SUPPORTING VOCABULARY LEARNING IN DEAF LEARNERS THROUGH ASSISTIVE TECHNOLOGY: A STUDY OF THE POCKET SIGN APP

Wiwin Suriani[1], Salasiah Ammade[2], Siti Hajar Larekeng[3]

[1234]English Language Education Of
Graduate Program of Muhammadiyah University of Parepare, Indonesia
Corresponding author: wiwinsuriani17@gmail.com[1], salasiahammade@gmail.com[2], sitihajar7773@gmail.com[3]

ABSTRACT

Teaching the English language to deaf students presents both unique challenges and tremendous opportunities for the teacher. Teachers of deaf learners are required to use certain strategies in instruction. The study focused on determining the extent to which the Pocket Sign app as an assistive technology supports the vocabulary development among deaf students. The study employed a quantitative method with a one-group pre-test post-test design. The instrument of the study was a vocabulary test, which was analysed quantitatively using a paired sample t-test. The study involved six deaf students of SLBN Lutang in grades 4, 5, and 6. The study found that there was a significant difference between the students' pre-test and post-test, which means that the H0 was rejected and the H1 was accepted. The study concludes that the use of the pocket sign app as an assistive technology supports the vocabulary learning of the deaf learners.

Keywords: assistive technology, deaf learners, pocket sign app, vocabulary

INTRODUCTION

Understanding vocabulary is essential to listening, speaking, reading, and writing. Without a sufficient vocabulary and an effective strategy to acquire new vocabulary, learners struggle to maximize their English learning abilities (Hamer & Lely, 2019). However, learning vocabulary is rather challenging for deaf students due to the linguistic barriers. Deaf students have less chance of contact with the spoken language than regular students. Traditional methods of teaching English vocabulary, like reading and rote memorization, are uninteresting for many deaf students because these methods are not oriented toward their preferred ways of learning visually. Limited exposure to spoken words and the complexities of English syntax render most deaf students unable to understand the vocabulary and grammar of the language (Nugroho & Lintangsari, 2022).

Other hindrances to vocabulary instruction among deaf students are pedagogical concerns in which teachers have no exposure to sign language. A majority of the teachers usually do not undergo any proper training or experience using sign language, and this can be a tremendous block when teaching deaf students (Yusuf et al., 2023). Sign language is not merely the putting together of gestures; it is well-structured, and its grammar and syntax are included. SLs are used by DHH people in daily communication (Núñez-Marcos et al., 2023). Teachers who are unfamiliar with it may hardly manage to convey some detailed information or understand the response of students, which might result in miscommunication during the process of learning. Teachers who are unfamiliar with it can barely handle the transmission of some detailed information or understand the answer of the students, which could result in the processes of learning.

Some research has been carried out to cope with problems arising in teaching vocabulary to deaf students. Indah and Chanastalia (2018) emphasizes that when deaf students learn English, they need

several communication methods to help them communicate with their hearing peers in daily conversation. Furthermore, the studies conducted by Birinci & Sariçoban (2021), González-Reyes et al. (2021) and Egy Prasetya (2023) reported consistent findings that the use of visual aids along with sign language to engage the learning process in the classroom is one of the most effective strategies for teaching deaf students. In line with that, Yasin & Mohamad (2024) in a literature review explains the important role that visual aids play in helping children's understanding, strengthening memorization and cognitive skills, and increasing active participation.

While the previous studies have explored the use of visual aids and technology in language learning, especially for students with hearing impairments, most of these have focused on general digital tools or teacher-created media without incorporating real-time sign language support. Yusuf et al. (2023) discovered that assistive technology is needed to support proper communication among teachers and the deaf students throughout the learning process. Yuniarti et al. (2024) and Ridha & Shehieb (2021) found that the lack of comparison with current assistive applications employed in teaching English to deaf learners revealed a need to carry out more research on assistive technology (Souza & Vieira, 2020) (Krsek, 2019). Future efforts should focus on exploring effective educational practices for deaf students (Silva & Cardoso, 2021). This gap highlights the critical necessity for focused investigations that not only examine the possibilities of assistive technologies but also confirm their efficacy in aiding deaf students to develop essential English language skills. It is essential to tackle this gap to guarantee that deaf students can take advantage of inclusive, technology-enhanced educational methods that fit to their learning needs.

The study focused on the determining the extent to which the Pocket Sign app as an assistive technology supports the vocabulary development among deaf students. This objective identifies whether or not applying the Pocket Sign app in teaching vocabulary offers a significant improvement in the vocabulary development of the deaf students. The use of the pocket sign app meets the deaf students' needs since it provides sign language visual support through videos and interactive flashcards which specifically adapted for students with hearing impairments. This Pocket Sign app is meant to assist students who are hearing impaired in overcoming learning difficulties through new vocabulary learning methods.

Therefore, this study contributes a novel perspective by bridging mobile sign language technology to enhance vocabulary learning among deaf students. The research outcomes had significant practical implications in inclusive education. The study addresses the acute need for quality instructional materials in inclusive education. It demonstrates the high-performance outcomes of incorporating assistive technology and visual and interactive instructional approaches, maximally enhancing instruction quality and communication in deaf students.

1. DEAFNESS

Hearing loss is generally described as slight, mild, moderate, severe, or profound, depending upon how well a person can hear the intensities or frequencies most strongly associated with speech. (Kushalnagar, 2019). According to the World Health Organization (WHO), hearing loss is a reduced ability to hear sounds within the normal threshold of 20 dB or better. This may be in a range from mild to profound and might affect one or both ears, potentially making it difficult for a person to understand speech or perceive loud sounds. Furthermore, WHO-proposed grades of hearing impairment and presumed functional consequences as follows:

a. No impairment—better than 20 dB. There are no or very slight hearing problems.
b. Mild (20–34 dB). No problems in quiet, but may have real difficulty following conversation in noise.
c. Moderate (35–49 dB). May have difficulty in quiet hearing a normal voice and has difficulty with conversation in noise.

d. Moderately severe (50–64 dB). Needs loud speech to hear in quiet and has great difficulty in noise.
e. Severe, (65–79 dB). In quiet, one can hear loud speech directly in one's ear and, in noise, has very great difficulty.
f. Profound impairment (80–94 dB). Unable to hear and understand even a shouted voice, whether in quiet or noise.

2. SIGN LANGUAGE

Sign language is the major way of communication for people who are deaf. It becomes a primary method to express thoughts, feelings, and ideas (Varghese et al., 2021). This language, in itself, is a fully developed visual mode of communication that makes use of handshapes, facial expressions, body movements, and gestures in order to convey meaning. Whereas spoken languages rely on auditory input, sign languages are purely visual and, hence, uniquely addressed to the needs of deaf individuals. Sign languages are natural languages with their grammatical rules, syntax, and vocabulary independent of the spoken languages used in the same geographic regions (Sandler & Lillo-Martin, 2003).

Sign languages are not universal; each developed in context to the deaf history and identity of the respective deaf community they belong to. For example, although English is the official language in both countries, American and British Sign Language bear much difference from each other (Martinez Del Rio et al., 2022). There are two sign languages widely used in Indonesia: SIBI (Sistem Isyarat Bahasa Indonesia) and BISINDO (Bahasa Isyarat Indonesia). SIBI is a borrowing from American Sign Language (ASL), now adopted and used in the context of special education schools—SLB (Aditama et al., 2021). The Indonesian government instituted this system, which is a standardized system developed to conform to the spoken form of Indonesian, known as Bahasa Indonesia.

In contrast, BISINDO is a sign language that has developed naturally among the Deaf people in Indonesia. Unlike SIBI, BISINDO is free from the spoken Indonesian grammatical constraints, allowing a much more authentic representation of the linguistic and cultural behaviors of its users (Aljabar & Suharjito, 2020). From this point, BISINDO often becomes the preferable channel of communication in both informal and formal settings in daily life within the Deaf community, since it is much closer to them in terms of experience and needs. Despite considerable support from the local community, BISINDO has not yet been granted the status of standard language for use in schools by government authorities. This creates an ongoing debate between the formal and community practices regarding which one of these two systems is best suited to cater to the needs of the deaf community in Indonesia.

In educational contexts, sign language is an important medium of instruction for developing a better learning environment for students with deafness. This approach encourages comprehension and dialogue among students in the classroom, thereby creating greater accessibility in assimilating the knowledge being instilled. Most teachers encourage a bilingual-bicultural model, provided with the term Bi-Bi, whereby a deaf or hard-of-hearing child becomes fluent in sign language as well as the written form of a spoken language, such as English (Siran & Dettman, 2018). This approach not only promotes academic development but also provides a strong first culture for the deaf students.

3. POCKET SIGN APPLICATION

Pocket Sign is an assistive technology which is designed specifically to help the deaf individuals in learning English. It is an interactive mobile application designed to teach sign language through engaging and accessible features. Through intuitive interactive lessons, this tool helps users learn more about each of the signs that are useful for ASL signers all over the world. It is designed for hearing people and the hard of hearing who want to communicate more easily with the deaf community or learn sign language. Pocket Sign facilitates sign learning in a simple and effective manner using its e-platform; hence, it is an important tool for education as well as communication.

For students, the Pocket Sign app provides visual support with big, colorful images and text, which would be especially beneficial for young deaf students. The features are interactive, like that of practicing signs using the cameras, so it makes the users feel interested, thus boosting sharing and engagement. Meanwhile, for teachers, the app offers tools that enable them to monitor progress and to adjust the teaching process. With this simple design, teachers of all levels would easily access the app, even if they are not excellent at technology. They are able to teach their students how to use the app without having the students undergo lengthy training, which means it can easily fit into the classroom setting. Overall, the Pocket Sign user-friendly interface makes it very well suited to getting integrated into an educational environment for both deaf students and teachers. This user-friendliness indeed increases the efficacy of the intervention and diminishes the barriers that could hinder learning.

Pocket Sign includes several features that make it a powerful educational tool:

a. Interactive learning modules.



Picture 1 Pocket sign lessons

Picture 1: The module provides structured lessons for learning how to sign specific words or phrases. Users can choose the module topic or difficulty level—and an individual makes a personalized choice. These lesson units are topically designed and organized based on common academic words, greetings, or terminology.

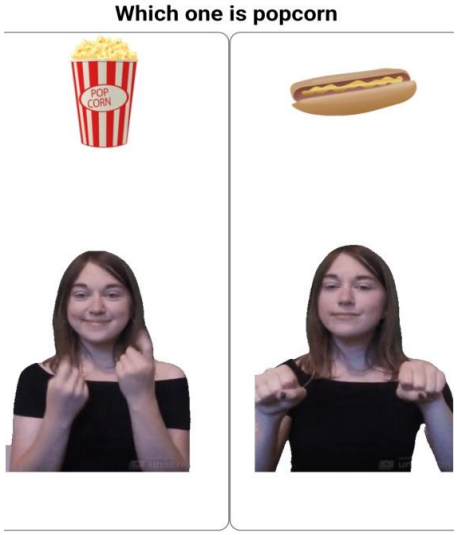
b. Sign language video demonstrations.



Picture 2. Video demonstration in pocket sign app

Picture 2: Each module provides videos of high quality show each sign in a clear and succinct manner, allowing the student to examine the proper hand forms, facial expressions, and movements.

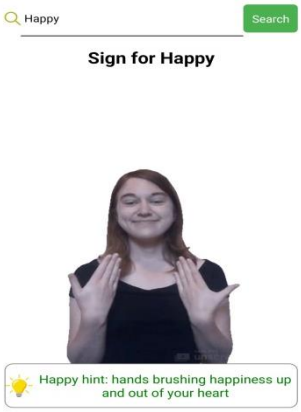
c. Gamified quizzes:



Picture 3. A gamified quiz in pocket sign app

Picture 3: These features are available in every learning module. The software uses gamification concepts to increase learning, measure knowledge, and engage users.

d. Sign vocabulary dictionary.



Picture 4. Looking up “happy” in the dictionary

Picture 4: This dictionary feature provides quick access to a large collection of signs, making it easy to find words as needed.

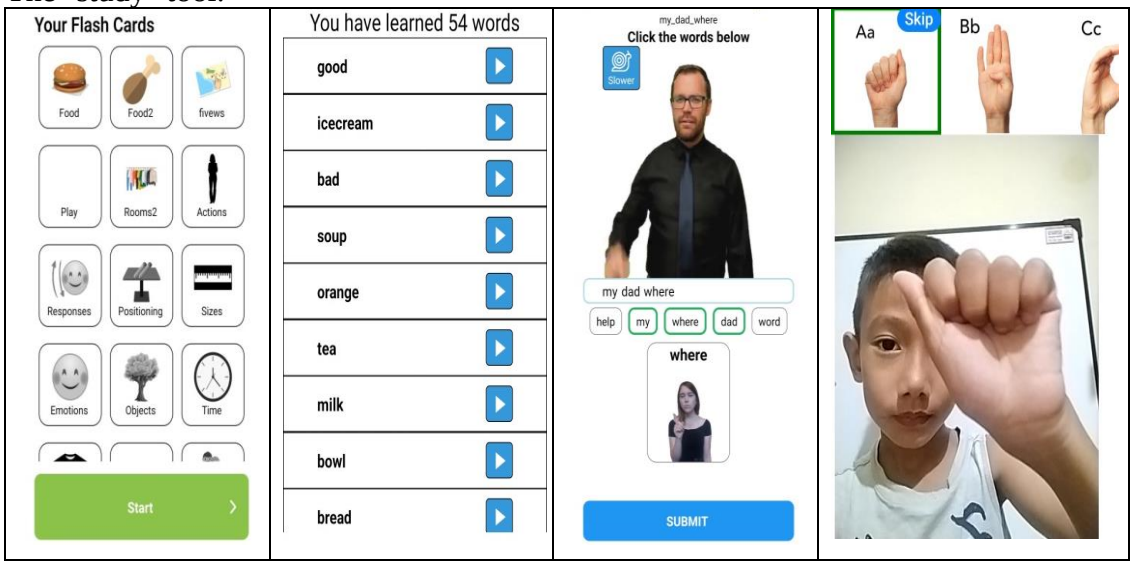
e. ASL alphabet.



Picture 5. ASL alphabet in pocket sign app

Picture 5: Similar to the SIBI alphabet, this is a 26-handed method for representing the letters of the English alphabet. This manual communication, often known as fingerspelling, is used to spell proper names, technical terms, and words for which no conventional signs have yet been developed. Each letter has its own unique configuration, allowing phrases to be spelled out clearly and precisely.

f. The "study" tool.



Picture 6. Features of "study" tool in pocket sign app

Picture 6: the feature of "study" tool includes 4 choices, namely flashcards, sign words, sentences, and camera sign practice. First, flashcards in Pocket Sign help users memorize signs and their meanings. The second is the sign words feature. It explores single words and their signs. The third is sign sentences, this feature takes it a step further than single words by showing users how to make and understand full sentences in sign language. The last is camera sign practice. It is a fun tool; using the smartphone's camera, it checks how well someone is signing.

All of Pocket Sign's characteristics make it ideal for deaf students to learn vocabulary in English. Visual learning is the major mode of instruction for deaf pupils, and Pocket Sign's video demos are appropriate for this. They enable pupils to readily connect the English word through its sign to the English word displayed in letters based on their mental images of the letters that comprise the word and its sign, respectively. Pocket Sign not only improves deaf students' sign language skills, but it also helps them learn English vocabulary. This takes advantage of both benefits: compensating for their primary language and providing a technique to use formal, written English efficiently, enhancing their literacy level and comprehension.

4. Vocabulary

Hiebert & Kamil (2005) enumerate vocabulary into specific types, telling of its intricate function in both language learning and understanding. The first type is oral vocabulary. It includes those words that a person knows and uses in oral language. Basically, it forms the foundation of speaking ability and listening comprehension. These are the words one comes across in day-to-day talk, stories, and even sounds. The second is print vocabulary. It is known and used by individuals when reading and/or writing. Print vocabulary is the cornerstone of literacy, as it enables people to read print and write their own ideas down on paper. In addition, print vocabulary complements oral literacy, hence bridging both oral and written communication.

The third type of vocabulary is receptive vocabulary. It is the vocabulary that a person understands when heard or seen, but that is not necessarily used by that person in any form of

speech or writing. Receptive vocabulary is the vocabulary that one understands when they hear or see it but it doesn't necessarily mean that those words are used in their spoken or written speech. The last is productive vocabulary. It is also called expressive vocabulary. On the other hand, it is the kind of vocabulary that people actively use in both oral and written production. Such choices manifest in words used for expressing thoughts, opinions, and feelings. The extent of productive vocabulary represents the ability of an individual to go beyond just mere understanding and express words in communicative situations.

The focus of the research is on print vocabulary and receptive vocabulary. These types of vocabulary become the focus due to the reasonable explanations. First, oral vocabulary is less applicable, as deaf students primarily communicate using sign language rather than speech. Second, the app's interactive features—such as the use of sign videos and flashcards—create an ideal environment for strengthening recognition and understanding and associating written words with their meanings. Finally, focusing on these types is related to the goal of building foundational language skills that can later support productive vocabulary development in signing or writing.

RESEARCH METHODOLOGY

The study employed a quantitative method with a one-group pre-test post-test design. The quantitative method is concerned with the systematic and objective measurement of variables, sometimes using numerical data to uncover a pattern, relationship, or even a causal link (Creswell, 2014). The data was collected by using a written vocabulary test. It consisted of 15 multiple-choice-type questions since it covers a wide range of learning objectives while making efficient use of testing time (Brookhart & Nitko, 2019). The vocabulary test was used for the pretest and post-test. The pretest was purposed toward the assessment of the students' proficiency in vocabulary knowledge at the time before the implementation of the Pocket Sign application. On the contrary, the posttest measured changes after learning vocabulary using Pocket Sign. The result of the pre-test and the post-test was analyzed quantitatively using a paired sample t-test.

The participants in this study were selected purposively since this sampling technique was considered very representative toward the purpose of the research. The participants consist of six deaf students from the elementary school of SLBN Lutang in grades 4, 5, and 6. According to the medical records provided by their parents, three individuals are classified as deaf. Student C is classified as experiencing profound hearing impairment, exhibiting a hearing sensitivity of 89 dB in the left ear and 100 dB in the right ear. Student H exhibits significant hearing impairment, as both of his ears register a hearing level of 100 dB. Student L exhibits depth as well. The left ear responds to sound levels of 100 dB, whereas the right ear reacts to 85 dB. The remaining three students—F, S, and M—have been accepted without the submission of medical records, as the school teachers have made their decisions based on their professional observations and expertise

FINDINGS AND DISCUSSION

The pre-test was conducted at the first meeting to measure the initial vocabulary knowledge of the students. Meanwhile, the post-test took place at the last meeting after six meetings of intervention applying the pocket sign in learning English vocabulary. The test focused on vocabulary connected to the theme "Food" and assessed the students' ability to recognize and understand English words through visual cues. The following chart shows the comparison of the students' pre-test and post-test:

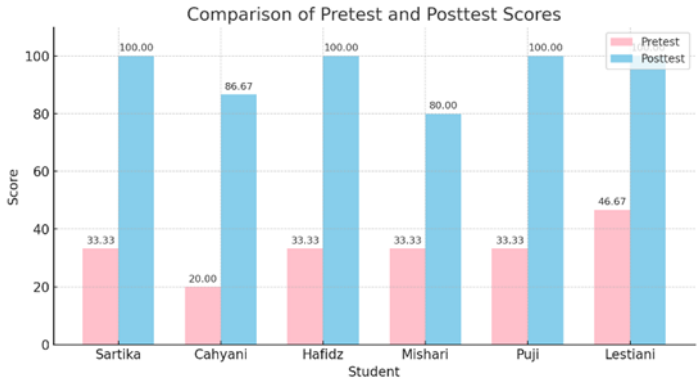


Chart 1. The comparison between the pre-test and the post test scores of the participants

Chart 1: It shows the comparison of the pre-test and post-test scores of six deaf students who underwent the Pocket Sign app-based vocabulary learning intervention. All the students have significantly improved from the pre-test. The chart reflects that all students have significant and consistent improvement. Student L received the highest score of 46.67 in the pre-test, while student C received the lowest score of 20.00. The pre-test results showed inadequate prior knowledge of the language, with an average of 33.00, which is considered very weak. On the other hand, post-test results significantly improved, with two students (C and M) getting 86.67 and 80.00, respectively, and four students (S, H, P, and L) earning a perfect score of 100.00. After the test, the average score increased to 94.45, which is considered significant.

To determine if students' vocabulary growth differed significantly before and after intervention, statistical analysis with SPSS version 26 was utilized. A paired sample t-test of the pre-test and post-test scores of six deaf students who participated in the research was utilized. This is the preferred test, as it is appropriate for finding the difference between two correlated samples in this case, i.e., the same group of students before and after being treated.

Table 1. Descriptive statistics of the pre-test and the post-test

	Mean	N	Std. deviation	Std. Error Mean
Pre-test	33.0	6	7.86	3.21
Post-test	94.45	6	8.22	3.35

Table 2. Paired sample t-test result is presented in the following table

	Mean difference	Std. deviation	t	Df	Sig. (2-tailed)
Pre-test – post test	61.45	5.36	28.49	5	0.000

Table 3. The comparison between the t-count and t-table

Description	Value
Number of Students (n)	6
Degrees of Freedom (df)	5
Significance Level (α)	0.05 (2-tailed)
t-Table (Critical Value)	2.571
t-Count (Observed Value)	28.49
Comparison Result	28.49 > 2.571
Conclusion	Reject H_0; accept H_1. There is a significant difference.

Based on table 1, the mean difference between the pre-test and post-test scores was 61.45, with a standard deviation of 5.36. It indicates a statistically significant difference between pre-test and post-test scores. In line with that, the paired samples t-test analysis in table 2, shows the significance value was less than 0.001 ($p < 0.001$) which means the is considerable improvement in students' vocabulary development after the intervention utilizing the Pocket Sign application. The t-test gave a t-count of 28.49, which is significantly more than the t-table value of 2.571 at the 0.05 significance level with 5 degrees of freedom. This statistical finding leads to the rejection of the null hypothesis (Ho) and the acceptance of the alternative hypothesis (H1), demonstrating that the Pocket Sign application had a significant beneficial impact on students' vocabulary achievement.

This result of the study accords with the primary purpose of the intervention, which was to support the vocabulary development among deaf children through a technology-enhanced learning strategy. The utilization of visual aids, sign language representation, and interactive features within the Pocket Sign app effectively aided students in understanding and memorizing new English words. The clear improvement in test results implies that the multimodal style of the pocket sign app catered well to the visual learning preferences of deaf learners.This conclusion is congruent with Ullah and Tabassum (2021), who reported that multimedia-based training greatly enhanced vocabulary memory among hearing-impaired pupils. Similarly, a study by Wicha et al. (2012) stressed that combining sign language in digital learning materials can considerably boost students' receptive vocabulary. However, while both studies validated the benefits of multimedia, this study adds innovation by explicitly using the Pocket Sign application, which mixes sign language, contextual words, and camera-based sign practice in one platform. This multimodal strategy appears to have a larger influence on both comprehension and recollection.

Furthermore, the findings supported Yasin (2024), who reported that structured vocabulary acquisition with repetitive visual input enhances memory reinforcement in deaf learners. The design of the six intervention meetings in this study followed a similar logic, progressively transitioning from exposure (by flashcards and sign words) to application (via sign sentences and camera sign), giving repeated, contextualized practice. In contrast, several prior research such as by Karal and Silbir (2010) focused on the use of paper sign language dictionaries, which revealed more limited advances in vocabulary learning compared to digital apps. This distinction illustrates the enhanced benefit of interactive and technology-based solutions, especially in giving immediate feedback and compelling material. The Pocket Sign app's user-centered design likely contributed to the higher learning gains in this study compared to non-digital or less interactive alternatives.

The results of this study are also well in line with other studies focusing on how important visual aids and sign language are when it comes to teaching deaf children. Birinci and Sariçoban (2021) explained how the utilization of visual aids like pictures, charts, and videos alongside sign language could help deaf learners acquire new words and understand what they read better. Likewise, González-Reyes et al. (2021) discovered that the utilization of multimodal resources, specifically those with sign language and image representation, makes learning more effective and interesting. These approaches allow people to convey meaning to each other better and give them cues on word meaning that make them easier to remember. These research studies validate the findings of the current study, which revealed that the Pocket Sign application, with its visual flashcards, sign demonstrations, and interactive options, enabled the students to learn new vocabulary significantly. The application rendered learning vocabulary fun and easy through the use of sign-supported visual modes of learning. This is also consistent with what previous research has advocated for in multimodal approaches.

Likewise, Prasetya (2023) created LetSign, an Android app that helps users learn English vocabulary by showing videos of sign language. His study also validated the effectiveness of the app for teaching and retaining new words among deaf children, citing classroom engagement and student happiness. Such findings strongly support the outcome of a similar study, in which the Pocket Sign app, offering the same combination of visual flashcards and sign language videos, greatly enhanced students' vocabulary performance. Pocket Sign's multimodality, like that of SignText and LetSign, covered the language and cognitive needs of deaf learners by exposing vocabulary in a clear, visually enriched format. That each of these platforms works successfully testifies to the benefit of sign-supported assistive technology in language teaching for deaf learners. It also shows that Pocket Sign is a successful tool for use in instructional settings in inclusive classrooms.

The present study supports the findings of Krsek (2019), who underscored the reality that assistive technologies play a crucial role in enabling learners with hearing disabilities to access and retain language content efficiently. Through an investigation of pedagogical practice, Krsek discovered that technology, which incorporates the use of visual input and sign language—such as visual dictionaries and sign-integrated mobile apps—helps overcome communication barriers and enhance language learning. Findings to date also resonate with Nasir et al. (2021), who investigated the use of mobile technologies among hearing-impaired learners of English as a second language. The study underscored that mobile apps designed with visual and interactive features considerably improved both accessibility and student motivation. Similarly, the Pocket Sign application—with its sign demonstrations, flashcards, and learner-friendly interface—was found to be effective in supporting vocabulary learning of students, as evidenced in this research through the vocabulary test. These parallels suggest that when mobile learning applications are designed with careful consideration for deaf students, they can be utilized as effective assistive technologies to enable inclusive and successful language learning.

The current findings are also heavily corroborated by Syamsuddin et al. (2023), who designed a mobile dictionary application founded on the Indonesian Sign System (SIBI) to facilitate the learning of words by deaf students. Their research strongly highlighted the fact that sign-supported digital technology is an explicit, replicable, and accessible means of enhancing language development in children with special needs. Although Pocket Sign uses ASL, its function and design are the same—providing sign-based visual input to aid English vocabulary acquisition. Like the SIBI dictionary app, Pocket Sign showed a beneficial effect on students' vocabulary acquisition and engagement. The convergence of findings establishes that sign language mobile learning apps are not just effective across diverse sign systems (SIBI or ASL) but also sensitive to deaf students' particular needs in inclusive classrooms.

The research findings of this study support the implications drawn by Al Siyabi et al. (2022), who explored the realities and attitudes of utilizing assistive technology in English language classrooms. Their findings affirmed that when used with caution, assistive devices have the potential to enhance greatly vocabulary development, comprehension, and

independence among learners with disabilities. The findings of the present study also validate this premise in that the Pocket Sign app—in virtue of its sign-supported visual features—was able to enhance the acquisition of vocabulary among deaf students. Also, just like the perceptions of teachers in Al Siyabi et al.'s study, this research recognizes the relevance of accessibility, ease of use, and pedagogical alignment in determining the success of technology-enhanced language learning for deaf students. Thus, this study not only supports earlier research on the utility of visual and digital supports for special education, but also adds new information on the actual rollout of mobile sign language technologies in structured classroom interventions.

CONCLUSION

The results of the study demonstrated a substantial rise in students' vocabulary development after using the Pocket Sign app. The mean difference between pre-test and post-test scores was 61.45, with a t-count of 28.49, which is substantially above the t-table value of 2.571 at a significance level of 0.05. This reveals that the Pocket Sign software effectively enhanced vocabulary growth among deaf children. The visual, interactive, and sign language-based components of the program fit the particular learning demands of the children, allowing them to process, retain, and apply English terminology in a meaningful and contextual way. In summary, the Pocket Sign can function as a pedagogical tool, supporting the value of assistive technology in fostering inclusive, engaging, and effective learning environments for students with hearing impairments. Teachers of deaf students are urged to integrate visual and sign-based tools like Pocket Sign into their vocabulary training. These tools can make learning more accessible and participatory.

ACKNOWLEDGEMENT

We acknowledge our thanks to Directorate of Research, Technology, and Community Service, Ministry of Education, Culture, Research, and Technology of Indonesia for financial support to our research. Thus, our gratitude goes to inclusive students of SLBN Lutang for their wonderful involvement during the research implementation.

REFERENCES

Aditama, P. W., Putra, P. S. U., Yusa, I. M. M., & Putra, I. N. T. A. (2021, March). Designing augmented reality SIBI sign language as a learning media. In *Journal of Physics: Conference Series* (Vol. 1810, No. 1, p. 012038). IOP Publishing. https://doi.org/10.1088/1742-6596/1810/1/012038

Aljabar, A., & Suharjito, S. (2020). BISINDO (Bahasa Isyarat Indonesia) Sign language recognition using CNN and LSTM. *Advances in Science, Technology and Engineering Systems Journal, 5*(5), 282–287. https://doi.org/10.25046/aj050535

Al Siyabi, J., Tuzlukova, V., Al Kaabi, K., & Hadra, M. (2022). Assistive technology in the English language classroom: Reality and perspectives. *Journal of Language Teaching and Research, 13*(6), 1203–1210. https://doi.org/10.17507/jltr.1306.17

Brookhart, S. M., & Nitko, A. J. (2019). *Educational assessment of students (eighth edition).* Pearson.

Creswell, J. W. (2014). *Research design: Qualitative, quantitative, and mixed methods approaches* (4. ed). SAGE.

González-Reyes, N., Ibáñez-Acevedo, P., Inostroza-Araos, M.-J., & Strickland, B. (2021). Exploratory action research: teaching EFL vocabulary to deaf students through the use of visual aids. *Colombian Applied Linguistics Journal*, *23*(1), 94–116. https://doi.org/10.14483/22487085.16125

Gülengül Birinci, F., & Sariçoban, A. (2021). The effectiveness of visual materials in teaching vocabulary to deaf students of EFL. *Journal of Language and Linguistic Studies*, *17*(1), 628–645. https://doi.org/10.52462/jlls.43

Hamer, W., & Lely, L. N. (2019). Using pictionary game to increase learners' vocabulary mastery in english language instruction. *Journal of English Education Studies*, *2*(1), 43–51. https://doi.org/10.30653/005.201921.30

Hiebert, E. H., & Kamil, M. L. (Eds.). (2005). *Teaching and Learning Vocabulary* (0 ed.). Routledge. https://doi.org/10.4324/9781410612922

Indah, R. N., & Chanastalia, C. (2018). The communication methods in English classroom for Indonesian deaf students. *Theory and Practice in Language Studies*, *8*(1), 9. https://doi.org/10.17507/tpls.0801.02

Karal, H., & Şılbır, L. (2010). The research about the usability of a visual dictionary developed for the hearing-impaired students. Procedia-Social and Behavioral Sciences, 9, 1624-1628.

Krsek, O. Ye. (2019). Use of assistive technologies for language learners with visual and hearing impairments in the USA. *Духовність Особистості: Методологія, Теорія і Практика*, *93*(6), 148–155. https://doi.org/10.33216/2220-6310-2019-93-6-148-155

Kushalnagar, R. (2019). Deafness and hearing loss. In *Web accessibility: A foundation for research* (pp. 35-47). London: Springer London. Núñez-Marcos, A., Perez-de-Viñaspre, O., & Labaka, G. (2023). A survey on Sign Language machine translation. *Expert Systems with Applications*, *213*, 118993. https://doi.org/10.1016/j.eswa.2022.118993

Martinez Del Rio, A., Ferrara, C., Kim, S. J., Hakgüder, E., & Brentari, D. (2022). Identifying the correlations between the semantics and the phonology of American sign language and British sign language: A vector space approach. *Frontiers in Psychology*, *13*, 806471. https://doi.org/10.3389/fpsyg.2022.806471

Nasir, N. A. M., Hashim, H., Rashid, S. M. M., & Yunus, M. M. (2021). Exploring the potential usage of mobile technologies among the hearing-impaired students in learning English as a second language (ESL). *International Journal of Interactive Mobile Technologies (iJIM)*, *15*(19), 48–60. https://doi.org/10.3991/ijim.v15i19.24751

Nugroho, F. A., & Lintangsari, A. P. (2022). Deaf students' Challenges in learning English: a literature review. *IJDS Indonesian Journal of Disability Studies*, *9*(02), 217–224. https://doi.org/10.21776/ub.ijds.2022.009.02.06

Prasetya, E., Apriliaswati, R., Suhartono, L., Susilawati, E., & Riyanti, D. (2023). Teachers challenges and efforts in teaching english vocabulary for deaf students: A case study of non-certified special education English teacher at SMALB-B Dharma Asih Pontianak. *Journal of Scientific Research, Education, and Technology (JSRET)*, *2*(2), 545-552

Ridha, A. M., & Shehieb, W. (2021). Assistive technology for hearing-impaired and deaf students utilizing augmented reality. *2021 IEEE Canadian Conference on Electrical and Computer Engineering (CCECE)*, 1–5. https://doi.org/10.1109/CCECE53047.2021.9569193

Sandler, W., & Lillo-Martin, D. (2003). Natural Sign Languages. In M. Aronoff & Saman, F. I., Shariff, N. F. M., & Nasaruddin, N. I. S. (2019). i-Sign: Sign language learning application via gamification. Asian Journal of University Education, 15(3), 187-197.

Syamsuddin, S., Pristiwaluyo, T., Saleh, W. A., & Zulfitrah, Z. (2023). Development of Indonesian Sign Language System (SIBI) Dictionary Application for Students with Special Needs. *AL-ISHLAH: Jurnal Pendidikan*, *15*(3), 3132-3143.Silva, E. G. N. D., & Cardoso, C. D. N. A. (2021). A importância do uso da tecnologia assistiva na

educação de surdos. *Research, Society and Development*, *10*(3), e28410313153. https://doi.org/10.33448/rsd-v10i3.13153

Siran, S., & Dettman, S. (2018). Qualitative analysis of caregivers' perspectives regarding using Auslan within a Bilingual-Bicultural (Bi-Bi) approach with their children who use cochlear implants. *Deafness & Education International*, *20*(3–4), 205–227. https://doi.org/10.1080/14643154.2018.1519965

Souza, C. J. D., & Vieira, A. A. (2020). A utilização das tecnologias assistivas para alunos surdos em tempos de pandemia: Um estudo introdutório. *Itinerarius Reflectionis*, *16*(1), 01–25. https://doi.org/10.5216/rir.v16i1.65382

Ullah, I., & Tabassum, R. (2021). Effect of teaching English stories through multimedia on vocabulary development of hearing impaired students at elementary level. The Dialogue, 16(1), 10-21.

Varghese, R. M., Siddharth, S., Biju, J., Dutta, S., Aggarwal, A., & Vaegae, N. K. (2021). Sign Language recognition using convolutional neural networks. In S. Choudhury, R. Gowri, B. Sena Paul, & D.-T. Do (Eds.), *Intelligent Communication, Control and Devices* (Vol. 1341, pp. 415–425). Springer Singapore. https://doi.org/10.1007/978-981-16-1510-8_40

Wicha, S., Chakpitak, N., & Adipattaranan, N. (2012). An active vocabulary learning tool for primary school students with a hearing impairment. International Journal of Innovation and Learning, 11(2), 115-135.

Yasin, M. M., & Mohamad, M. (2024). The use of visual aids to improve deaf students' english vocabulary: A literature review. *SHS Web of Conferences, 182*, 02001. https://doi.org/10.1051/shsconf/202418202001

Yuniarti, F., Pratiwi, D., & Novianto, R. (2024). Developing podcast-based learning media for english education among deaf students. *Voices of English Language Education Society*, *8*(1), 293–302. https://doi.org/10.29408/veles.v8i1.24854

Yusuf, M., Adriyanto, F., Priyono, P., & Rahman, A. (2023). Pedagogical problem faced by teachers in communication and language learning for deaf students in special schools. In I. Ifdil (Ed.), *Proceedings of the 3rd Progress in Social Science, Humanities and Education Research Symposium (PSSHERS 2021)* (pp. 15–27). Atlantis Press SARL. https://doi.org/10.2991/978-2-494069-33-6_3