Java language. They tend to prefer Indonesian, which is considered more modern, meaning that Javanese is often neglected. The conventional teaching method involves providing examples of letters and their use in words or sentences. This approach encourages students to memorise the shape of the script, but it quickly causes boredom. The learning media used by teachers are still limited to worksheets, letter cards and posters, with no interactive digital media.

The interviews with teachers revealed that they believe the ideal learning media would help students to understand the form of the script and how to write it properly and correctly. They believe that Android-based media would facilitate the learning process as long as it is designed to be interactive. Teachers suggested that the media be developed with game features, problem exercises, multilevel activities and cultural elements, such as wayang figures, to make learning more fun and foster a love of Javanese culture. Overall, the interview results showed that learning Javanese script still faces obstacles in the form of students finding it difficult to memorise the script and having low motivation to learn, as well as limitations in the media used. However, both students and teachers responded positively to the idea of developing Android-based learning media. This confirms that interactive digital media incorporating game features, exercises and cultural content has great potential to boost students' interest in and understanding of Javanese script.

DISCUSSION

This study shows that students' literacy skills (β = 0,341; p = 0,000) and their conceptual understanding of Javanese script (β = 0,486; p = 0,000) have a significant positive effect on their interest in using Android-based learning media. This finding corroborates literature emphasising the role of technology in countering the waning interest among the younger generation in Javanese script, which is attributed to the unappealing nature of traditional methods.[18,19,20]The effectiveness of digital media depends not only on the format, but also on the pedagogical design that is relevant to children. Game-based media have been proven to improve early childhood literacy skills by 77 %.[21] This aligns with research emphasising the importance of integrating philosophical principles, active learning and critical thinking in digital educational media.[22,23,24]

The study confirms that Android-based learning media design requires a dual focus: it must be aesthetically appealing and support cognitive development and critical thinking skills.[25,26] Aesthetically pleasing interactive media can significantly increase student engagement,[27,28] but engagement stems from interaction with the content. These findings demand a shift from rote methods to interactive learning for educators. The use of digital media can address student disengagement while catering to different learning styles and academic outcomes.[29,30] The findings emphasise that a strong conceptual understanding increases student interest, enthusiasm and engagement.[31,32,33]

This study demonstrates that digital technology is an effective means of preserving intangible cultural heritage. The effectiveness of Android-based media supports the argument that government agencies and educational institutions should invest in developing easily accessible, relevant, well-designed digital resources. This approach can overcome cultural shifts that are making Javanese script and other regional languages increasingly less used among the younger generation, while ensuring the sustainability of cultural heritage amid globalisation.[34,35,36] The dominance of Indonesian in everyday life has exacerbated the issue of cultural erosion and the loss of Javanese script use.[37] The complexity of characters that resemble one another makes learning difficult.[38,39] This study provides concrete solutions in the form of Android-based interactive learning media

utilising familiar platforms, thereby overcoming traditional barriers to learning Javanese script.

The findings of this study align with existing literature confirming the role of digital technology in education and cultural preservation. Previous research by Ariza[40] shows that integrating technology can make cultural heritage more accessible and appealing, while also bridging the gap between tradition and modernity. This approach ensures that cultural knowledge can be meaningfully passed on to future generations. In response to declining interest in local culture, academics emphasise the importance of innovative, fun and student-centred learning. This study reinforces this idea by providing quantitative evidence that digital media can improve both students' conceptual understanding and interest. In line with other studies on educational games and interactive animations, these results affirm the effectiveness of technology in promoting cultural literacy.

More broadly, combining the study's findings with existing academic literature suggests a clear direction for the future: the development of technologically sophisticated yet pedagogically powerful digital devices capable of overcoming the crisis of cultural indifference. Thus, technology can encourage a new generation of cultural literacy and ensure the continued relevance of cultural heritage in the digital age. The interviews revealed significant pedagogical challenges in learning the Javanese script. Students reported that they found it "difficult" and "unpleasant", not only due to a lack of interest, but also because of a cognitive mismatch between the memorisation methods and the complexity of the material. This increases cognitive load and affects emotions as well as long-term learning outcomes.[41] Dependence on pepak and worksheets by both teachers and students exacerbates low conceptual understanding, while traditional methods fail to provide adequate cognitive scaffolding.[42]

Although the findings of this study suggest that student literacy and conceptual understanding of Javanese script have a positive and significant effect on interest in using Android-based learning media, further interpretation is needed to understand the dynamics of these relationships. The results show that conceptual understanding has a stronger influence than literacy. This indicates that students' interest is triggered not only by the basic ability to read or write, but also by a sense of meaningfulness when they understand the context, cultural value and function of Javanese script as cultural heritage. This aligns with qualitative data indicating that students view traditional learning as 'monotonous' and irrelevant to modern learning experiences. Conversely, gamification features such as levels, challenges, and rewards can reduce cognitive load and boost intrinsic motivation. Digital media are not only a means of delivering material, but also a learning experience that encourages active learning, emotional engagement, and connection to cultural identity.

In addition, the media effects developed in this study are consistent with global trends regarding the effectiveness of gamification in education when compared to previous studies, but offer a unique perspective on the preservation of local cultures. The use of interactivity, personalisation and visual cultural elements, such as batik motifs and puppets, provides a pedagogical differentiation compared to general education applications that focus solely on technical literacy. However, this interpretation must be considered alongside the limitations of the research, including the relatively short duration of the intervention and limited variation in schools, as well as potential response bias due to initial enthusiasm for new technologies. A study design that is not strictly experimental may limit the generalisability of the results. Therefore, further research involving a more diverse population and a longitudinal design, as well as comparative evaluation with other learning models, is recommended.

Teachers support this finding, stating that learning the Javanese language tends to be 'monotonous' and still relies on conventional teaching materials such as worksheets and posters. The absence of interactive media quickly leads to student boredom, whereas the use of digital media has the potential to reduce boredom by providing a more engaging learning experience.[43,44] The teachers expressed a willingness to adopt Android-based media as a means of motivation and innovation. Students highlighted their preference for mobile technology and wanted "games", "levels" and "practice" features.

This desire aligns with the established concept of gamification, which uses elements such as points, leaderboards, and rewards to enhance motivation and learning outcomes.[45,46] Gamification provides a safe space for students to practise without fear of failure, replacing boring rote methods. These findings demand a deliberate Android-based media design strategy. The developed application should provide interactive exercises such as tracing, character matching games and filling in the blanks in sentences to help students distinguish between similar characters. It should also integrate level-based progression according to the stages of learning Javanese script in elementary school, with rewards in the form of new content and features.

Implementing this new media requires teachers to shift from a passive role to that of an active learning facilitator. Apps should complement classroom learning, freeing up more time for collaboration and personalised guidance. Policy barriers, such as the ban on mobile phone use in schools, necessitate alternative implementation strategies. When implementing applications in schools, it is important to consider infrastructure readiness, teacher competence, school policy support and the sustainability of use outside the formal learning environment. A more systematic approach and in-depth advanced research could enable Android-based digital media to contribute to the revitalisation of Javanese script and foster a generation of learners who are technically

proficient and culturally literate.

CONCLUSIONS

Android-based learning media has great potential to increase student interest and motivation while contributing to cultural preservation. Applications designed interactively and according to cultural context can provide a more meaningful learning experience, supporting an educational process relevant to the needs of the digital generation. Integrating technology into learning enriches pedagogical strategies and is a key way of maintaining the sustainability of cultural heritage in the context of globalisation. Further research suggests that educators should begin to integrate digital media into learning to support interactive processes in the classroom. Ideally, media developers should design applications that are visually appealing and pay attention to pedagogical, interactive, and cultural aspects. Educational institutions and policymakers are expected to provide real support through policies, infrastructure and investment in the development of technology-based learning media. Further research could expand the use of such applications in the context of regional languages or other cultural heritage, strengthening the role of technology in cultural preservation and improving educational quality.

REFERENCES

1. Wardana SK, Sufa FF, Hapsari AMS. Rancang Bangun Game Edukasi 'Den Sarwo' Berbasis Mobile Mata Pelajaran Bahasa Jawa Materi Aksara Jawa di Kelas IVB SD Negeri Mojosongo 3. Jurnal Teknologi Informasi dan Komunikasi (TIKomSiN). 2023;11(2):1. Available from: https://doi.org/10.30646/tikomsin.v11i2.773

2. Susilo H, Sudargo S, Menarianti I. Aplikasi Pengenalan Aksara Jawa "Hanacaraka" Berbasis Augmented Reality. Jipetik:Jurnal Ilmiah Penelitian Teknologi Informasi & Komputer. 2022;2(2):41–8. Available from: https://doi.org/10.26877/jipetik.v2i2.9719

3. Fardani MA, Rohmah F, Fajrie N. Pengembangan Media Pembelajaran Pokja (Poster Aksara Jawa) Untuk Pengenalan Aksara Jawa Pada Siswa Kelas Iii Sekolah Dasar. Afeksi: Jurnal Penelitian dan Evaluasi Pendidikan. 2023;4(4):423–32. Available from: https://doi.org/10.35672/afeksi.v4i4.147

4. Ismiati, Darni, Raharjo RP, Ahmadi A. Penggunaan Media Aksara Jawa Digital Dalam Pembelajaran Menulis Aksara Jawa. Kawruh: Journal of Language Education, Literature and Local Culture. 2025;7(1):66–81. Available from: https://doi.org/10.32585/kawruh.v7i1.6593

5. Alakrash HM, Razak NA. Technology-Based Language Learning: Investigation of Digital Technology and Digital Literacy. Vol. 13, Sustainability. MDPI AG; 2021. p. 12304. Available from: http://dx.doi.org/10.3390/su132112304

6. Nurunisa FA, Shodiq SF. Developing Quality Social Relationships: Technology-Based Learning Model to Enhance Social Skills in Boarding Schools. Journal of Innovation in Educational and Cultural Research. 2024;5(3):364–72. Available from: https://doi.org/10.46843/jiecr.v5i3.1537

7. Valencia NP, Shodiq SF. Educational Transformation: Implementation of Technology-Based Learning Models in Improving Critical Thinking Skills in Boarding School Environments. Journal of Innovation in Educational and Cultural Research. 2024;5(2):329–36. Available from: https://doi.org/10.46843/jiecr.v5i2.1538

8. Thilagam PS, Sahidul Islam MD, P T, Vijayakumar S, Hameed NS, Infant raj I. Mobile Applications for Self-Assessment in English Language Learning: Enhancing Learner Autonomy and Reflection. In: 2025 3rd International Conference on Intelligent Systems, Advanced Computing and Communication (ISACC). 2025. p. 422–6.

9. Ahmad Y, Kune S, Syamsuddin A. Application of Problem-Based Learning-Audio Visual Approach to Improve Science Problem-Solving Ability of Elementary School Students. Pedagogik Journal of Islamic Elementary School. Institut Agama Islam Negeri (IAIN) Palopo; 2022. p. 227–42. Available from: http://dx.doi.org/10.24256/pijies.v5i2.2857

10. Hattie J. The applicability of Visible Learning to higher education. Scholarsh Teach Learn Psychol. 2015;1(1):79–91.

11. Kholifaturrohmah N, Insani NH. "Writing Javanese Script" Application as a Support for Learning to Write Javanese Script in Junior High Schools. Journal of Education Research and Evaluation. 2025;9(2):399–408.

Available from: https://doi.org/10.23887/jere.v9i2.94856

12. Yenadiputri E, Windraya MR, Sambuhak N, Rokhim DA. The Development of Scrabble Game-Based Learning Media Using Javanese Script: Jable Board. Piwulang : Jurnal Pendidikan Bahasa Jawa. 2023;11(1):65–79. Available from: https://doi.org/10.15294/piwulang.v11i1.67298

13. Al-Hamzah S, Firdaus M, Zainollah. Strategy Of Education Quality Improvement On Senior High School Argopuro Panti. Vol. 4, MBA - Journal of Management and Business Aplication. P3M STIE Mandala Jember; 2021. p. 427–35. Available from: http://dx.doi.org/10.31967/mba.v4i2.509

14. Strijker D. Research methods in rural studies: Qualitative, quantitative and mixed methods. J Rural Study. 2020;78:262–70. Available from: https://api.elsevier.com/content/article/eid/1-s2.0-S074301671830740X

15. Creswell JW, Creswell JD. Research design: Qualitative, quantitative, and mixed methods approaches. Sage publications; 2017.

16. Campbell KA. Reflexive thematic analysis for applied qualitative health research. Qualitative Report. 2021;26(6):2011–28. Available from: https://www.scopus.com/inward/record.uri?partnerID=HzOxMe3b&scp=85109099141&origin=inward

17. Memon MA. Addressing Common Method Bias, Operationalization, Sampling, And Data Collection Issues In Quantitative Research: Review And Recommendations. Journal of Applied Structural Equation Modeling. 2023;7(2). Available from: https://www.scopus.com/inward/record.uri?partnerID=HzOxMe3b&scp=85173045308&origin=inward

18. Nugraha R, Wijayanto C, Nurcahyawati E. Pelatihan Menulis Aksara Jawa: Meningkatkan Kemampuan Menulis dan Melestarikan Budaya Jawa. KANGMAS: Karya Ilmiah Pengabdian Masyarakat. 2024;5(3):183–9. Available from: https://doi.org/10.37010/kangmas.v5i3.1911

19. Sari PR, Nartani CI. Peningkatan Keterampilan Membaca Dan Menulis Aksara Jawa Melalui Papan Aksara Jawa (Pasar Jawa) Pada Siswa Kelas Iv Sd N Ngoto. Trihayu: Jurnal Pendidikan Ke-SD-an. 2020;6(2). Available from: https://doi.org/10.30738/trihayu.v6i2.8051

20. Asrianti T, Fauziah PY. Pendampingan Belajar Aksara Jawa dalam Upaya Pelestarian Budaya Jawa. Abdi: Jurnal Pengabdian dan Pemberdayaan Masyarakat. 2023;5(3):398–402. Available from: https://doi.org/10.24036/abdi.v5i3.472

21. Adi S, Rohidi TR, Rustiadi T. Digital literacy of physical education teachers in the 5.0 era. Sport TK. 2023;12.

22. Huda N, Marsono. Development of Learning Media for Android-Based During The COVID-19 Pandemic. In: 2021 7th International Conference on Electrical, Electronics and Information Engineering (ICEEIE). 2021. p. 1–6.

23. Gunawan, Sumardi, Hardi R, Suprijadi, Servanda Y. Integration of Academic Mobile Applications at University. J Phys Conf Ser. 2021 Apr;1807(1):12035. Available from: https://doi.org/10.1088/1742-6596/1807/1/012035

24. Ramdani D, Rizal E, Zulkifli Z. Pemanfaatan Game Educandy Sebagai Media Pembelajaran Interaktif Dalam Pembelajaran Bahasa Arab Di SDI Sjech M. Djamil Djambek Bukittinggi. Vol. 11, Al-Tadris: Jurnal Pendidikan Bahasa Arab. IAIN Tulungagung; 2023. p. 152–68. Available from: https://doi.org/10.21274/tadris.2023.11.1.152-168

25. Matsuri M, Atmojo IRW, Chumdari C, Adi FP, Ardiansyah R, Saputri DY, et al. Analysis of Elementary School Students' Literacy Ability of Javanese Script Through the Use of Script Card Reviewed Based on Critical Thinking Skills. AL-ISHLAH: Jurnal Pendidikan. 2023;15(4). Available from: https://doi.org/10.35445/alishlah.v15i4.4519

26. Xu H. Critical thinking in academic writing: a cultural approach. Innovation in Language Learning and Teaching. 2022;17(3):760–2. Available from: https://doi.org/10.1080/17501229.2022.2082445

27. Astuti E, Nurcahyo H. Development of Biology Learning Media Based on Adobe Flash to Increase Interest and Conceptual Understanding. J Phys Conf Ser. 2019 Jun;1241(1):12050. Available from: https://doi.org/10.1088/1742-6596/1241/1/012050

28. Huda AK, Efendi A. Implementasi Media Berbasis Sport Edukasi untuk Meningkatkan Pembelajaran Jasmani. Jurnal Porkes. 2025;8(2):1040–50. Available from: https://doi.org/10.29408/porkes.v8i2.31002

29. Pahlifi DM, Nurcahyo H. The Effect of Android-based Pictorial Biology Dictionary on Students' Motivation on Topic of Invertebrate. J Phys Conf Ser. 2019 Jun;1241(1):12048. Available from: https://doi.org/10.1088/1742-6596/1241/1/012048

30. Eliza F, Hakiki M, Fadli R, Ridoh A, Fauziah F, Suri RM, et al. Android-based mobile learning application using app inventor on computer operating system material: The development and validity study. TEM Journal. 2024;13(1):624.

31. Höft L, Bernholt S. Longitudinal couplings between interest and conceptual understanding in secondary school chemistry: an activity-based perspective. Int J Sci Educ. 2019;41(5):607–27. Available from: https://doi.org/10.1080/09500693.2019.1571650

32. Maidan, Halim A, Safitri R, Nurfadilla E. Impact of Problem-based Learning (PBL) model through Science Technology Society (STS) approach on students' interest. J Phys Conf Ser. 2020 Feb;1460(1):12145. Available from: https://doi.org/10.1088/1742-6596/1460/1/012145

33. Kapici HO. Does inquiry-based learning work better in regular classrooms or computer-based settings? Instr Sci. 2025;53(4):705–28. Available from: https://doi.org/10.1007/s11251-025-09711-0

34. Mahastama AW, Krisnawati LD. Optical Character Recognition for Printed Javanese Script Using Projection Profile Segmentation and Nearest Centroid Classifier. 2020 Asia Conference on Computers and Communications (ACCC). 2020;52–6. Available from: https://doi.org/10.1109/accc51160.2020.9347895

35. Prieto J, Martinez C, Robles M, Moreno A, Palacios S, Manrique R. Translation systems for low-resource Colombian Indigenous languages, a first step towards cultural preservation. In: Mager M, Ebrahimi A, Rijhwani S, Oncevay A, Chiruzzo L, Pugh R, et al., editors. Proceedings of the 4th Workshop on Natural Language Processing for Indigenous Languages of the Americas (AmericasNLP 2024). Mexico City, Mexico: Association for Computational Linguistics; 2024. p. 7–14. Available from: https://aclanthology.org/2024.americasnlp-1.2/

36. Wulandari IS, Agustini F, Rofian R. Pengembangan Media Pembelajaran PARAWA (Pandai Aksara Jawa) Berbasis Audio Visual Pembelajaran Bahasa Jawa Materi Sandhangan Swara Kelas IV SD Negeri Sawah Besar 01 Semarang. Wawasan Pendidikan. 2023;3(1):299–308. Available from: https://doi.org/10.26877/wp.v3i1.11554

37. Bashori M. Lost in leisure? The decline of Javanese language use in Indonesia. Int J Multiling. 2025;0(0):1–19. Available from: https://doi.org/10.1080/14790718.2025.2528662

38. Prihandi I, Ranggadara I, Dwiasnati S, Sari YS, Suhendra. Implementation of Backpropagation Method for Identified Javanese Scripts. J Phys Conf Ser. 2020 Mar;1477(3):32020. Available from: https://doi.org/10.1088/1742-6596/1477/3/032020

39. Sudarmilah E. Theoretical Educational Practices of Siraja Javanese Script Interactive Learning Media Based On 2D Application. Educational Administration: Theory and Practice. 2021;27(2):1098–110. Available from: https://doi.org/10.17762/kuey.v27i2.255

40. Ariza-Colpas Paola-Patricia and Piñeres-Melo MA and MORC and RBAF and BAS and del CCCL and MMR and ARAV and OBA. Exploring the History and Culture of Main Square Los Tupes with Augmented Reality in San Diego, Cesar. In: Schlippe Tim and Cheng ECK and WT, editor. Artificial Intelligence in Education Technologies: New Development and Innovative Practices. Singapore: Springer Nature Singapore; 2023. p. 253–63.

41. Lin J, Liu RD, Ding Y, Yang Y, Jiang S, Ding Z. Counter-attitudinal intervention decreased positive attitudes and behavioral tendencies towards video games. Comput Educ. 2023;201:104816. Available from: https://www.sciencedirect.com/science/article/pii/S0360131523000933

42. Mandic D. Report on Smart Education in the Republic of Serbia. In: Zhuang Rongxia and Liu D and SD and MD and ZS and HY and HR, editor. Smart Education in China and Central & Eastern European Countries. Singapore: Springer Nature Singapore; 2023. p. 271–91. Available from: https://doi.org/10.1007/978-981-19-7319-2_11

43. Iskandar D, Hidayat S, Jamaludin U, Leksono SM. Javanese script digitalization and its utilization as learning media: an etnopedagogical approach. International Journal of Mathematics and Sciences Education. 2023;1(1):21–30. Available from: https://doi.org/10.59965/ijmsed.v1i1.24

44. Febriani SR, Ritonga AW. The Perception of Millennial Generation on Religious Moderation through Social Media in the Digital Era. Millah: Journal of Religious Studies. 2022;313–34. Available from: https://doi.org/10.20885/millah.vol21.iss2.art1

45. Nair S, Mathew J. Evaluation of Gamified Training A Solomon Four-Group Analysis of the Impact of Gamification on Learning Outcomes. TechTrends. 2021;65(5):750–9. Available from: https://doi.org/10.1007/s11528-021-00651-3

46. Shahbazi F, Villa López FH. Enhancing Student Engagement And Deep Learning Through Innovative Learning Strategies In Engineering Education: Point-Based Gaming (Pbg) Framework. Zenodo; 2024. Available from: https://doi.org/10.5281/zenodo.14256933

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CONFLICT OF INTEREST

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