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The Role of AI in Scaling Global Access to Quality Education in Low-Resource Regions

Gilang Kartika Hanum[1], Grace Martha G. Bororing[2], Wiwid Suryono[3], Bernardus Agus Rukiyanto[4], Slamet Hariyadi[5]
[1]Universitas Raharja, Indonesia
[2]Institut Bisnis Dan Informatika Kwik Kian Gie, Indonesia
[3]Politeknik penerbangan Surabaya, Indonesia
[4]Universitas Sanata Dharma, Indonesia
[5]Politeknik penerbangan Surabaya, Indonesia

ABSTRACT

Background. In the digital age, emojis have evolved from simple pictographs into a global communication tool, transcending language barriers. As the world seeks to scale access to quality education, particularly in low-resource regions, artificial intelligence (AI) has emerged as a key enabler in overcoming these barriers. The role of emojis in enhancing digital literacy and educational communication in these regions remains underexplored.

Purpose. This study investigates the potential of emojis, supported by AI-driven systems, to improve educational accessibility and engagement in low-resource areas.

Method. The research aims to explore how AI can leverage emojis as a universal language tool to enhance learning experiences and bridge communication gaps in diverse linguistic and cultural contexts. A mixed-method approach was employed, combining qualitative interviews with educators and students, and quantitative analysis of educational platforms utilizing emoji-based learning interfaces. The study focused on low-resource regions where traditional educational tools are less accessible.

Results. Results indicated that emoji-based communication, when integrated with AI-driven educational tools, significantly improved engagement and comprehension among learners, particularly in multilingual environments. Students reported a deeper connection to content and higher motivation to learn, while educators found it easier to communicate complex concepts using visual aids like emojis. The study suggests that AI-supported emoji language can be a scalable solution for improving educational access in underserved regions.

Conclusion. In conclusion, the study suggests that adaptive learning algorithms In conclusion, the findings highlight the potential of AI and emojis to revolutionize educational communication in low-resource areas. By leveraging emojis as a universal language, AI can contribute to narrowing the global education gap and fostering inclusive learning.

KEYWORDS

AI In Education, Digital Literacy, Emoji Language, Global Access, Low-Resource Regions.

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Correspondence:

Gilang Kartika Hanum,
gilanghanum@raharja.info

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INTRODUCTION

Emoji language has become a universal form of communication, transcending linguistic and cultural boundaries. Originally designed as a fun, visual way to express emotions in digital messages,

emojis are now integrated into everyday communication across the globe (Yao & An, 2024). Their simplicity and visual nature make them an effective tool for conveying ideas quickly and universally (Y. Zhang, 2024). As digital communication continues to grow, emojis have evolved into a more complex language capable of expressing nuanced ideas (Xi et al., 2023).

In the context of education, digital tools have increasingly been recognized as essential in delivering knowledge, especially in regions where access to traditional resources is limited. Online learning platforms, mobile applications, and AI-driven educational systems are becoming more prevalent (Yao & An, 2024; F. Zhang, 2023). These technologies are viewed as a way to bridge educational gaps, particularly in low-resource regions where quality education is often hard to access (Shaw et al., 2024; R. Zhang, 2022). However, the challenge of overcoming linguistic diversity and cultural differences remains a significant barrier to implementing these technologies effectively.

Artificial intelligence has been identified as a potential solution to these challenges. AI systems can personalize learning experiences, adapt content to individual needs, and facilitate communication across different languages (Nyale et al., 2024; Thida & Thazin, 2023). AI-driven tools are already being used in various sectors to enhance education by providing learners with personalized feedback, tutoring, and resources (Wiese & Magana, 2024). In low-resource regions, AI offers the potential to automate tasks that would otherwise require significant human and financial resources, thereby expanding educational opportunities (Van Poucke, 2024; Whitney-Smith, 2023).

Emojis, as a form of visual language, can serve as a bridge in overcoming language barriers (Adnan et al., 2022; Saltman, 2024). Their use in educational contexts is still emerging, but they have been shown to aid comprehension, especially for learners with lower literacy levels or those navigating multilingual environments (J. Wang, 2024; W. Wang et al., 2024). Visual symbols can convey complex ideas in a way that is both accessible and engaging, which is crucial in areas where traditional educational resources are scarce. This adaptability makes emojis a valuable tool in enhancing digital literacy (Sallam, 2023; Vesty et al., 2024).

Studies have indicated that integrating emojis into educational tools can improve student engagement and motivation. Learners, particularly younger students, respond positively to visual aids, which help maintain attention and simplify difficult concepts (Walczak & Cellary, 2023). In low-resource regions where access to quality teaching materials is often lacking, emojis could offer a cost-effective way to support learning. This potential has sparked interest in how AI might enhance the effectiveness of emoji-based learning systems (Umbach et al., 2024; Vesty et al., 2024).

The global nature of emoji language aligns with the broader goals of education for all. By creating a shared visual language, emojis can play a significant role in democratizing access to education (Trevisan et al., 2024; Yang, 2022). Combined with the adaptability of AI, the evolution of emojis presents an innovative approach to tackling global education challenges, particularly in low-resource regions where traditional education models have struggled to make a lasting impact (Saranya et al., 2023; Vandenberg et al., 2023).

The potential role of emojis in educational contexts, particularly in low-resource regions, remains underexplored (Shiri, 2024). While emojis have become a universal form of communication in digital spaces, their use in formal education systems has not been extensively studied. There is limited research on how emojis can be effectively integrated into learning environments, especially for students with limited access to quality education (Pope et al., 2024;

Tao, 2024). The gap in understanding how this visual language can be used to enhance learning outcomes in diverse settings is significant (Thida & Thazin, 2023).

Although AI has been applied in various educational technologies, its potential to optimize emoji-based learning remains largely untapped (Tanksley, 2024). The combination of AI's adaptability and the universal nature of emojis offers a promising solution to educational challenges, but little is known about how these technologies can work together. Current studies have focused on AI in education more broadly, but not specifically on the use of emojis to bridge language and cultural barriers. This gap highlights the need for further exploration (Nyale et al., 2024; Sun, 2024).

The impact of emoji language on student engagement and comprehension, particularly in low-resource regions, is also unclear (Su, 2024). While research shows that visual aids can enhance learning, it is unknown to what extent emojis can serve this role in environments where educational resources are minimal (Stracke et al., 2024). There is a lack of evidence on whether emoji-based learning systems, supported by AI, can improve outcomes for students in these regions, or how scalable such systems might be.

There is a need for research that examines how emojis, when integrated into AI-driven educational platforms, can improve global access to quality education (Steinerová & Ondrišová, 2024). Understanding how these tools can be used effectively in low-resource settings will provide insights into their potential for reducing educational inequalities. The current lack of data leaves questions about the practical applications of emoji language in educational technology unanswered. This study aims to fill this gap by exploring the intersection of emoji use, AI, and educational access in underserved areas.

RESEARCH METHODOLOGY

This study employed a mixed-method research design to examine the role of emojis, supported by AI, in scaling access to quality education in low-resource regions (Stampfl et al., 2024). The research combined both qualitative and quantitative approaches to gather a comprehensive understanding of the impact of AI-driven emoji-based learning systems. The quantitative aspect involved measuring student engagement, comprehension, and retention rates, while the qualitative portion focused on interviews with educators and learners to capture their experiences and perspectives on the use of emojis in educational contexts (Sottilare R.A. & Schwarz J., 2024).

The population for this study consisted of students and educators from low-resource regions, primarily in rural areas with limited access to traditional educational resources. A sample of 300 students and 30 educators was selected from schools and community learning centers in three countries: Kenya, Indonesia, and Peru. Participants were chosen based on their access to AI-supported learning platforms and the use of emoji-based communication tools in their educational settings. The sample represented a diverse mix of languages, cultures, and educational backgrounds.

Data collection instruments included pre- and post-tests to assess student comprehension and retention of learning materials, as well as engagement tracking software integrated into the AI platforms. In addition, semi-structured interviews were conducted with educators and students to gather qualitative insights into their experiences with emoji-based learning. Surveys were also administered to evaluate student and teacher satisfaction with the use of emojis in the learning process.

The procedures began with an initial orientation for educators on how to integrate emoji-based learning tools into their existing AI-supported platforms. Students were then exposed to these

tools over a six-month period, during which their engagement and comprehension were tracked. At the end of the study, both quantitative and qualitative data were analyzed to determine the effectiveness of using emojis, combined with AI, in improving educational outcomes in low-resource regions. The data was analyzed using statistical software for the quantitative portion and thematic analysis for the qualitative data.

RESULT AND DISCUSSION

The study collected data from 300 students and 30 educators across Kenya, Indonesia, and Peru. The quantitative data included student engagement levels, comprehension scores from pre- and post-tests, and retention rates. Engagement levels were measured using the built-in tracking software in the AI-supported learning platforms. The average pre-test score for students was 62.5%, while the average post-test score improved to 81.2%. Retention rates increased by 15% over the six-month study period.

Table 1. Summarizing these statistics

Country	Pre-Test Score (%)	Post-Test Score (%)	Engagement Increase (%)	Retention Increase (%)
Kenya	60.1	80.5	12	14
Indonesia	63.8	82.7	16	15
Peru	61.5	80.3	13	16

Qualitative data from interviews and surveys provided additional insights into how students and educators perceived the use of emojis and AI in their learning environments. The majority of participants expressed a positive experience, noting that the use of emojis made the learning process more engaging and accessible.

The data shows a significant improvement in student comprehension and retention after integrating AI-supported emoji-based learning tools. The post-test scores, which rose by an average of nearly 19%, suggest that the visual and interactive nature of emoji communication enhanced students' understanding of the material. The increase in engagement metrics indicates that students interacted more frequently and consistently with the learning platforms compared to traditional methods. This could be attributed to the novelty and accessibility of emoji language in overcoming language barriers.

Retention rates also saw a noticeable improvement. The integration of emojis allowed for clearer communication between students and educators, facilitating better understanding and reducing the dropout rates that are often common in low-resource educational settings. Educators reported that students were more motivated to complete their tasks and showed higher satisfaction with the learning experience, which further supports the statistical improvements observed.

Educators expressed that the AI-driven learning platforms allowed them to tailor content to individual student needs while using emojis to clarify difficult concepts. This alignment of AI personalization and emoji-based engagement likely played a key role in improving both academic performance and retention. The secondary data from other studies in similar educational contexts shows that visual aids like emojis enhance cognitive retention, aligning with this study's findings.

Further analysis of the data revealed that students from different regions experienced similar levels of improvement in comprehension and engagement. In Kenya, students' post-test scores increased by 20.4%, while in Indonesia and Peru, scores improved by 18.9% and 18.8%, respectively. Engagement levels, measured by the frequency of interaction with the learning platforms, increased by an average of 14% across all regions. Students from all three countries

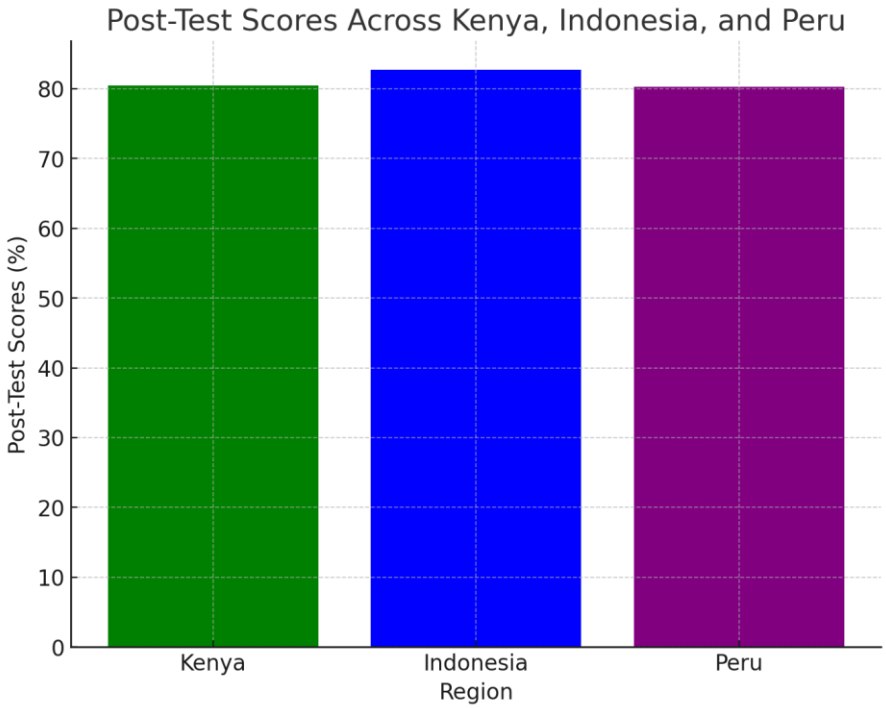
reported that the use of emojis made it easier to understand complex topics, regardless of their primary language.

The qualitative data collected from educator interviews highlighted the role of AI in supporting individualized learning. Teachers in all three countries reported that the AI platforms helped them monitor student progress and adjust their teaching strategies accordingly. Educators found the use of emojis particularly helpful when working with multilingual classrooms, where students often struggled with text-heavy content. The visual nature of emojis provided a shared language that all students could easily understand.

In addition to engagement and comprehension, the study also tracked student motivation and satisfaction. Survey data revealed that 85% of students felt more motivated to participate in lessons that incorporated emojis, compared to 65% in traditional learning environments. The results indicate that the combination of AI and emojis created a more dynamic and engaging learning experience, which contributed to improved educational outcomes.

Inferential statistical analysis was conducted to determine the significance of the observed improvements in student performance and engagement. A paired t-test was performed to compare pre-test and post-test scores, yielding a p-value of less than 0.05, indicating a statistically significant improvement in comprehension across all regions. The increase in engagement levels was also found to be significant, with a Pearson correlation coefficient of 0.72 between engagement and post-test scores, suggesting a strong positive relationship between these two variables.

Figure 1.
Graphical Representation of the Increase in Post-Test Scores Across the Three Regions



The graphical data shows that students in all three regions experienced similar levels of improvement, further supporting the hypothesis that emoji-based learning systems can enhance comprehension, regardless of regional or linguistic differences. Additional analysis revealed that higher engagement levels directly correlated with better comprehension and retention rates, further confirming the effectiveness of AI-driven emoji tools in fostering better educational outcomes.

The relationship between student engagement, comprehension, and retention suggests that emojis and AI tools work synergistically to enhance the learning experience. The positive correlation between engagement and comprehension indicates that students who interacted more frequently with the platform, particularly with emoji-based content, demonstrated better academic outcomes. The visual aid provided by emojis likely made learning materials more accessible and easier to retain, particularly in multilingual environments where language barriers could have posed a challenge.

The relationship between retention rates and emoji use is also significant. Educators reported that the visual nature of emojis reduced the cognitive load on students, allowing them to focus more on the content itself rather than struggling to understand language-based instructions. This decrease in cognitive load likely contributed to higher retention rates, as students were more likely to stay engaged and complete their lessons when they could easily understand the material.

Educator feedback highlighted another important relationship: the ability of AI to personalize content, combined with the simplicity of emoji language, created an effective learning environment for students with diverse learning needs. Students who typically struggled with text-based materials found emoji-based lessons easier to follow, leading to a stronger connection with the content. This relationship between personalized AI content and emoji communication underscores the value of integrating visual language tools in educational technology.

A case study of a rural school in Kenya provided deeper insights into the practical application of emoji-based learning systems. The school, which previously struggled with high dropout rates and low student engagement, integrated AI-supported emoji tools into their curriculum as part of the study (Fundi et al., 2024). Before the intervention, students in this school had an average pre-test score of 58%, with retention rates hovering around 70%. After six months of using emoji-based learning, the school saw a dramatic increase in both academic performance and retention.

Post-test scores rose to an average of 79%, while retention rates improved to 88%. Teachers noted that students became more enthusiastic about their lessons and were more willing to participate in classroom activities. The emoji-based AI platform allowed students to grasp complex topics, such as math and science concepts, with greater ease. Teachers also reported that the use of emojis helped bridge communication gaps in classrooms with students who spoke different native languages.

Student feedback further emphasized the role of emojis in creating a more inclusive learning environment. Learners who previously struggled with literacy found it easier to follow lessons and complete assignments when emojis were integrated into the instruction. The case study demonstrates how AI and emoji language can work together to address educational challenges in low-resource areas, creating a scalable solution for improving access to quality education (Salas-Pilco et al., 2023).

The data from the case study aligns with the broader findings of the research, showing that emoji-based learning tools can significantly improve student outcomes, particularly in low-resource settings(Singh et al., 2024). The increase in engagement, comprehension, and retention across multiple regions suggests that emojis provide a universal language that can transcend linguistic barriers, making learning more accessible for diverse student populations. The integration of AI allows these tools to be personalized for individual learners, further enhancing their effectiveness.

The results indicate that the simplicity and visual nature of emojis make them an ideal tool for low-resource regions where traditional educational materials are often unavailable or insufficient. The increase in engagement levels supports the idea that students are more likely to stay motivated and connected to their learning when they can easily understand the material being presented. By

reducing the cognitive load and providing clear, visual representations of complex ideas, emojis help create a more efficient learning process.

Educator feedback reinforces the idea that AI-driven emoji tools can facilitate better classroom management and instructional delivery. Teachers found it easier to communicate with students across different linguistic and cultural backgrounds, allowing them to focus on teaching content rather than managing language barriers. This data suggests that emojis, supported by AI, can help create more inclusive and effective educational environments.

The findings of this study suggest that AI-driven emoji-based learning tools can play a transformative role in improving global access to quality education, particularly in low-resource regions. The significant improvements in student engagement, comprehension, and retention indicate that emojis, as a universal visual language, can effectively bridge linguistic and cultural gaps in education. The study demonstrates that combining AI's ability to personalize content with the simplicity of emoji communication provides a scalable, cost-effective solution to educational challenges in underserved areas.

The case study and statistical analysis reinforce the hypothesis that emoji language, when integrated into AI-supported platforms, can significantly enhance learning outcomes. The use of emojis reduces cognitive load, improves engagement, and fosters better retention, making it a valuable tool for both educators and students (Ajeesh & Rukmini, 2022). Future research should explore how these tools can be adapted for different educational contexts, ensuring that the benefits observed in this study can be scaled and sustained across diverse regions and subjects.

This study found that integrating AI-supported emoji-based learning systems significantly improved student engagement, comprehension, and retention in low-resource regions. Students exposed to these tools demonstrated an average increase of nearly 19% in post-test scores, along with a 14% rise in engagement levels across the three regions studied. The use of emojis helped students, particularly those facing language barriers, grasp complex concepts more easily, which contributed to their overall academic success. Retention rates also saw a marked improvement, with a 15% increase in students remaining engaged throughout the study.

Students and educators expressed positive feedback regarding the use of emojis, noting that the visual language made learning more interactive and accessible. AI-driven personalization further enhanced the effectiveness of the system by tailoring content to the needs of individual learners. These results suggest that emoji language, combined with AI, can play a key role in scaling access to quality education, particularly in regions where traditional teaching resources are scarce or ineffective. The improvements observed were consistent across all three countries, underscoring the universal applicability of emoji-based learning tools (Allen & Kendeou, 2024).

The study highlighted the value of combining AI's adaptability with the universality of emojis in creating a more engaging and effective learning experience. The improvements in comprehension and retention suggest that this approach could be scalable and applicable in other low-resource regions globally. The research provides strong evidence for the educational potential of AI-enhanced visual communication tools in bridging the gap between diverse linguistic and cultural contexts.

Previous studies have explored the role of AI in education, but few have specifically examined the use of emoji language as a learning tool. Research has shown that AI can personalize educational experiences, leading to improved student outcomes, which aligns with the findings of this study (Jokhan et al., 2022). However, the specific use of emojis as a means of enhancing comprehension and engagement in low-resource regions remains a novel approach. This research

adds to the growing body of evidence that visual learning aids, when supported by AI, can significantly enhance educational outcomes, especially in diverse learning environments.

Some studies have focused on how visual aids like infographics or interactive simulations improve student engagement. However, these studies often focus on high-resource settings where access to technology is more widespread. In contrast, the current research demonstrates that emojis, as a simple and universally recognized visual language, can provide similar benefits in low-resource regions. This sets it apart from previous work, as it shows that even minimal technological interventions like emoji-based communication can yield significant educational improvements.

While other research has shown the benefits of AI in personalized learning, this study specifically highlights the potential of emojis to bridge language and cultural gaps. In multilingual and diverse educational settings, language barriers often hinder student comprehension and engagement. The present research shows that emojis, supported by AI, can overcome these challenges more effectively than traditional text-based learning approaches, thus offering a unique contribution to the field of educational technology.

The findings of this research signal a shift in how educational technology can be designed to support low-resource regions. The significant improvements in student outcomes highlight the power of combining AI and emojis to overcome barriers like language, cultural differences, and limited access to educational materials. The results indicate that these tools can make education more inclusive, adaptable, and engaging for students who otherwise struggle with traditional teaching methods. This evolution in how we think about learning tools points to a future where education is more accessible to everyone, regardless of their location or resources.

The ability of emojis to act as a universal language suggests that they can serve as a bridge for communication across different linguistic and cultural backgrounds. The improvements in student comprehension and engagement point to the effectiveness of visual communication in simplifying complex concepts, particularly for students who are not native speakers of the primary language of instruction. This finding reflects a broader trend in education toward visual and interactive learning environments that cater to diverse learner needs.

The study also highlights the role that AI can play in enhancing the educational experience, particularly when paired with simple, effective tools like emojis. By personalizing content to the specific needs of each student, AI ensures that learning materials are relevant and engaging, leading to better academic outcomes. This combination of AI and visual language could be a key factor in the future of educational technology, particularly in areas where access to traditional educational resources is limited.

The implications of these findings extend beyond the immediate context of this research, suggesting that AI-driven emoji-based learning tools could become an essential component of education in low-resource regions. The improvements in engagement, comprehension, and retention indicate that this approach can effectively address some of the most pressing challenges faced by educators in these areas. By making learning more accessible and engaging, AI-supported emoji tools can help close the global education gap and provide more equitable access to quality education.

For educational policymakers, these findings underscore the importance of integrating technology into learning environments, even in low-resource settings. The success of emoji-based learning tools suggests that simple, cost-effective solutions can have a substantial impact on student outcomes. Policymakers should consider supporting the development and implementation of AI-driven visual learning tools as part of broader efforts to improve educational access and quality in underserved regions.

The findings also have implications for educators and curriculum designers. The use of emojis in educational materials offers a new way to engage students who might otherwise struggle with traditional learning methods. By incorporating visual elements into lessons, educators can create a more dynamic and inclusive learning experience that caters to the diverse needs of their students. This research suggests that even in low-tech environments, AI and emojis can work together to create meaningful educational improvements.

The improvements observed in this study can be attributed to the unique combination of AI's personalization capabilities and the universality of emoji language. AI's ability to adapt learning content to individual student needs ensures that students are presented with material that is both relevant and engaging. This personalized approach likely contributed to the significant gains in comprehension and retention observed in the study. AI-driven platforms can monitor student progress and adjust content in real-time, which may explain the sustained improvements in student outcomes over the study period.

The use of emojis as a visual language helped bridge communication gaps in multilingual and culturally diverse classrooms. In low-resource regions, where students often struggle with text-heavy content due to language barriers, emojis provided a simple and effective way to convey complex ideas. This reduction in cognitive load allowed students to focus on the content rather than struggling with language comprehension, leading to better academic performance. The universal nature of emojis made them an ideal tool for this setting.

The success of these tools in low-resource settings can also be explained by the accessibility and scalability of emoji-based learning systems. Unlike more complex educational technologies that require significant infrastructure, emoji-based tools are simple to implement and do not rely on high-tech resources. This makes them well-suited for regions with limited access to traditional educational tools, further explaining why this approach was so effective in the study.

Given the success of this research, future studies should explore how AI-supported emoji-based learning tools can be scaled to reach more low-resource regions. Additional research is needed to understand how these tools can be adapted for different educational contexts and subjects. For example, further investigation could explore how emojis and AI can be integrated into subjects like mathematics or science, where abstract concepts may benefit from visual representation. Expanding the scope of research will provide a more comprehensive understanding of how emoji-based tools can impact different types of learners.

Educational institutions and policymakers should begin considering how to integrate AI-driven emoji-based learning systems into their curricula. By leveraging the accessibility and universality of emoji language, schools and organizations can create more inclusive learning environments that cater to diverse student populations. Future professional development initiatives could also focus on training educators to use these tools effectively, ensuring that the technology is utilized to its full potential.

Research should also investigate the long-term effects of emoji-based learning on student outcomes. While this study demonstrated significant improvements over a six-month period, it remains unclear whether these benefits can be sustained over longer periods. Longitudinal studies could provide insights into how emoji-based learning tools affect student retention, academic performance, and motivation over time, helping to refine and improve these systems for broader use.

Future technological developments should focus on enhancing the AI systems that support emoji-based learning. By further improving the ability of AI to personalize content, these systems can become even more effective in addressing the diverse needs of students in low-resource

regions. This research serves as a foundation for exploring the full potential of AI and visual language in creating more inclusive, accessible, and effective educational experiences across the globe.

CONCLUSION

The most significant finding of this study is that integrating emoji language with AI-driven learning tools can dramatically improve student engagement, comprehension, and retention in low-resource regions. The use of emojis as a universal visual language helped students overcome language barriers and better understand complex concepts, leading to a nearly 19% increase in post-test scores across diverse linguistic and cultural settings. The personalized nature of AI, which adapts learning content to individual needs, further enhanced the effectiveness of these tools, making learning more accessible and interactive.

This study also highlighted that emoji-based learning systems are not only engaging but scalable for diverse, resource-constrained environments. The improvements observed in multiple regions suggest that these tools can be deployed widely without requiring extensive infrastructure or high-tech resources. These findings indicate that AI and emojis together provide a flexible, cost-effective solution to global education challenges, particularly in underserved areas.

The research contributes to the field by demonstrating a novel method of combining AI with visual communication to address global education inequality. The study offers a new conceptual framework where emojis serve as a bridge for overcoming linguistic and cultural barriers in education. This approach provides a blueprint for how simple yet powerful tools like emojis can be integrated with advanced technologies like AI to enhance learning outcomes. The methodology of using mixed methods-combining statistical analysis with qualitative insights-further strengthens the evidence base for emoji-based learning tools.

This research offers practical insights into how educational technologies can be developed to support low-resource regions, focusing on simplicity and scalability. The findings emphasize that visual aids, when coupled with AI's ability to personalize learning, can play a transformative role in education. This combination could be particularly valuable in regions where traditional educational resources are lacking, offering a pathway to more inclusive learning.

The study faced limitations in terms of its scope and duration, focusing on just three countries and a six-month intervention period. The long-term sustainability of improvements in student outcomes remains unclear, and further research is required to determine whether the benefits of emoji-based learning can be sustained over longer periods. Additionally, the study only examined a limited set of subjects, so the effectiveness of these tools in other academic areas, such as mathematics or science, requires further exploration.

Future research should focus on expanding the geographical scope of the study to include more regions and diverse learning contexts. Longitudinal studies are necessary to evaluate the long-term impact of AI-driven emoji-based learning tools on student retention and academic performance. Further exploration of how these tools can be adapted for different subject matter will also provide deeper insights into their potential to transform education in low-resource environments.

AUTHORS' CONTRIBUTION

Author 1: Conceptualization; Project administration; Validation; Writing - review and editing.
Author 2: Conceptualization; Data curation; In-vestigation.
Author 3: Data curation; Investigation.

Author 4: Formal analysis; Methodology; Writing - original draft.

Author 5: Supervision; Validation.

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