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Software in the sign language teaching and learning process: A systematic and bibliometric review

Software en el proceso de enseñanza aprendizaje de lengua de señas: una revisión sistemática y bibliométrica

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Abstract

The objective of this systematic and bibliometric review was to analyze the impact of software on the teaching and learning process of sign language. To this end, publications from 2010 to 2023 were reviewed using the PRISMA method and a structured search in Scopus and Web of Science. Of the 628 studies identified, 16 met the inclusion criteria. The selected articles evaluated diverse technological tools, such as convolutional neural networks, augmented reality, animated avatars, speech recognition, and computer vision systems. The results reveal that these technologies foster more accessible and efficient learning, especially for people with hearing impairments and hearing learners. Furthermore, the greatest scientific output was concentrated in countries such as India, Saudi Arabia, and Egypt. In conclusion, the findings highlight the potential of these tools to enhance communication and promote educational inclusion.

Keywords: learning, teaching, software.

Resumen

El objetivo de esta revisión sistemática y bibliométrica fue analizar el impacto del software en el proceso de enseñanza-aprendizaje de la lengua de señas. Para ello, se revisaron publicaciones entre 2010 y 2023, aplicando el método PRISMA y una búsqueda estructurada en Scopus y Web of Science. De los 628 estudios identificados, 16 cumplieron los criterios de inclusión. Los artículos seleccionados evaluaron herramientas tecnológicas diversas, como redes neuronales convolucionales, realidad aumentada, avatares animados, reconocimiento de voz y sistemas de visión computacional. Los resultados revelan que estas tecnologías fomentan un aprendizaje más accesible y eficiente, especialmente para personas con discapacidad auditiva y usuarios oyentes en formación. Además, se concentró la mayor producción científica en países como India, Arabia Saudita y Egipto. En conclusión, los hallazgos destacan el potencial de estas herramientas para potenciar la comunicación y promover la inclusión educativa.

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Palabras clave: aprendizaje, enseñanza, software.

Introduction

Globally, over 400 million individuals are affected by varying degrees of hearing impairment (Organización Mundial de la Salud, 2025). This population constitutes a distinct community with its own language and culture (Falvo et al., 2020). However, these differences often go unnoticed, and society frequently overlooks how their modes of perception and interaction with the environment differ significantly from those of hearing individuals (Saksiri & Ruenwongsa, 2010).

In Peru, for instance, it has been documented that among a population exceeding one million, over 100,000 individuals experience some form of disability (Instituto Nacional de Estadística e Informática [INEI], 2017). Furthermore, the Ministerio de Educación (2020) reports 430 centers for special basic education (CEBE) aimed at promoting the inclusion of children with hearing impairments. Additionally, the Federation of the Deaf represents over 72 million members, striving to integrate them into standard regular education (EBR) and alternative basic education (EBA) through the instruction of Peruvian Sign Language (LSP). Nevertheless, this endeavor faces significant challenges, particularly due to the lack of trained professionals and appropriate technological tools to facilitate learning (Defensoría del Pueblo, 2020).

Within the educational system, there is a notable deficiency of programs or software that enable educators and students to comprehend sign language (Alaín et al., 2020; Hepp et al., 2015). Therefore, leveraging Information and Communication Technologies (ICT) to design such software represents a crucial multicultural paradigm (Labrada-Pérez et al., 2015). Consequently, given the scarcity of virtual systems as tools for understanding and including individuals with hearing impairments (Yeh & Tseng, 2020), this software becomes indispensable in the teaching and learning processes.

Considering the challenges faced by students with hearing impairments, it is imperative to promote technological applications that enhance content comprehension (Cheah & Lee, 2015). This approach encourages both independent and cooperative learning, thereby preventing social isolation and fostering adequate socialization through ICT and inclusive education (Brow et al., 2015).

Moreover, research on sign language (SL) consistently garners interest in linguistics and the teaching-learning process, acknowledging the complexities associated with teaching and learning SL (Naranjo-Zeledón et al., 2021). Additionally, it has been observed that technology opens up new avenues for communication, enhancing exchanges and making the reinforcement of programs that deepen understanding of SL essential (Costa et al., 2017).

Thus, this study focuses on reviewing primary research concerning the design of software that optimizes the teaching-learning process of sign language, as tools on practical platforms significantly enhance comprehension (Li et al., 2022). These systems integrate artificial environments with real-world experiences, an approach that has proven highly effective in practice (Mohd & Boilis, 2021). Furthermore, software that transcends mere educational content by incorporating stimulating elements enables students to assimilate information more deeply, both cognitively and emotionally (Antunes et al., 2018). Consequently, this study analyzes empirical articles concerning the use of such software in sign language education, alongside the most relevant co-occurrences in authors, countries, and conceptual structures of the selected documents.

Methodology

This methodology outlines the systematic approach employed to examine the impact of software on the teaching-learning process of sign language. It is based on an exhaustive review of scientific literature, guided by the PRISMA (Preferred Reporting Items for Systematic Reviews and Meta-Analyses) method, ensuring rigor, transparency, and reproducibility in the selection, extraction, and analysis of relevant studies (Liberati et al., 2009; Moher et al., 2007). Hence, a theoretical design for systematic review was adopted to collate summarized and structured information on the issue, integrating various key bibliographic sources (Ato et al., 2013; Siddaway et al., 2019).

The literature search was conducted in high-impact journals indexed in Scopus and Web of Science, covering the period from 2010 to 2023. These publications document the necessity of software to optimize the aforementioned educational process.

Specifically, the search was executed in these two primary databases. In Scopus, the query applied was: TITLE-ABS-KEY(“sign language” OR “deaf communication” OR “gestural language” OR “hand language”) AND TITLE-ABS-KEY(“software” OR “assistive technology” OR “devices”) AND TITLE-ABS-KEY(“learning”). In Web of

Science, the query was: (TS=(sign language OR deaf communication OR gestural language OR hand language) AND TS=(software OR assistive technology OR devices) AND TS=(learning)), yielding a total of 628 articles.

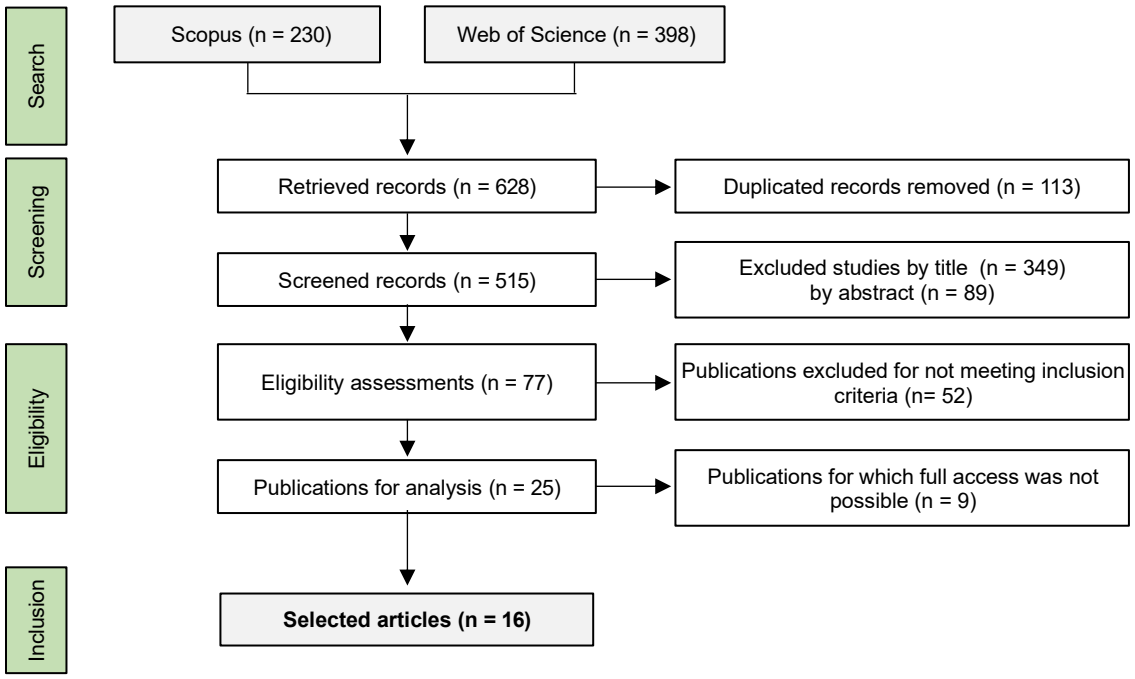
Selection criteria for studies

To minimize biases in selection, rigorous inclusion and exclusion criteria were employed. The inclusion criteria encompassed: 1) Articles exploring software for learning sign language; 2) Studies involving social groups without cognitive deficits. The criteria excluded theoretical reviews and articles focused on the validation or design of instruments.

In Scopus, 230 documents were identified, and in Web of Science, 398, resulting in the elimination of 113 duplicates and leaving 515 screened records. Subsequently, after reading titles and abstracts, 349 were discarded based on the title, and 89 based on the abstract for being unrelated to the topic. Out of the 77 full texts retrieved, 52 were filtered out for not meeting the criteria, resulting in a final total of 25 publications. Of these, access to 9 full articles was not granted, leading to the analysis of 16 articles. Data were systematically extracted according to the study's objectives, organized under the following headings: author(s), year of publication, country, title, system used, and results. Figure 1 illustrates the complete flow of the selection process.

Figure 1

PRISMA flow diagram



Source. Authors' own elaboration

Results

Sixteen studies published between 2013 and 2023 were examined, with their summaries presented in Table 1. The majority of this research was conducted in India; however, a significant number of cross-cultural applications were identified. Most studies predominantly utilized software and mobile applications.

The selected documents originate from various countries, including India, Spain, Saudi Arabia, Japan, Egypt, Lithuania, Poland, Brazil, Malaysia, Indonesia, Jordan, and the United States. Collectively, these findings reveal the application of multiple technologies and approaches in the teaching-learning process of sign language.

Among the most utilized technologies are machine learning and motion capture devices. For instance, Saleem et al. (2023) developed a duplex system based on machine learning and Leap Motion devices, capable of translating gestures from sign languages (ASL, PSL, SSL) into audio messages comprehensible to hearing

individuals. Similarly, Lu et al. (2023) implemented data gloves with flexion sensors for high-precision capture of hand movements, thus optimizing sign recognition.

Convolutional neural networks (CNN) have also demonstrated efficacy in recognizing gestures from both Arabic and American sign languages, achieving increased accuracy in translation (Alshomrani et al., 2021; Shanableh, 2023). Additionally, augmented reality and animated avatars have gained prominence, such as an avatar that translates spoken and written Arabic into sign language in real time (Mosa et al., 2023), and the LEARNSIGN software, which integrates augmented reality and voice recognition to enhance interaction with individuals with hearing impairments (Mohd & Boilis, 2021).

Mobile applications and educational games have emerged as effective tools for autonomous and playful learning. In this context, Joy et al. (2019, 2020) introduced SignQuiz and SignDict for independent learning of Indian sign language, highlighting the value of mobile dictionaries. Following this approach, Pontes et al. (2020) created MatLIBRAS Racing, an educational game that teaches numbers in Brazilian sign language while promoting social interaction and playful learning.

Finally, deep learning models contributed significant evidence. Fadlilah et al. (2022) developed a translator based on Raspberry Pi and neural networks, aimed at identifying letters and words in Indonesian sign language, while Duwairi and Holloush (2022) applied the VGGNet model for the automatic recognition of alphabets in Arabic sign language.

Table 1

Studies analyzing software in the teaching-learning process of sign language

Author/Year	Country	Title	System Used	Result
Saleem et al. (2023)	Spain	A Machine Learning Based Full Duplex System Supporting Multiple Sign Languages for the Deaf and Mute	Duplex communication system (Machine Learning & Leap Motion device)	The system employs machine learning techniques to identify and interpret gestures of deaf-mute individuals, transforming them into audio messages comprehensible to hearing individuals. A dataset encompassing three sign languages—American Sign Language (ASL), Pakistani Sign Language (PSL), and Spanish Sign Language (SSL)—has been developed.
Alshomrani et al., 2021	Saudi Arabia	Arabic and American Sign Languages Alphabet Recognition by Convolutional Neural Network	Convolutional Neural Network (CNN)	A system was developed for the automatic detection of gestures and signs in Arabic and American sign languages, utilizing image capture devices such as cameras.
Joy et al., 2019	India	SignQuiz: A Quiz Based Tool for Learning Fingerspelled Signs in Indian Sign Language Using ASLR	SignQuiz	Learning written finger signs represents the initial phase in mastering sign language, used when no corresponding sign exists or the user is unfamiliar with it. SignQuiz provides a tool for learning these signs autonomously, without the need for external assistance.

Lu et al., 2023	Japan	Data Glove with Bending Sensor and Inertial Sensor Based on Weighted DTW Fusion for Sign Language Recognition	Sign-Glove	The use of portable sensors, such as the data glove in this study, allows for precise data collection in complex environments and facilitates the dynamic capture of hand movements. This approach enables a wide range of sign language features to be collected, thereby improving recognition accuracy.
Mosa et al., 2023	Egypt	A Real-Time Arabic Avatar for Deaf–Mute Community Using Attention Mechanism	2D Animated Avatar	This article presents a real-time avatar system that uses an attention mechanism to automatically translate spoken and written Arabic into Arabic sign language, facilitating effective communication between hearing individuals and deaf users of this sign system.
Vaitkevičius et al., 2019	Lithuania & Poland	Recognition of American Sign Language Gestures in a Virtual Reality Using Leap Motion	Leap Motion	This study introduces a system that utilizes Leap Motion to recognize gestures performed by users while interacting in virtual reality environments.
Joy et al., 2020	India	Developing a Bilingual Mobile Dictionary for Indian Sign Language and Gathering Users' Experience with SignDict	SignDict	The study highlights the fundamental importance of having a sign language dictionary as a crucial tool for promoting literacy among deaf individuals.
Kothadiya et al., 2023	India, Saudi Arabia & USA	SIGNFORMER: DeepVision Transformer for Sign Language Recognition	Vision Transformer	The study presents a system that utilizes vision transformers to recognize sign languages, successfully identifying static gestures in Indian sign language.
Shanableh (2023)	United Arab Emirates	Two-Stage Deep Learning Solution for Continuous Arabic Sign Language Recognition Using Word Count Prediction and Motion Images	Convolutional Neural Networks (CNN)	Two deep learning models are developed: one for predicting the number of words per sentence and another for interpreting the meanings of sentences in sign language.
Pontes et al., 2020	Brazil	An Educational Game to Teach Numbers in Brazilian Sign Language While Having Fun	MatLIBRAS Racing	The game promotes social interaction and facilitates the learning of signs in Brazilian sign language (LIBRAS), indicating promising potential for its application in academic contexts.

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Mohd & Boilis (2021)	Malaysia	Sign Language Communication through Augmented Reality and Speech Recognition (LEARNSIGN)	Unity Software & C# Programming	The use of augmented reality (AR) and speech recognition technology benefits the deaf-mute community by facilitating communication with non-disabled individuals and vice versa. The paper emphasizes the importance of AR for enhancing real-time interaction and its potential to improve teaching and learning methods.
Sahoo (2021)	India	Indian Sign Language Recognition Using Machine Learning Techniques	k-Nearest Neighbor and Naive Bayes Classifiers	The system was developed to translate Indian sign language into conventional text and vice versa, aiming to facilitate communication between deaf-mute individuals and those unfamiliar with sign language.
Fadlilah et al., (2022)	Indonesia & Malaysia	Modelling of Basic Indonesian Sign Language Translator Based on Raspberry Pi Technology	Raspberry Pi Technology & Convolutional Neural Networks	The developed model can identify letters, words, sentences, and basic numbers in Indonesian sign language.
Wang et al., (2006)	United States	American Sign Language Recognition Using Multi-Dimensional Hidden Markov Models	Cyberglove & Flock of Birds	The objective is to achieve continuous and real-time recognition of gestures in American Sign Language (ASL).
Duwairi & Halloush (2022)	Jordan	Automatic Recognition of Arabic Alphabets Sign Language Using Deep Learning	VGGNet Model	The study focuses on the automatic recognition of Arabic sign language using advanced deep learning techniques, underscoring the importance of improving communication for individuals with disabilities through innovative assistive technologies.
Biju et al., (2023)	-	Glove Based Wearable Devices for Sign Language—GloSign	GloSign	GloSign facilitates the conversion of sign language gestures into letters and words in English, contributing to mitigating the communication barrier between deaf and hearing individuals.

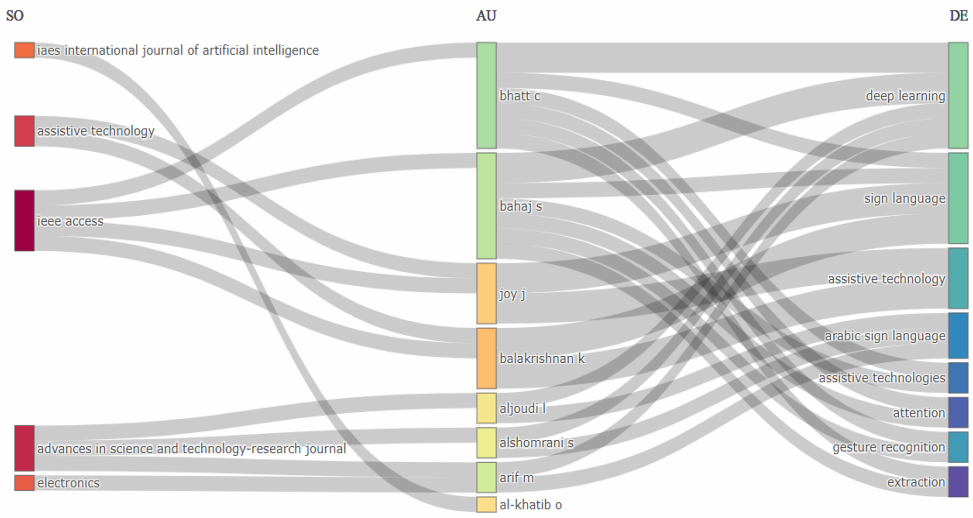
Source. Authors' own elaboration

Parcel of three fields

Figure 2 presents a parcel of three fields integrating three main components: journals (SO), authors (AU), and keywords (DE). These elements are represented by rectangles, with their sizes reflecting the number of associated articles, interconnected by gray lines illustrating their interdependent relationships. This visualization demonstrates how specific publications in certain journals are linked to particular authors, who in turn focus on relevant thematic descriptors for the study of software applied to the teaching of sign language.

For example, articles published in IEEE Access primarily originate from authors such as Bhatt C. and Balakrishnan K., who have explored topics related to deep learning and Arabic sign language. Moreover, recent studies indicate a clear trend toward the use of advanced artificial intelligence technologies to optimize access to and the teaching of sign languages.

Figure 2
Parcel of three fields

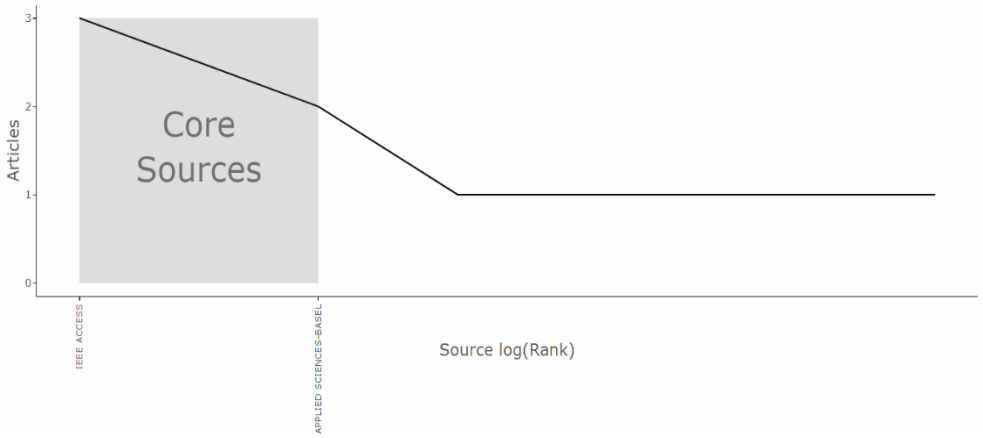


Bradford's Law

Figure 3 classifies journals according to their productivity (source and number of articles), revealing how literature on software for teaching sign language is concentrated in a few key publications, in accordance with Bradford's Law. This bibliometric law establishes that articles are distributed across three zones of equal production: a central core (Zone 1) with highly specialized journals, a transition zone (Zone 2) with n times more publications, and a dispersion zone (Zone 3) with n² less productive journals.

In this analysis, IEEE Access leads with 3 documents, followed by Applied Sciences-Basel with 2, consolidating itself as the central core (Zone 1) of the primary knowledge in this area. Thus, this classification not only visualizes the uneven distribution of scientific output but also provides an accurate perspective on the dominant influence of these sources in research on technologies for sign languages.

Figure 3
Bradford's Law



Scientific production by authors

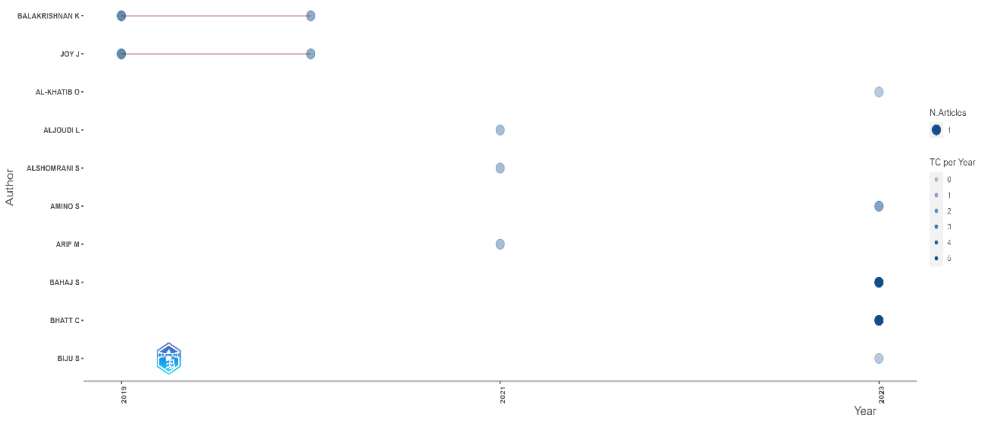
Figure 4 visualizes the individual contributions of authors to the topic of software for the teaching and learning of sign language between 2013 and 2023. Each horizontal line represents a specific author, while the

circles positioned above indicate annual publications; the size of the circles proportionally reflects the number of articles published in that year, and their color—from light to dark—corresponds to the number of citations received during that period.

Among the most prolific authors are Joy J. and Balakrishnan K., with multiple publications concentrated in 2019 and 2020. Additionally, 2023 records a notable increase in scientific output, driven by recent contributions from authors such as Amino S., Bhatt C., and Biju S., identified in the general bibliometric analysis of the consulted databases—although not included in the detailed analysis of this systematic review.

Figure 4

Author production over time



Author collaboration network

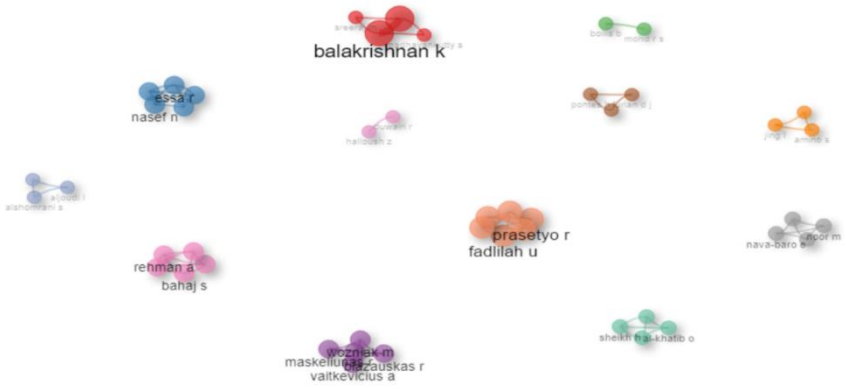
Figure 5 represents the collaboration network based on the scientific output of authors. Balakrishnan K. and Joy J. stand out in Cluster 1 (red) for their high centrality of betweenness and closeness, positioning them as key nodes facilitating connections within their group and to the global network.

On the other hand, authors in Cluster 2 (blue)—Essa R., Lotfy A., Mosa D., Nasef N., and Salem A.—exhibit moderate betweenness metrics, but their high closeness suggests a close and intense collaboration within the group. Finally, the authors in Cluster 4 (purple)—Blažauskas R., Maskeliunas R., Taroza M., Vaitkevicius A., and Wozniak M.—show moderate interactions in terms of collaborative closeness, indicating teamwork but without acting as critical bridges in the global network.

In summary, Balakrishnan K. and Joy J. not only coordinate their cluster but also exert significant influence over the overall collaborative structure.

Figure 5

Author collaboration network

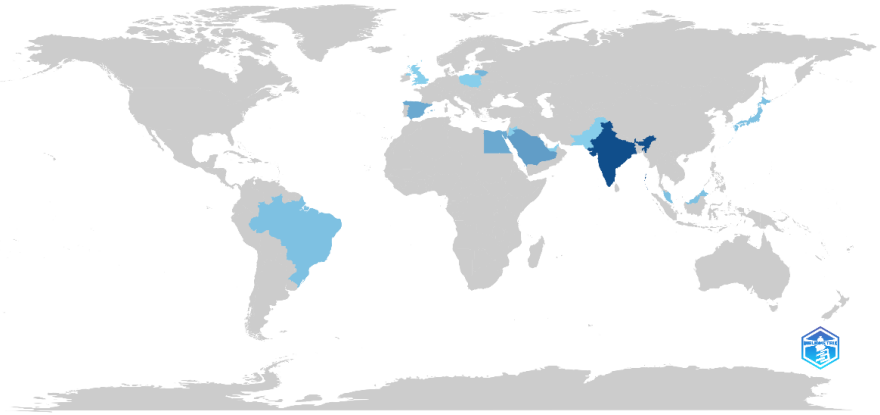


Collaboration by country

Figure 6 presents a world map where blue gradations indicate scientific productivity by country, with darker shades representing a higher frequency of publications. India leads with 12 studies, shown in deep blue, followed by Saudi Arabia with 5 publications. Egypt and Spain each register 4 contributions, indicated by moderate blue shades. Countries with lower frequencies appear in lighter gradations, revealing a notable geographic concentration in West Asia and South Asia in developing software for sign languages.

Figure 6

World map of scientific production by country



Frequency of terms used and conceptual structure

Figure 7 analyzes the frequency of authors' keywords, revealing that "deep learning" and "sign language" dominate, each comprising 20% of the focus, illustrating a predominant emphasis on deep learning techniques for the recognition and translation of sign languages. Moreover, terms such as "assistive technology" and "gesture recognition," each at 10%, underscore the relevance of support technologies and gesture recognition in this research field.

Figure 7

Authors' keywords



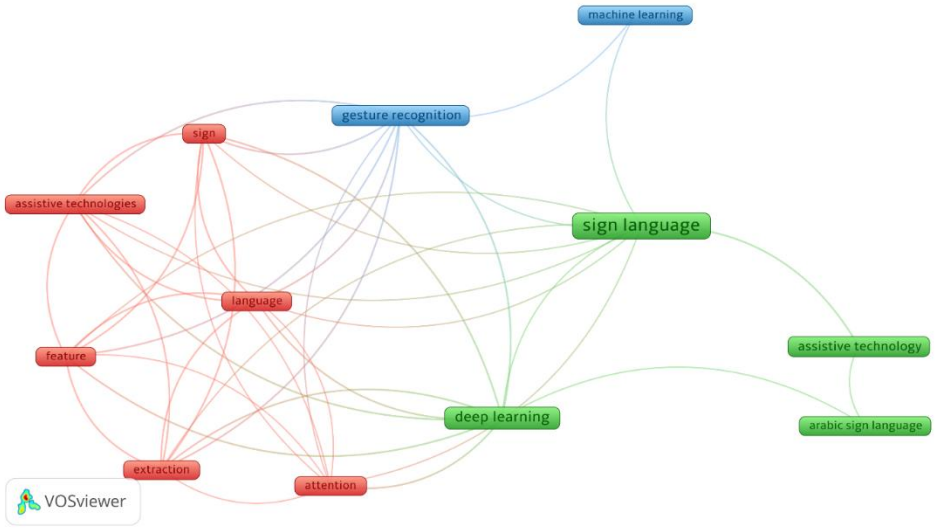
Co-occurrence of authors' keywords

Figure 8 reveals the co-occurrence networks between authors' keywords. "Deep learning" stands out due to its high frequency (4 occurrences) and link strength (16), highlighting its central role in the development of advanced technologies for sign language recognition. Following closely is "sign language" (6 occurrences, link strength 11), solidifying its pivotal role in the creation of educational support tools.

Additionally, "gesture recognition" (3 occurrences, link strength 15) emphasizes the growing interest in technologies for interpreting gestures, an essential element of sign communication. This configuration suggests a robust interconnection between "deep learning," "sign language," and "gesture recognition," promoting an interdisciplinary approach for future collaborative research.

Figure 8

Co-occurrence of authors' keywords



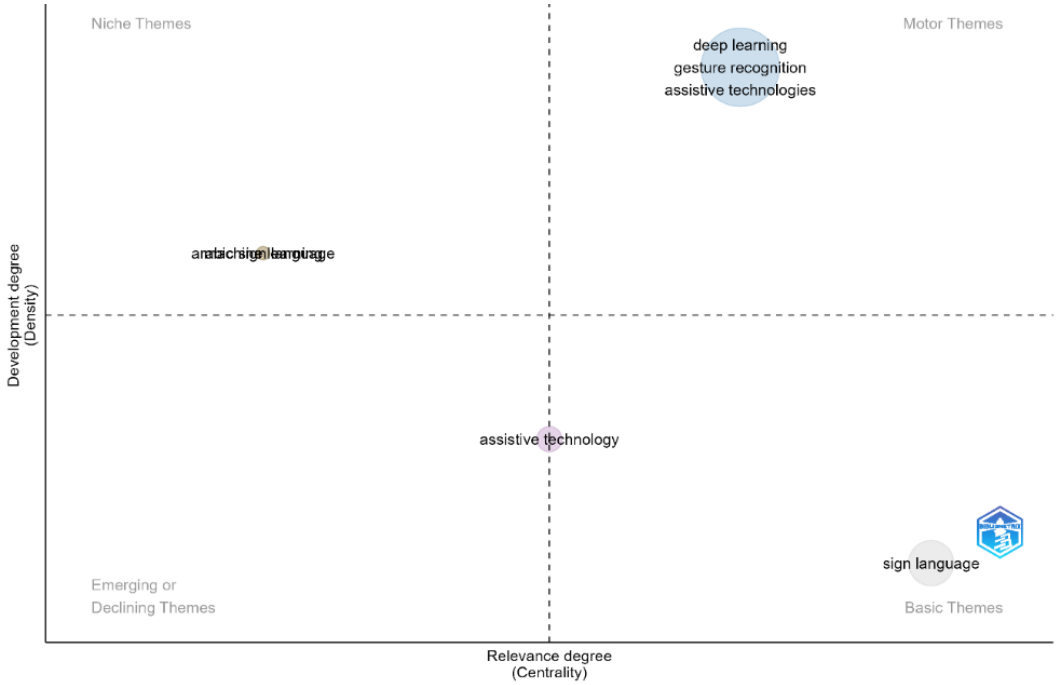
Thematic map

Figure 9 organizes themes into four quadrants based on their development and relevance. The driving themes (upper right quadrant)—"deep learning," "gesture recognition," and "assistive technologies"—stand out due to their high development and relevance, positioning them as central indicators of current research on software for sign languages.

Conversely, "sign language" appears in the foundational themes (lower right quadrant)—essential and highly relevant, yet underdeveloped in the selected studies. This configuration reveals significant opportunities for deeper technological research on sign languages.

Finally, "Arabic sign language" is located in the niche themes (upper left quadrant), with considerable development but lesser global relevance, suggesting potential for strategic expansion in future research directions.

Figure 9
Thematic map



Discussion

This systematic review highlights the positive impact of software on the teaching-learning process of sign language. Following a comprehensive search for publications between 2010 and 2023, 16 cross-cultural studies were selected, predominantly developed in India (Joy et al., 2019, 2020; Kothadiya et al., 2023; Sahoo, 2021). These works demonstrate that virtual devices and applications are fundamental for developing skills in both individuals with hearing disabilities and hearing individuals.

Therefore, it is alarming that there is a scarcity of virtual systems specifically designed to facilitate the comprehension and inclusion of individuals with hearing disabilities in educational settings (Yeh & Tseng, 2020). In this context, tools like SignDict promote literacy through interactive sign language dictionaries (Joy et al., 2020), while other systems predict the number of words per sentence and interpret their meanings in sign language (Shanableh, 2023). These technologies not only optimize learning absorption but also facilitate smooth interactions, especially through augmented reality (AR) and voice recognition, benefiting both the deaf community and hearing individuals (Mohd & Boilis, 2021; Sahoo, 2021).

Moreover, the lack of specialized instructors in sign language represents a critical challenge, making the need for autonomous support mechanisms imperative. Tools like SignQuiz allow individuals to learn sign language independently, without external assistance, using innovative technologies that foster deep learning (Joy et al., 2019; Duwairi & Halloush, 2022).

Most studies focus on devices for real-time gesture recognition and interpretation, employing image capture systems with convolutional neural networks (CNN) to convert signs into audio, letters, or words (Alshomrani et al., 2021; Pontes et al., 2020; Vaitkevicius et al., 2019; Wang et al., 2006). Consequently, these advancements help mitigate communication barriers between deaf and hearing individuals (Biju et al., 2023; Fadlilah et al., 2022; Saleem et al., 2023).

Unlike previous reviews, this analysis emphasizes innovations such as 2D animated avatars translating spoken/written language into signs (Mosa et al., 2023), Sign-Glove data gloves for precise movement capture (Lu et al., 2023), and Vision Transformer systems for static gestures (Kothadiya et al., 2023).

Furthermore, the growing interdisciplinary interest in sign language—encompassing linguistics, computer science, and education—underscores the inherent complexity of its teaching. While practical devices blend

artificial environments with physical experiences to enhance sign language comprehension, there remain opportunities and challenges in implementing artificial intelligence technologies.

However, this review also reveals practical limitations, such as the lack of trained professionals and appropriate technological instruments in real educational contexts. Among the methodological limitations of the study are the variability in the quality of the reviewed articles and the absence of uniform assessments of software effectiveness. Additionally, as most studies focus on specific contexts, the findings have limitations concerning their generalization to diverse populations and educational environments.

Conclusions

New technologies—primarily Android devices, deep learning software, and virtual applications—facilitate accelerated and accessible learning of sign language, as evidenced by the 16 reviewed studies. India leads scientific production (12 publications), followed by Saudi Arabia and Egypt, concentrating efforts on tools such as convolutional neural networks (CNN), augmented reality, and gesture capture systems (Leap Motion, sensory gloves). These resources are indispensable for both individuals with hearing disabilities and hearing individuals, promoting smooth interactions, optimal knowledge absorption, and effective educational inclusion.

Therefore, interdisciplinary study of sign languages generates growing interest in linguistics, computer science, and education, where terms like "gesture recognition" and "assistive technology" dominate conceptual networks. However, significant challenges persist: a shortage of specialized instructors, limitations in cross-cultural generalization, and the need for uniform assessments of effectiveness. Consequently, it is essential to expand autonomous technological support mechanisms—such as SignQuiz and SignDict—that optimize this inclusive process, especially in educational contexts with limited resources, such as Peru.

This review not only validates the transformative potential of software but also identifies priority opportunities for future research that can bridge these gaps and enhance universal communication.

References

Alaín, L., Gallego, J. L., Navarro, A., & Rodríguez, A. (2020). Evaluation for teachers and students in higher education. *Sustainability*, *12*(10), Artículo 4078. https://doi.org/10.3390/su12104078

Alshomrani, S., Aljoudi, L., & Arif, M. (2021). Arabic and American sign languages alphabet recognition by convolutional neural network. *Advances in Science and Technology Research Journal*, *15*(4), 136–148. https://doi.org/10.12913/22998624/142012

Antunes, B. R., Abreu, F. D. L., Rodrigues, S. C. M., Silva, D. P., Bonini, L. M. M., & Bissaco, M. A. S. (2018). Computerized method for teaching the Brazilian Sign Language. En Costa-Felix, R., Machado, J., Alvarenga, A. (Eds.) *XXVI Brazilian Congress on Biomedical Engineering*. IFMBE Proceedings, Vol. 70/2. Springer, Singapore. https://doi.org/10.1007/978-981-13-2517-5_101

Ato, M., López, J., & Benavente, A. (2013). Un sistema de clasificación de los diseños de investigación en psicología. *Anales de Psicología*, *29*(3), 1038–1059. https://doi.org/10.6018/analesps.29.3.178511

Biju, S. M., Al-Khatib, O., Sheikh, H. Z., & Oroumchian, F. (2023). Glove based wearable devices for sign language—GloSign. *IAES International Journal of Artificial Intelligence (IJ-AI)*, *12*(4), 1666–1676. https://doi.org/10.11591/ijai.v12.i4.pp1666-1676

Brow, B., Dressler, R., Eaton, S. E., & Jacobsen, M. (2015). Practicing what we teach: Using action research to learn about teaching action research. *The Canadian Journal of Action Research*, *16*(3), 61–78. https://journals.nipissingu.ca/index.php/cjar/article/view/228

Cheah, H. M., & Lee, L. L. (2015). Teaching and learning in an ICT-enhanced environment: Automating the assessment of 21st century skills. *Advances in the Scholarship of Teaching and Learning*, *2*(1), 1–15.

Costa Machado, M., Diniz Gomes, C. A., Graciano Leal dos Santos, G., Dias de Sousa, L., & Borcard Cancela, L. (2017). Inclusao social de deficientes auditivos por meio de tecnologias assistivas. *Anais do Encontro Virtual de Documentação em Software Livre e Congresso Internacional de Linguagem e Tecnologia Online*, *6*(1), 1–6. http://www.periodicos.letras.ufmg.br/index.php/anais_linguagem_tecnologia/article/view/12091

Defensoría del Pueblo. (24 de septiembre de 2020). Defensoría del Pueblo: Debe facilitarse el aprendizaje de la lengua de señas peruana y promover la identidad lingüística y cultural de las personas sordas. *Defensoría del Pueblo*. https://www.defensoria.gob.pe/defensoria-del-pueblo-debe-facilitarse-el-aprendizaje-de-la-lengua-de-senas-peruana-y-promover-la-identidad-linguistica-y-cultural-de-las-personas-sordas/

Duwairi, R. M., & Halloush, Z. A. (2022). Automatic recognition of Arabic alphabets sign language using deep learning. *International Journal of Electrical and Computer Engineering (IJECE)*, *12*(3), 2996–3004. https://doi.org/10.11591/ijece.v12i3.pp2996-3004

Fadlilah, U., Prasetyo, R. A. R., Mahamad, A. K., Handaga, B., Saon, S., & Sudarmilah, E. (2022). Modelling of basic Indonesian Sign Language translator based on Raspberry Pi technology. *Scientific and Technical Journal of Information Technologies, Mechanics and Optics*, *22*(3), 574–584. https://doi.org/10.17586/2226-1494-2022-22-3-574-584

Falvo, V., Scatalon, L., & Francine, E. (2020). The role of technology to teaching and learning sign languages: A systematic mapping. *Proceedings - Frontiers in Education Conference, FIE*, 1-9. https://doi.org/10.1109/FIE44824.2020.9274169

Hepp, K., Prats, P., A, M., & Holgado, J. (2015). Formació d'educadors: La tecnologia al servei del desenvolupament d'un perfil professional innovador i reflexiu. *RUSC. Universities and Knowledge Society Journal*, *12*(2), 30–43. https://doi.org/10.7238/rusc.v12i2.2458

Instituto Nacional de Estadística e Informática. (2017). *Perú: Perfil sociodemográfico informe nacional. Censos Nacionales 2017: XII de Población, VII de Vivienda y III de Comunidades Indígenas.* INEI. https://www.inei.gob.pe/media/MenuRecursivo/publicaciones_digitales/Est/Lib1539/libro.pdf

Joy, J., Balakrishnan, K., & Madhavankutty, S. (2020). Developing a bilingual mobile dictionary for Indian Sign Language and gathering users experience with SignDict. *Assistive Technology*, *32*(3), 153–160. https://doi.org/10.1080/10400435.2018.1508093

Joy, J., Balakrishnan, K., & Sreeraj, M. (2019). SignQuiz: A quiz based tool for learning fingerspelled signs in Indian sign language using ASLR. *IEEE Access*, *7*, 28363–28371. https://doi.org/10.1109/ACCESS.2019.2901863

Kothadiya, D. R., Bhatt, C. M., Saba, T., Rehman, A., & Bahaj, S. A. (2023). SIGNFORMER: DeepVision Transformer for Sign Language Recognition. *IEEE Access*, *11*, 4730–4739. https://doi.org/10.1109/ACCESS.2022.3231130

Labrada-Pérez, M., Fuentes-Rodríguez, H., & Jiménez-Peña, Y. (2015). Procedimientos para la enseñanza-aprendizaje de la lengua de señas. *Revista Electrónica Trimestral de la Universidad de Holguín*, *14*, 37–46. https://www.redalyc.org/pdf/5891/589165732005.pdf

Li, J., Zhang, P., Chang, J., & Cai, S. (2022). Design and effect of AR sign language teaching software based on natural interaction. *30th International Conference on Computers in Education Conference, ICCE 2022 – Proceedings*, *1*, 402–409. https://library.apsce.net/index.php/ICCE/article/view/4513

Liberati, A., Altman, D. G., Tetzlaff, J., Mulrow, C., Gøtzsche, P. C., Ioannidis, J. P. A., Clarke, M., Devereaux, P. J., Kleijnen, J., & Moher, D. (2009). The PRISMA statement for reporting systematic reviews and meta-analyses of studies that evaluate health care interventions: Explanation and elaboration. *PLoS Medicine*, *6*(7), Artículo e1000100. https://doi.org/10.1371/journal.pmed.1000100

Lu, C., Amino, S., & Jing, L. (2023). Data glove with bending sensor and inertial sensor based on weighted DTW fusion for sign language recognition. *Electronics*, *12*(3), Artículo 613. https://doi.org/10.3390/electronics12030613

Ministerio de Educación. (2020). *Orientaciones para la atención educativa de estudiantes con discapacidad auditiva*. Dirección General de Educación Básica Especial. http://www.minedu.gob.pe/minedu/archivos/a/002/05-bibliografia-para-ebe/6-orientaciones-para-la-atencion-educativa-de-estudiantes-con-discapacidad-auditiva.pdf

Mohd, S. N., & Boilis, B. I. (2021). Sign language communication through augmented reality and speech recognition (LEARNSIGN). *International Journal of Engineering Trends and Technology - IJETT*, *69*(4), 125–130. https://doi.org/10.14445/22315381/IJETT-V69I4P218

Moher, D., Tetzlaff, J., Tricco, A. C., Sampson, M., & Altman, D. G. (2007). Epidemiology and reporting characteristics of systematic reviews. *PLoS Medicine*, *4*(3), Artículo e78. https://doi.org/10.1371/journal.pmed.0040078

Mosa, D. T., Nasef, N. A., Lotfy, M. A., Abohany, A. A., Essa, R. M., & Salem, A. (2023). A real-time Arabic avatar for deaf–mute community using attention mechanism. *Neural Computing and Applications*, *35*(29), 21709–21723. https://doi.org/10.1007/s00521-023-08858-6

Naranjo-Zeledón, L., Chacón-Rivas, M., Peral, J., Ferrández, A., & Gil, D. (2021). Improvement of a sign language learning reinforcement tool through phonological proximity. *Springer Proceedings in Complexity*, *9*, 99–107. https://orion.tec.ac.cr/en/publications/improvement-of-a-sign-language-learning-reinforcement-tool-throug/

Organización Mundial de la Salud. (26 de febrero de 2025). Sordera y pérdida de la audición. *OMS*. https://www.who.int/es/news-room/fact-sheets/detail/deafness-and-hearing-loss

Pontes, H. P., Furlan Duarte, J. B., & Pinheiro, P. R. (2020). An educational game to teach numbers in Brazilian Sign Language while having fun. *Computers in Human Behavior*, *107*, Artículo 105825. https://doi.org/10.1016/j.chb.2018.12.003

Sahoo, A. K. (2021). Indian Sign Language Recognition Using Machine Learning Techniques. *Macromolecular Symposia*, *397*(1), Article 2000241. https://doi.org/10.1002/masy.202000241

Saksiri, B., & Ruenwongsa, P. (2010). Effects of a virtual sign animated pedagogical agent on ICT learning. *The International Journal of Learning: Annual Review*, *17*(3), 37–50. https://doi.org/10.18848/1447-9494/CGP/v17i03/46931

Saleem, M. I., Siddiqui, A., Noor, S., Luque-Nieto, M. A., & Nava-Baro, E. (2023). A machine learning based full duplex system supporting multiple sign languages for the deaf and mute. *Applied Sciences*, *13*(5), Artículo 3114. https://doi.org/10.3390/app13053114

Shanableh, T. (2023). Two-stage deep learning solution for continuous Arabic Sign Language recognition using word count prediction and motion images. *IEEE Access*, *11*, 126823–126833. https://doi.org/10.1109/ACCESS.2023.3332250

Siddaway, A. P., Wood, A. M., & Hedges, L. V. (2019). How to do a systematic review: A best practice guide for conducting and reporting narrative reviews, meta-analyses, and meta-syntheses. *Annual Review of Psychology*, *70*, 747–770. https://doi.org/10.1146/annurev-psych-010418-102803

Vaitkevičius, A., Taroza, M., Blažauskas, T., Damaševičius, R., Maskeliunas, R., & Woźniak, M. (2019). Recognition of American Sign Language gestures in a virtual reality using Leap Motion. *Applied Sciences*, *9*(3), Artículo 445. https://doi.org/10.3390/app9030445

Wang, H., Ming, C., Leu, & Cemil, O. (2006). American Sign Language recognition using multi-dimensional Hidden Markov Models. *Journal of Information Science and Engineering*, *22*, 1109–1123. https://www.researchgate.net/publication/243788237

Yeh, H.-C., & Tseng, S.-S. (2020). Enhancing multimodal literacy using augmented reality. *Language Learning & Technology*, *24*(1), 27–37. https://doi.org/10125/44706

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