

# Development of a Mobile Application for Interactive Sign Language Learning Using AI-Powered Gesture Recognition and Gamification

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## Introduction

Language is the foundation of communication, enabling individuals to express their thoughts, emotions, and ideas (Vygotsky, 2012). However, for the deaf and hard-of-hearing (DHH) community, verbal communication is not always an option, making sign language an essential tool for interaction. Sign language is a rich and complex linguistic system that allows DHH individuals to communicate fluently, yet it remains underappreciated and underutilized by the general population (Willoughby & Sell, 2019). The learning of sign language is not only beneficial for those with hearing impairments but also for society as a whole, as it fosters inclusivity, improves communication accessibility, and enhances cognitive and social development.

One of the most significant reasons for learning sign language is its role in promoting inclusivity (Stokoe Jr, 2005). Deaf individuals often face communication barriers in education, healthcare, workplaces, and social settings, limiting their opportunities and participation in society. By encouraging sign language learning among the hearing population, these barriers can be reduced, allowing for a more inclusive and accessible environment. Schools, businesses, and public institutions that incorporate sign language training create spaces where DHH individuals feel valued and included, strengthening social integration and equality (Bauman & Murray, 2014).

Additionally, sign language is vital in education, particularly for deaf children. Many deaf students struggle in traditional learning environments due to a lack of accessible communication. Teachers, parents, and peers who learn sign language can significantly improve the learning experiences of deaf students by ensuring they receive quality education without language barriers (Marschark & Hauser, 2012). Furthermore, bilingual education that includes both sign and spoken languages enhances literacy skills and cognitive abilities, fostering better academic performance (Rodríguez et al., 2014).

Another crucial advantage of sign language learning is its positive impact on cognitive and social development. Studies have shown that learning a second language,

including sign language, enhances brain function, improves memory, and strengthens problem-solving skills (Marschark & Knoors, 2012). Unlike spoken languages, sign language requires the use of visual and spatial processing, which can boost mental flexibility and creativity. Additionally, it improves social skills by encouraging empathy, patience, and active listening, as sign language users must pay close attention to facial expressions and body movements.

Moreover, sign language has applications beyond the DHH community. It is beneficial for young children, as they can develop communication skills earlier through sign language before mastering spoken words (Geers et al., 2003). It is also useful for individuals with speech disorders, autism, or other communication challenges. In emergency situations or noisy environments, sign language serves as an effective alternative communication method.

Despite its importance, sign language is not widely taught in mainstream education, and there is still a lack of awareness regarding its benefits. To address this, governments and institutions should integrate sign language into school curriculums and public awareness campaigns. Encouraging mobile applications, online courses, and sign language interpretation services can also promote widespread learning (Fernández-López et al., 2013).

The advancement of mobile technology offers a promising solution to bridge this gap (Looi et al., 2010). Mobile applications provide a flexible, interactive, and engaging platform for learning sign language, making it more accessible to a wider audience. Unlike traditional learning methods, mobile applications can incorporate multimedia elements such as videos, animations, interactive quizzes, and gesture recognition technologies to enhance the learning experience. Additionally, artificial intelligence (AI) and machine learning can be integrated to improve real-time gesture recognition, making the learning process more effective and personalized.

Despite the availability of several sign language learning applications, many still have limitations, such as a lack of interactivity, limited sign language vocabulary, and the absence of AI-powered recognition features (Naranjo-Zeledón et al., 2019). Some applications rely solely on static images or text-based explanations, which do not effectively teach the fluid and dynamic nature of sign language gestures. Moreover, many existing apps are not designed with user-centered accessibility features, making them difficult for beginners or individuals with disabilities to use.

Given these challenges, this research focuses on developing a mobile application that enhances the learning process of sign language by integrating innovative technologies

and user-friendly features(Parvez et al., 2019). The study aims to explore how interactive learning models, AI-driven gesture recognition, and multimedia resources can improve user engagement and retention in sign language learning. Additionally, the research seeks to address usability concerns by ensuring the application is accessible to diverse users, including individuals with hearing impairments, educators, and non-signers who wish to learn.

By developing a comprehensive and technologically enhanced mobile application for sign language learning, this research contributes to the promotion of inclusivity and accessibility for the DHH community. It also provides a modern and effective learning tool that can be adopted in educational institutions, workplaces, and personal learning environments.

### **Research Problem Statement**

Communication is a fundamental aspect of human interaction, yet millions of deaf and hard-of-hearing (DHH) individuals around the world face significant barriers due to a lack of widespread knowledge of sign language(Pizzo, 2016). Sign language serves as a primary means of communication for the DHH community, but many hearing individuals, including educators, healthcare professionals, and family members, do not have the necessary skills to communicate effectively using sign language. This gap in communication creates challenges in education, employment, social inclusion, and access to essential services(Camarero & Oliva, 2019). While efforts have been made to promote sign language learning, traditional learning methods often lack accessibility, engagement, and effectiveness.

In recent years, mobile technology has transformed the way people learn languages, offering interactive and accessible learning experiences. However, the development of mobile applications for sign language learning remains limited, and many existing applications have significant shortcomings. Some lack interactive features, making learning passive and less engaging, while others provide only static images or videos without real-time feedback(Cherrett et al., 2009). Additionally, the absence of artificial intelligence (AI) or machine learning-based gesture recognition limits the ability of learners to practice and receive immediate corrections on their signing techniques(Paudyal, 2020). These limitations reduce the effectiveness of current solutions and discourage learners from mastering sign language.

Another challenge is the lack of inclusivity and accessibility in existing sign language learning applications. Many are not designed with user-centered approaches, making them difficult to navigate for users with disabilities(Jafri & Khan, 2018). Furthermore, most applications focus on only one sign language variant (such as American Sign

Language or British Sign Language), ignoring the diverse sign languages used worldwide. This restricts the global reach and usability of such applications, leaving many potential learners without appropriate learning resources.

Given these challenges, there is a pressing need for a more effective, interactive, and accessible mobile application that enhances sign language learning. This research aims to develop a mobile application that incorporates innovative technologies such as AI-powered gesture recognition, interactive learning modules, and multimedia resources to improve user engagement and retention. By addressing the limitations of existing applications, this study seeks to contribute to the advancement of sign language education and promote inclusivity for the DHH community.

The lack of accessible, interactive, and technology-enhanced tools for sign language learning presents a significant barrier to communication for both DHH individuals and the hearing population (Toofaninejad et al., 2017). This research seeks to bridge that gap by developing a mobile application that enhances the learning experience through modern technological solutions. By doing so, it aims to support sign language learners, improve communication accessibility, and foster greater social inclusion for the DHH community.

### **Novelty of Research**

The development of sign language learning applications has seen significant progress in recent years, yet many existing solutions still have limitations in terms of interactivity, accessibility, and technological integration. While various applications offer basic sign language lessons through images and videos, they often lack real-time feedback, adaptive learning mechanisms, and user-friendly accessibility features (Drigas et al., 2004). This research introduces an innovative approach to sign language learning by integrating advanced technologies such as artificial intelligence (AI), machine learning, and interactive multimedia elements to create a more effective and engaging mobile learning experience.

One of the key novelties of this research is the incorporation of AI-powered gesture recognition to enable real-time feedback for learners. Unlike conventional applications that rely solely on video demonstrations, this system will allow users to practice sign language gestures while receiving immediate corrections and guidance (Von Agris et al., 2008). By leveraging computer vision and machine learning techniques, the application will analyze hand movements, positioning, and accuracy, providing a more interactive and immersive learning process. This real-time evaluation feature sets the proposed application apart from many existing tools that do not offer personalized feedback to learners (Motiwalla, 2007).

Another unique aspect of this research is its focus on a user-centered design approach to improve accessibility for both deaf and hearing users. Many current applications are not designed with inclusivity in mind, making navigation difficult for individuals with disabilities (Abascal & Nicolle, 2005). This study aims to develop an intuitive and accessible user interface that incorporates voice commands, text-to-sign translation, and adaptive learning paths based on user progress. By ensuring that the application meets the diverse needs of learners, the research contributes to the development of a truly inclusive educational tool.

Furthermore, this study seeks to address the multilingual and multicultural limitations present in many sign language learning applications. Most existing solutions focus on a single sign language variant, such as American Sign Language (ASL) or British Sign Language (BSL), leaving out users who rely on different national or regional sign languages (Brentari, 2010). This research aims to integrate multiple sign language systems into a single platform, allowing users to switch between different sign languages based on their preferences and needs. By doing so, the application will serve as a valuable resource for a global audience, bridging the gap between different linguistic communities.

Additionally, the research introduces gamification and adaptive learning techniques to enhance user engagement and motivation. Traditional sign language learning methods often lack interactivity, which can lead to decreased motivation among learners (Baber, 2020). By incorporating elements such as quizzes, progress tracking, and reward-based challenges, the application will encourage consistent learning and skill retention. The use of AI-driven adaptive learning will also tailor the difficulty level of lessons based on user performance, ensuring a personalized and effective learning experience.

This research presents a novel contribution to the field of sign language education by developing a mobile application that combines AI-driven gesture recognition, user-centered accessibility features, multilingual support, and gamification elements. These innovations address the current limitations in sign language learning tools, offering a more interactive, inclusive, and effective platform for both deaf and hearing users (Martins et al., 2015). By integrating cutting-edge technology and user-friendly design, this research has the potential to revolutionize the way sign language is taught and learned, ultimately promoting greater communication accessibility and social inclusion for the deaf and hard-of-hearing community.

### **Plan for the results and discussion of this research**

The results and discussion section of this research will focus on analyzing the effectiveness, usability, and impact of the developed mobile application for sign language learning. The evaluation will be conducted through a combination of usability testing, performance assessments, and user feedback. By assessing the application's ability to enhance sign language acquisition and engagement, this section will provide critical insights into the strengths, limitations, and future improvements of the proposed solution.

The first part of the results section will present findings on the effectiveness of the application in improving sign language learning outcomes. This will be measured by tracking users' progress over time, analyzing their ability to recognize and replicate signs correctly, and evaluating their retention of learned gestures. Pre- and post-test assessments will be conducted to compare users' proficiency before and after using the application. The discussion will interpret these results, comparing them with traditional learning methods to determine whether the mobile application provides a significant advantage.

A key aspect of the research will be assessing user experience (UX) and engagement with the application. Surveys, interviews, and usability tests will be conducted to gather feedback from learners, including both deaf and hearing individuals. The discussion will explore users' perceptions of the app's ease of use, accessibility, and overall learning experience. Specific attention will be given to the interactive features, such as AI-powered gesture recognition, gamification elements, and multilingual support, to determine their impact on motivation and learning effectiveness.

Since one of the novel contributions of this research is the integration of AI-driven gesture recognition, the accuracy and responsiveness of this feature will be critically examined. The results will include data on how well the system identifies hand gestures, the rate of correct versus incorrect classifications, and how effective it is in providing real-time feedback. The discussion will highlight the benefits of this technology in sign language learning while addressing any limitations, such as recognition errors, system latency, or challenges with complex signs.

Another critical component of the discussion will be the application's accessibility and inclusivity. The results will examine whether the application successfully caters to diverse users, including those with different levels of digital literacy, varying sign language proficiencies, and disabilities. The discussion will analyze whether features such as voice commands, text-to-sign translation, and an intuitive user interface effectively enhance usability for all target audiences. If usability issues arise, recommendations for improvement will be provided.

To position the research within the broader context of sign language learning technology, a comparative analysis will be included. The results will compare the developed application with existing sign language learning apps in terms of features, usability, and learning outcomes. The discussion will highlight how the new approach improves upon previous methods, emphasizing the contributions of AI, gamification, and multilingual support. This comparison will help validate the novelty and practical value of the research.

While the application aims to provide an innovative solution, it is essential to recognize potential challenges and areas for improvement. The discussion will address any technical limitations, such as difficulties in gesture recognition, user feedback limitations, or scalability issues. Additionally, recommendations for future enhancements, such as expanding the application to support more sign languages or integrating virtual reality (VR) for a more immersive experience, will be explored.

The results and discussion section will provide a comprehensive evaluation of the mobile application's effectiveness, engagement, and usability. By analyzing both quantitative and qualitative data, the research aims to present a balanced assessment of the application's contributions to sign language education. Ultimately, this section will highlight how the integration of AI, interactive learning, and accessibility features can transform the way sign language is taught and learned, promoting greater inclusion for the deaf and hard-of-hearing community.

## References

- Abascal, J., & Nicolle, C. (2005). Moving towards inclusive design guidelines for socially and ethically aware HCI. *Interacting with Computers*, 17(5), 484–505.
- Baber, H. (2020). Determinants of students' perceived learning outcome and satisfaction in online learning during the pandemic of COVID-19. *Journal of Education and E-Learning Research*, 7(3), 285–292.
- Bauman, H.-D. L., & Murray, J. J. (2014). *Deaf gain: Raising the stakes for human diversity*. U of Minnesota Press.
- Brentari, D. (2010). *Sign languages*. Cambridge University Press.
- Camarero, L., & Oliva, J. (2019). Thinking in rural gap: mobility and social inequalities. *Palgrave Communications*, 5(1), 1–7.
- Cherrett, T., Wills, G., Price, J., Maynard, S., & Dror, I. E. (2009). Making training more cognitively effective: Making videos interactive. *British Journal of Educational Technology*, 40(6), 1124–1134.
- Drigas, A. S., Vrettaros, J., Stavrou, L., & Kouremenos, D. (2004). E-learning Environment for Deaf People in the E-commerce and New Technologies Sector.

- WSEAS Transactions on Information Science and Applications*, 1(5), 1189–1196.
- Fernández-López, Á., Rodríguez-Fórtiz, M. J., Rodríguez-Almendros, M. L., & Martínez-Segura, M. J. (2013). Mobile learning technology based on iOS devices to support students with special education needs. *Computers & Education*, 61, 77–90.
- Geers, A. E., Nicholas, J. G., & Sedey, A. L. (2003). Language skills of children with early cochlear implantation. *Ear and Hearing*, 24(1), 46S–58S.
- Jafri, R., & Khan, M. M. (2018). User-centered design of a depth data based obstacle detection and avoidance system for the visually impaired. *Human-Centric Computing and Information Sciences*, 8, 1–30.
- Looi, C., Seow, P., Zhang, B., So, H., Chen, W., & Wong, L. (2010). Leveraging mobile technology for sustainable seamless learning: A research agenda. *British Journal of Educational Technology*, 41(2), 154–169.
- Marschark, M., & Hauser, P. C. (2012). *How deaf children learn: What parents and teachers need to know*. OUP USA.
- Marschark, M., & Knoors, H. (2012). Educating deaf children: Language, cognition, and learning. *Deafness & Education International*, 14(3), 136–160.
- Martins, P., Rodrigues, H., Rocha, T., Francisco, M., & Morgado, L. (2015). Accessible options for deaf people in e-learning platforms: technology solutions for sign language translation. *Procedia Computer Science*, 67, 263–272.
- Motiwalla, L. F. (2007). Mobile learning: A framework and evaluation. *Computers & Education*, 49(3), 581–596.
- Naranjo-Zeledón, L., Peral, J., Ferrández, A., & Chacón-Rivas, M. (2019). A systematic mapping of translation-enabling technologies for sign languages. *Electronics*, 8(9), 1047.
- Parvez, K., Khan, M., Iqbal, J., Tahir, M., Alghamdi, A., Alqarni, M., Alzaidi, A. A., & Javaid, N. (2019). Measuring effectiveness of mobile application in learning basic mathematical concepts using sign language. *Sustainability*, 11(11), 3064.
- Paudyal, P. (2020). *Towards Building an Intelligent Tutor for Gestural Languages using Concept Level Explainable AI*. Arizona State University.
- Pizzo, L. (2016). d/Deaf and hard of hearing multilingual learners: The development of communication and language. *American Annals of the Deaf*, 161(1), 17–32.
- Rodríguez, D., Carrasquillo, A., & Lee, K. S. (2014). *The bilingual advantage: Promoting academic development, biliteracy, and native language in the classroom*. Teachers College Press.
- Stokoe Jr, W. C. (2005). Sign language structure: An outline of the visual communication systems of the American deaf. *Journal of Deaf Studies and Deaf Education*, 10(1), 3–37.
- Toofaninejad, E., Zaraii Zavaraki, E., Dawson, S., Poquet, O., & Sharifi Daramadi, P. (2017). Social media use for deaf and hard of hearing students in educational

settings: a systematic review of literature. *Deafness & Education International*, 19(3–4), 144–161.

Von Agris, U., Zieren, J., Canzler, U., Bauer, B., & Kraiss, K.-F. (2008). Recent developments in visual sign language recognition. *Universal Access in the Information Society*, 6, 323–362.

Vygotsky, L. S. (2012). *Thought and language*. MIT press.

Willoughby, L., & Sell, C. (2019). Studying a Sign Language. *Sign Language Studies*, 19(3), 453–478.