Augmentative and Alternative Communication and Communication Skills in Deaf Students: A Systematic Review

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Abstract
Limited access to auditory input can create significant barriers for Deaf and Hard-of-Hearing students, particularly in language acquisition and social communication. This study aims to systematically review empirical research on the use of AAC systems in enhancing the communication abilities of hearing-impaired students. Articles were retrieved from the Scopus database and by using Preferred Reporting Items for Systematic Reviews and Meta-Analyses procedures. A total of five empirical studies met the inclusion criteria and were analyzed through qualitative analysis. Results showed that Augmentative and Alternative Communication treatments led to gains in initiations, single-word spoken-language production, receptive and expressive vocabulary, single-word reading accuracy, social communication skills. Results found were positive with both low and high technology approaches, although benefited most when used in conjunction with speech-language therapy and early intervention programs. Implementation obstacles included insufficient support for training teachers and providing places to go online. In general, these results indicated that Augmentative and Alternative Communication systems contributed to the communication development process, enhancing language acquisition skills and serving social participation in students with hearing disabilities. It was suggested that additional larger-scaled empirical studies with experimental designs should be conducted to reinforce the existing evidence.

1. Introduction

Communication skills form a basic basis for the social, emotional and academic development of students (Efrina et al., 2020; Rautakoski et al., 2021). Students with hearing impairments tend to have restricted access to auditory information, which impedes acquisition of spoken language, vocabulary development and pragmatic skills (Matthews et al., 2022; Penna et al., 2015). The consequences of these obstacles not only format academic achievement but also social involvement, self-esteem and preparation to engage in wider educational environments (Link et al., 2025; Oyelami, 2025). Hence, there is indeed a crucial necessity to develop proper communication interventions in educating hearing impaired students (Tsaputra & Amani,2025). These communication barriers indicate the importance of developing accessible and adaptive communication interventions for students with hearing impairments (Tsaputra & Amani, 2025).

One of the rapidly emerging approaches is Augmentative and Alternative Communication (AAC), which uses symbols, images, text, electronic devices or mobile-based applications to provide a communication system to bolster or replace verbal speech (Elsahar et al., 2019; Iacono et al., 2021). Digital technology has deployed a wide range of AAC from traditional low-tech media to application-dependent systems with electronic speech output (high-tech AAC) to date (Farzana et al., 2025; Ciulla, 2025). Research has shown that using AAC (Augmentative and Alternative Communication) in conjunction with language therapy and educational contexts provides an opportunity for children with hearing loss to use longer utterances, more vocabulary, and improve pragmatic aspects of social communication (Meinzen-Derr et al., 2019; Efrina et al., 2018). But these results are spread across research designs with different interests that have not been integrated thus far, leaving a synthesis on effectiveness, differences in methods and challenges in implementing vague (Marlina et al., 2022; Schick-makaroff et al., 2016). Therefore, AAC has increasingly been considered a promising intervention to support communication and language development among students with hearing impairments

At the same time, a major problem which this study attempts to cover is that no systematic mapping of mobile-based sectored Technologies in AAC for improving communication skills among students with hearing impairments has been made to date and what impact do they have on social interaction and educational outcomes (Moorcroft et al., 2019; Marlina et al., 2023). Nothing in the literature provide a systematic synthesis of implementation barriers such as teacher readiness, family support, technology access and factors affecting

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educational context. This gap points to the need for a more consolidated analysis to characterize how far AAC is supporting its intended goal and what influences this efficacy. However, previous studies remain fragmented across different research designs and intervention contexts. Existing studies have not comprehensively synthesized the effectiveness of AAC systems, implementation barriers, and the role of mobile-based AAC applications for students with hearing impairments.

In addition, limited attention has been given to how AAC interventions influence social interaction and educational outcomes within inclusive learning environments. This indicates the need for a systematic review that integrates findings across studies to provide clearer evidence regarding the effectiveness and implementation of AAC systems.

With this background in mind, the objective of this paper is to execute a SLR for dividing: (1) Through their communication development; (2) what type/s and/or strategy/ies have been used within educational/ instructional practices as well as interventions; (3) examining the efficiency or effectiveness of mobile-based AAC applications on augmenting communication skills; (4) The challenges/barriers to their implementation and (5) The effect they have or social interaction & educational performance. This systematic review summarises studies across a variety of contexts that examines how, and to what extent AAC systems are used and applied as an intervention variable (IV) related to the communicative skill measured (outcome variable, OV), conditioned by relevant educational- or social-contexts defined as context-supporting variables.

This paper adopts a PRISMA-based approach to synthesise empirical findings from pertinent publications regarding the effectiveness and implications of AAC. The results are expected to have theoretical implications that would help bolster the conceptual basis of technology-based communication interventions, and practical ones offering guidance for educators, therapists, and policymakers on how to design more individualized, evidence-based communication strategies for students with hearing disabilities. Additionally, this study highlights the evidential gaps in future research pertaining to contextual and sustainable uses of AAC technology with inclusive education systems.

2. Method

This study employed a Systematic Literature Review (SLR) design to identify, evaluate, and synthesize empirical evidence regarding the use of Augmentative and Alternative Communication (AAC) systems for students with hearing impairments (Pati & Lorusso, 2018; Mangaroo-pillay & Coetzee, 2022). The review process followed the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) guidelines to ensure methodological transparency and reproducibility (Rogge et al., 2024; Cooper et al., 2018).

The data sources included Scopus database courses which gave wide repute of various international peer-reviewed journals. The search terms included a combination of the words “Augmentative and Alternative Communication (AAC)” AND “students with hearing disabilities” OR “hearing impairment” AND “mobile AAC applications” AND “improving oral communicative skills.” Boolean operator was used to narrow down the search results. This is a broad search that was not limited by research design, though it was restricted to full-text scholarly journal articles.

We included all empirical research studies examining the use of AAC systems with children with hearing impairment. A purposive sampling strategy was used as per inclusion and exclusion criteria Eligibility criteria were: (1) empirical studies; (2) participants studied were students with hearing impairments or users of cochlear implants; (3) AAC intervention or use was the main explanatory variable and (4) communication-related outcomes, such as language development, vocabulary acquisition, speech production or social interaction were reported. Specifically, the exclusion criteria were conceptual papers or literature reviews, studies in populations other than individuals with hearing impairments and articles without full-text availability.

The process of article selection adhered to PRISMA (Preferred Reporting Items for Systematic Reviews and Meta Analyses) guidelines for procedural transparency. In the identification stage, 51 articles were obtained from the Scopus Database (Zhang et al., 2020). After removal of 1 duplicate reference using reference management software; 50 records were taken forward for data extraction. Screening: 50 articles were screened based on their titles and abstracts. Of these, 45 articles were excluded as they did not meet the inclusion criteria with most exclusion owing to a lack of relevance to the target population or insufficient direct focus on AAC or failure to report any communication-related outcomes. The eligibility stage consists of full-text assessment of the remaining five articles. At this stage, no articles were excluded because all of them met the inclusion criteria. As a result, five articles were retrieved for the final qualitative synthesis. A summary of the article selection process based on the PRISMA framework is presented in Table 1.

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Table 1. PRISMA Framework

PRISMA	Amount (n)
Identification (Records identified from databases – Scopus)	51 records identified
Records after duplicates removed	50 records (after duplicate removal)
Records screened (Title & Abstract)	50 records screened
Records excluded after title & abstract screening	45 records excluded
Full-text articles assessed for eligibility	5 articles assessed
Full-text articles excluded (reasons documented)	0 articles excluded
Studies included in qualitative synthesis	5 articles included for analysis

Besides of applying the PRISMA methodology, this study performed a bibliometric analysis to clarify trends in research and its conceptual structure on AAC and hearing loss literature (Page et al., 2021). Bibliographic data of those 51 articles were exported in the CSV format and analyzed using bibliometric visualization software (like VOSviewer). This work used keyword co-occurrence mapping for thematic clustering, correlation analysis between variables and research intensity (Xu & Ma, 2021). Network visualization was applied for the analysis of term co-occurrence, such as AAC, hearing impairment, language development, and mobile applications; density visualization helped in exploring possible dominant research areas. This macro-level analysis characterized the broad trends in research prior to synthetically analyzing the followed readings.

The research instrument was a data extraction sheet designed for entering the necessary information from each selected article, such as: author(s) and publication year, research design (single-case experimental design, mixed methods or qualitative), characteristics of participants, type of AAC system (low-tech/high-tech), intervention procedures with duration measures implemented and credit given to variables measured and important results. The extraction was carried out systematically to ensure data consistency and accuracy.

Two-stage data analysis was performed. The first step was to use bibliometric analysis to detect global patterns and research trends (Ghorbani et al. The second stage was a descriptive qualitative synthesis of the five selected articles to evaluate AAC intervention effectiveness, methods used with their variations and implementation facilitators and barriers (Broomfield et al., 2024). Statistical meta-analysis was also not conducted due to the small number of articles and the heterogeneity in terms of research designs. Accordingly, a narrative synthesis methodology was applied to avoid aggregation bias and more accurately interpret the results.

To strengthen the rigor of this analytical process, the study followed PRISMA guidelines with explicitly defined selection criteria and detailed methodological procedures, thereby supporting the methodological validity of the bibliometric analysis (Pham, 2023). This study assumes that the articles indexed in Scopus and evaluated through peer review meet satisfactory methodological quality standards. However, because the review relied on a single database and included only a small number of studies, caution should be exercised when generalizing the findings to a broader population.

3. Results and Discussion

3.1. Result

The outputs of the bibliometric analysis suggest that research regarding Augmentative and Alternative Communication (AAC) in the context of hearing impairments has grown rapidly over the last 10 years. Statistical analysis reveals a total of 51 documents were produced from 38 journal sources in the years2016-2025 with an annual growth rate of 36.08%. Such a growth implies that the use of technology-based AAC for the education of students with hearing impairments is a more appropriate global topic in research.

The production of sources over time, as shown in Figure 1, indicates that the number of publications remained relatively stable between 2016 and 2018, but then from 2019 the number started to increase steadily in the long run. The strongest increase occurred during the years 2023–2025, showing an increasing academic interest in using AAC technologies as communication interventions. This increase is potentially connected to advances in digital technology and demand for more technology-based interventions, particularly in special education.

AAC research is not stationary: the graph suggests gradual growth, particularly where assistive technology integration is concerned. This trend indicates a changing of research focus away from traditional methods toward digital-oriented solutions.

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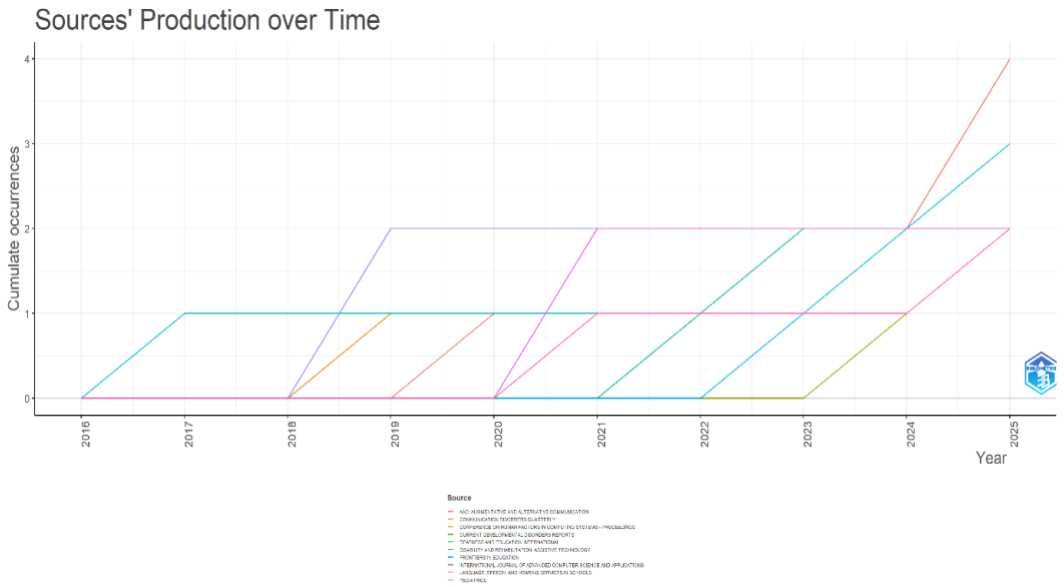

Figure 1. Sources Production Over Time

In addition, the normal citations per year are shown in figure 2. Citation rate varies in time as seen from the graph where the maximum occurred in 2020–2021. The average citation rates from these years are therefore much higher than the others, indicating that publications assigned to this span have had a significant role in moving forward AAC research. The remaining two images show the number of citations has receded in more recent years; this is to be expected given their publication date being relatively recent and not yet allowing sufficient time for additional citation numbers to have accrued. These results suggest valuable scientific contributions of AAC research, especially when the technology integration started to contribute more intensively.

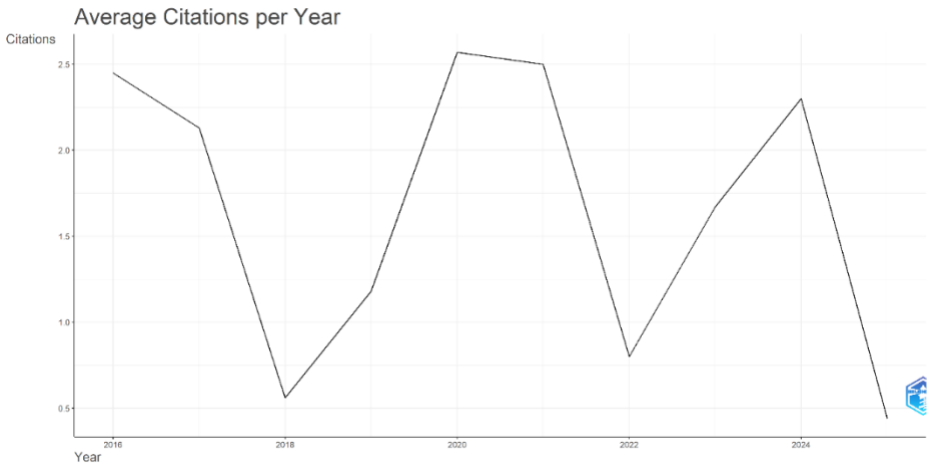

Figure 2. Average Citations per Year

All the Most Relevant Sources are presented in Figure 3. The journal that emerged as having the largest number of publications was Augmentative and Alternative Communication, followed by Disability and Rehabilitation: Assistive Technology, some journals in different areas such as education and communication disorders. This shift demonstrates that research on AAC is not specifically related only to special education, and speech-language therapy as with Assistive Technology. The predominance of these journals signals the fact that AAC research goes beyond education and into rehabilitation and technology, thus reinforcing that this field is multidisciplinary in nature.

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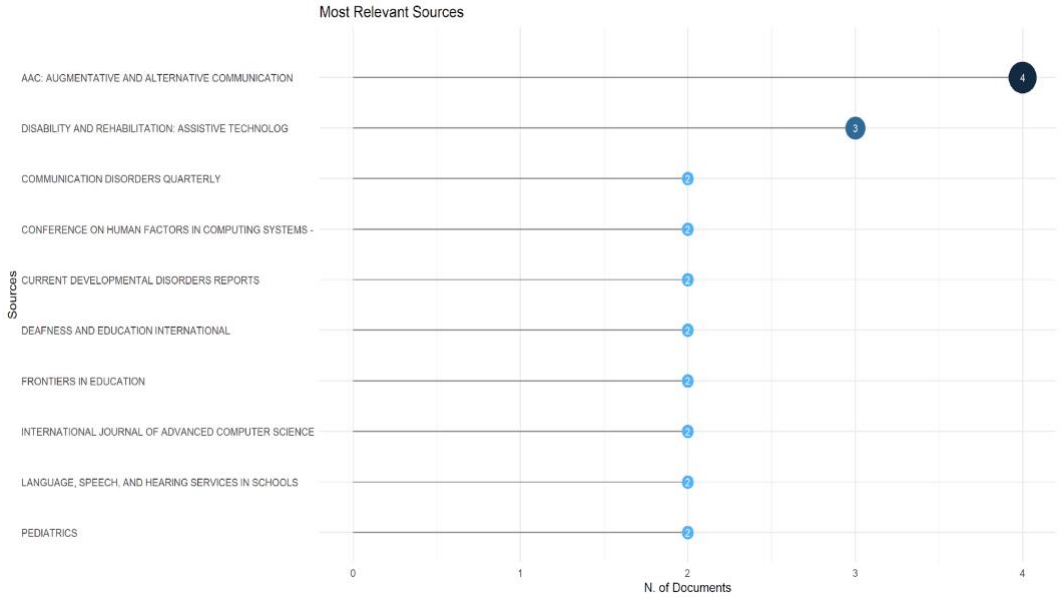

Figure 3. Most Relevant Sources

The keyword co-occurrence network is displayed in figure 4. The primary cluster is located around the expression 'augmentative and alternative communication' with strong connections to 'human,' 'language development,' 'hearing impairment,' and 'speech therapy. The other clusters connect you to terms like preschool child and assistive technology that suggest a predominance of studies in the area of early intervention and language therapy approaches. As evidenced by this network map, AAC research primarily revolves around interventions to assist with language development. The appearance of words associated with IT and mobile applications in smaller clusters, reflects that this area is very immature and still has a lot of potential for growth, especially if we define what counts as an application level technologies.

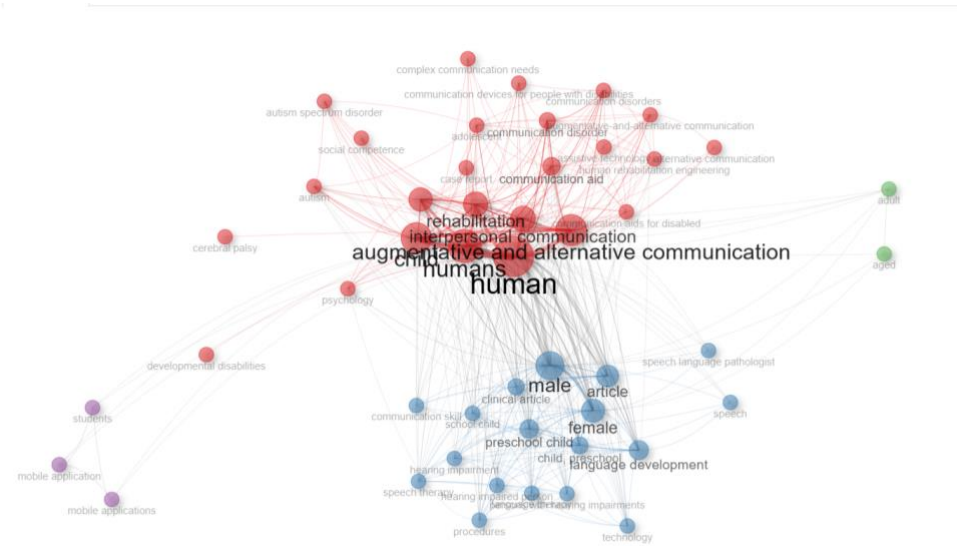

Figure 4. Keyword Co-occurrence Network

The systematic synthesis of five studies retrieved using the PRISMA guidelines alongside the bibliometric analysis highlight repeated patterns in findings. Table 2 is a summary of the studies analyzed.

Table 2. Synthesis of the Analyzed Studies

Author & Year	Title	Research Design	Focus RQ	Key Findings
(Meinzen-derr et al., 2019)	Enhancing language in students who are deaf/hard-of-hearing using augmentative and	Single-case experimental design	Does integrating AAC core word strategies into speech-language therapy improve	Significant improvement in spoken language outcomes (mean length of utterance, words

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Author & Year	Title	Research Design	Focus RQ	Key Findings
	alternative communication technology strategies		spoken language outcomes in students who are D/HH?	spoken, pragmatic skills) through AAC strategies integrated with speech therapy.
(Wu et al., 2022)	Augmentative and Alternative Communication in the Context of Dramatic Storytelling: A Single-Case Study of a Preschooler With a Cochlear Implant	Single-case study	How does integrating AAC with dramatic storytelling help improve functional communication in a child with severe communication difficulties and a cochlear implant?	AAC integrated with dramatic storytelling improved the preschooler's functional communication vocabulary and oral language use frequency.
(Caron et al., 2021)	Effects of a Literacy Feature in an Augmentative and Alternative Communication App on Single-Word Reading of Individuals with Severe Autism Spectrum Disorders	Single-subject, multiple-probe design	How does the AAC app with transition to literacy features affect single-word reading in individuals with severe autism and minimal speech?	The AAC app's literacy features (dynamic text and speech output) significantly improved the accuracy of single-word reading in individuals with ASD who had minimal speech.
(Meinzen-derr et al., 2016)	Disability and Rehabilitation: Assistive Technology Technology-assisted language intervention for students who are deaf or hard-of-hearing; a pilot study of augmentative and alternative communication for enhancing language development	Pilot study with mixed methods	Can integrating AAC technology with speech therapy improve language outcomes in students with cochlear implants?	Using AAC technology in therapy improved language production, receptive vocabulary, and social communication skills in students with cochlear implants.
(Dall et al., 2022)	Understanding the Impact of Child, Intervention, and Family Factors on Developmental Trajectories of Students with Hearing Loss at Preschool Age: Design of the AChild Study	Qualitative research	What AAC techniques and tools are most effective in early intervention for preschoolers with hearing loss?	Early use of AAC tools in preschoolers significantly supported communication development, particularly in speech and vocabulary acquisition for students with hearing loss.

The synthesis of the five studies suggests that using AAC is effective in stimulating communication skills development among students with hearing impairments, especially related to language production, both receptive and expressive vocabulary skills, and social communication. These results speak to the first research question, showing that AAC systems can enhance communication development as part of structured interventions.

Moreover, the strategies used varied between low- and high-tech interventions, with technology-based intervention revealing further possibilities for improving language and social communication therewith. Yet, their success continues to depend on other variables including high intensity of therapy, the presence/absence of teachers or therapists and support by environment.

The findings of the bibliometric analysis and study synthesis demonstrate an overall in-depth emergence of AAC research for hearing impairments as a consistent substantive field with robust evidence supporting its effectiveness on communication outcome measures. However, still most studies use small sample size designs; hence there is a need for conducting larger-sized experimental research designs to ensure the generalizability of the results.

3.2. Discussion

The findings of this review indicate that Augmentative and Alternative Communication (AAC) systems contribute positively to the communication development of students with hearing impairments. Improvements were identified in language production, receptive and expressive vocabulary, reading accuracy, and social communication skills (Ryan et al., 2016). These findings suggest that AAC functions not only as a compensatory communication tool but also as an effective support for language development.

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The first research question is answered by showing the positive effects that use of AAC systems has on communication development. Several studies have shown that AAC integrated with speech therapy is associated with wider outcomes compared to the separate application of either solution. This indicates a strong reliance on the context in which AAC is implemented. Thus technology should not be positioned as separated intervention but rather be perceived within a communication support ecosystem including therapists, teachers and families (Biggs & Hacker, 2021).

In terms of methodological variation (RQ2): results show that both low-tech and hightech approaches positively contribute to materialisation (Hansen & Winther, 2011). However, approaches using technology particularly apps featuring dynamic text and speech output provide additional promise for enhancing early literacy and social communication. This finding concurs with previous literature that features both visual and auditory components are relevant in learning for deaf students. However, the evidence that high-tech AAC is more effective compared to low-tech approaches is not convincing. Intervention intensity and need congruence, however, continue to moderate effectiveness.

To respond to the third research question, which targeted the effectiveness of mobile AAC applications, it was determined that digital literacy and speech output features assist in achieving greater language production and enhancing reading accuracy. But most studies use a single-case design or are small-scale. Thus, while these data are encouraging, such results need to be interpreted with caution, and the findings cannot be extrapolated beyond the experimental situation without confirmation in clinical studies of larger scale.

As for the implementation challenges (research question 4), limited teacher training, limited availability of devices and the necessity for parental support, were reported as main barriers. We conclude that effective AAC is dependent on factors beyond the technology itself, including, the readiness of the educational system and social context for appropriate device implementation. Thus, technology based approaches need to make adequate training and support strategies (Tena-Chollet et al., 2017). With respect to the fifth research question, it has been established that AAC usage contributes positively in terms of both social interaction and communication (a mixture of those two factors is called communication participation). Social communication is critical in both clinical and educational settings, because effective social interaction is essential for academic achievement and emotional growth. Nevertheless, more research is warranted to establish the causal relationship between AAC use and long-term educational outcomes.

There are various rival explanations that must be examined. The improvements in communication skills reported in the studies may well be either due to effects of intensive therapy or simply a function of normal developmental progression (the Hawthorne effect) rather than being solely attributable to AAC use (Pope et al., 2025). Moreover, personal factors including age, severity of hearing loss, and experience with cochlear implant may also moderate responses to intervention. Thus, the results should be understood in light of the research designs analyzed.

Future research should employ controlled experimental designs with larger samples in order to build a stronger evidence base for the effectiveness of AAC. Moreover, curricula-based inclusive education alongside research on the development of more adaptive mobile-based AAC applications has been an important agenda. We also need longitudinal studies that can investigate the effects of AAC use on educational performance or social participation over time in students with hearing loss (van der Straaten et al., 2020).

In general, this conversation points out that AAC systems have a very big potential to improve communication only combined with language therapy and these used under supportive surroundings by the students with hearing impairments. These results support the multi-modal potential of AAC within special education at large, while also highlighting the need for evidence based practices in the development of assistive communication technology. In practical settings, AAC systems can serve as alternative instructional supports to facilitate communication access for students with hearing impairments in both special and inclusive education environments. Teachers may use AAC-based applications, visual symbols, and speech-output technologies to enhance classroom interaction, vocabulary learning, and student participation (Light et al., 2019). Furthermore, early integration of AAC interventions may help students develop more effective communication strategies and improve their confidence in social interactions.

These findings also suggest the importance of institutional support, including teacher professional development, provision of assistive technology resources, and collaboration between educators, speech therapists, and families. Policymakers and educational institutions should consider integrating AAC-based communication supports into inclusive education programs to improve accessibility and communication opportunities for students with hearing impairments.

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3.3. Implications

The findings of this systematic review provide important implications for both theoretical development and practical implementation of Augmentative and Alternative Communication (AAC) in the education of students with hearing impairments. From a theoretical perspective, the results reinforce the conceptual understanding that communication development in deaf and hard-of-hearing students is not solely dependent on auditory input but can be effectively supported through multimodal communication systems. The integration of AAC within language development frameworks highlights the relevance of socio-constructivist and multimodal learning theories, where communication is shaped through interaction, visual representation, and technological mediation. The evidence synthesized in this study further strengthens the position of AAC as not merely a compensatory tool, but as an active facilitator of language acquisition, literacy development, and social communication competence.

In practical terms, the results suggest that AAC systems can be strategically implemented as part of inclusive and special education practices to enhance communication accessibility. The positive outcomes associated with both low- and high-technology AAC indicate that educators and practitioners have flexible options that can be adapted to diverse student needs and resource contexts. However, the effectiveness of AAC is closely tied to the quality of its implementation, particularly the integration with speech-language therapy, early intervention programs, and consistent instructional support. This implies that successful application requires not only access to technology, but also systematic training for teachers, collaboration with therapists, and active involvement of families. Furthermore, the findings emphasize the importance of institutional readiness, including infrastructure provision and policy support, to ensure sustainable AAC integration in educational settings. These implications highlight that AAC should be embedded within a broader communication support ecosystem rather than treated as an isolated intervention.

3.4. Limitations

Despite providing valuable insights, this study is subject to several limitations that should be carefully considered when interpreting the findings. The scope of the review was restricted by the relatively small number of studies that met the inclusion criteria, with only a limited set of empirical articles included in the final synthesis. This constraint reduces the breadth of evidence and may limit the generalizability of the conclusions, particularly given that many of the included studies employed small-scale or single-case research designs.

In addition, the reliance on a single primary database for article retrieval may have resulted in the exclusion of relevant studies published in other databases or languages, thereby introducing potential selection bias. The heterogeneity of research designs, intervention types, and outcome measures across the included studies also posed challenges for synthesis, leading to the adoption of a narrative rather than a quantitative meta-analytic approach. While this qualitative synthesis allows for in-depth interpretation, it does not provide statistical estimates of effect size, which limits the ability to draw more definitive conclusions regarding the magnitude of AAC effectiveness.

Furthermore, variations in participant characteristics, such as age, severity of hearing impairment, and prior exposure to communication interventions, may have influenced the reported outcomes. These contextual differences make it difficult to isolate the specific contribution of AAC interventions from other influencing factors, such as therapy intensity or natural developmental progression. As a result, the findings should be interpreted as indicative rather than conclusive evidence of effectiveness. Collectively, these limitations underscore the need for future research employing larger samples, more rigorous experimental designs, and longitudinal approaches to strengthen the evidence base and enhance the applicability of AAC interventions in diverse educational contexts.

4. Conclusion

This Systematic Literature Review demonstrates that Augmentative and Alternative Communication (AAC) systems contribute positively to the communication development of students with hearing impairments, particularly in language production, receptive and expressive vocabulary, reading accuracy, and social communication skills. The findings indicate that both low-technology and high-technology AAC interventions can effectively support communication and language learning when integrated with educational and therapeutic support. In addition, this review highlights the importance of environmental factors such as teacher readiness, family involvement, and access to assistive technology in successful AAC implementation. This study contributes to the growing body of knowledge on AAC in special and inclusive education by providing a synthesized understanding of intervention effectiveness, implementation challenges, and the potential of AAC systems to improve communication accessibility and participation for students with hearing impairments.

Author Contributions

All authors have equal contributions to the paper. All the authors have read and approved the final manuscript.

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Declaration of Conflicting Interests

The authors declared no potential conflicts of interest with respect to the research, authorship, and/ or publication of this article.

Data Availability

The datasets generated during and/ or analyzed during the current study are available from the corresponding author on reasonable request.

Declaration on AI Use

The authors declare that no artificial intelligence (AI) or AI-assisted tools were used in the preparation of this manuscript.

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