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# Artificial Intelligence and D/deaf and Hard of Hearing Children

***A Commentary***

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## Abstract

*Generative artificial intelligence (AI) occupies a dominant transformational position in a wide range of fields, including education, business, law, medicine, rehabilitation – among others. Despite the controversies regarding the use and abuse of this technology, it is possible for professionals, especially those in education, to reap its benefits for instruction, research, and administrative endeavors. Keeping in mind the ethical concerns and the current limitations of the system, AI can provide substantial assistance to, for example, teachers, students, and scholars. Setting aside fears of this technology, teachers can save time and become more efficient and productive with their administrative and instructional tasks. Teachers can also use AI to improve the academic, communication, and social skills of students, including—and especially--students in special education programs. Students can learn to use AI independently; in fact, AI can help students to become autonomous and critical seekers of knowledge. After highlighting some challenges of using AI, the present manuscript discusses a few benefits of AI for children and adolescence who are d/Deaf and hard of hearing (d/Dhh). The manuscript also contains recommendations for teacher education and future research endeavors.*

***Keywords***: *artificial intelligence, d/Deaf and hard of hearing, teacher education*

Generative Artificial Intelligence (AI) has become one of the most transformative forces of our current world (Jackson, 2025; McGee et al., 2025). In education, AI has the potential to enhance efficiency, increase productivity, personalize learning, and reimagine teaching practices as well as to facilitate advances in theory and research. The exponential evolution and availability of AI tools can be seen inside and outside of classrooms and laboratories.

With the potential to revolutionize learning, educators should use AI to help students become autonomous, critical, and successful seekers of knowledge. As noted by Jackson (2025, p. 6):

*Artificial intelligence is a technology that simulates human abilities to perform tasks. A successful intelligence, whether artificial or not, is something that takes actions that can be expected to achieve objectives. That applies to you as much as it does to a*

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*chatbot. The objective is not the concern of the intelligence, per se, but by what means to achieve it.*

As editors and scientists, we are interested in discussing the benefits and challenges of using generative artificial intelligence, henceforth AI, to improve the academic, communication, and social skills of children and adolescents who are d/Deaf and hard of hearing (d/Dhh). In our minds, there is no doubt that technology can and has played a pivotal role in the education of d/Dhh students, providing teachers and educators are prepared and assertive in using the tools (see, e.g., the discussions in Hasanbegovic & Mahmutovic, 2014, 2022; Paul, 2025). There is a tendency to focus predominantly on developing the areas of language and literacy for d/Dhh students. However, we should not neglect other important domains such as science, mathematics, and the need for developing critical thinking skills, which is necessary for our complex world (see, e.g., the discussion in Paul & Hasanbegovic, 2025). In fact, AI can be combined with other concepts such as universal design for learning (UDL) and Philosophy for Children (P4C) to enhance creative and critical thinking skills as well as language and literacy acquisition (see, e.g., Ozcan & Paul, 2025).

Our plan for the present manuscript is as follows. First, we discuss the challenges (perils, disadvantages, etc.) of AI, including its use by students. Then, we provide a panorama of applications and benefits for d/Dhh children and adolescents. Finally, we provide recommendations for teacher education and future research endeavors. We remind our readers that this is not an exhaustive treatment of these issues; our goal is to stimulate debate and encourage the use of AI to improve educational and social lives of d/Dhh individuals (for perspectives, see Alkahtani, 2024; Coy et al., 2025).

**Perils of AI**

As with the advent of any new technological tool, there have been anxieties and concerns, especially about what are perceived to be the dangers of using these tools. Accounts of the perils of AI for students at all levels as well as teachers, can be found in popular magazines and newspapers (Singer, 2025, December; 2026, January). These concerns need to be addressed if educators desire to reap the benefits of using AI in the classroom.

With respect to teachers, similar to the beginning of the computer age, there is a high level of anxiety regarding how to use AI or to understand the manner in which AI operates (e.g., Wu & Li, 2025). Teachers are concerned with the impact of AI on learning behaviors and outcomes, particularly its effects on their instructional style and student interactions. Teachers desire more clarity regarding the need to redesign their instruction and curriculum to accommodate the use of AI tools. They worry about their professional agency and the shifting of their authority or expertise to this technology (Tripathi et al., 2025). The adoption of AI tools should be based on clear professional policies and buttressed by ethical safeguards addressing biases and privacy.

Without a doubt, the greatest concerns of teachers, indeed of all educators, center on the impact of AI on students. Considering the limits of AI, students need to be aware of inaccurate information, information that perpetuates bias, and AI "hallucinations" (see, e.g., the discussion in Paul, 2025; also, see; https://www.ibm.com/think/topics/ai-hallucinations#:~:text=AI%20hallucination%20can%20have%20significant,learning%20algorithms%20is%20input%20bias). Students also need to learn to obtain additional perspectives or use a variety of sources to minimize bias, misinformation, or false information. In short, the elements of credible research with respect to reliability and validity become critical aspects of instruction. This is a challenge for everyone, especially in this age of agnotology (Paul & Hasanbegovic, 2025).

And, of course, there exist the prevalence of cheating with respect to writing papers and taking tests (i.e., take-home tests). Even more disturbing is the strong dependence on this technology, which can diminish critical thinking and other important inferential and creative skills (also, see Michigan Virtual, 2025). There is also the concern that AI will limit the amount of human interactions and affect the development or enhancement of empathy.

In our view, there is a need for research to assist teachers in the use of AI; specifically, research is necessary for understanding how AI can be implemented to develop academic skills, including language and literacy—the predominate focus of educators and scholars interested in d/Deaf and hard of hearing students. The wide range of benefits of AI should not be underestimated, as discussed in the following paragraphs (also, see Alkahtani, 2024; Coy et al., 2025; Paul, 2025).

## The Applications of AI for d/Deaf and Hard of Hearing Students

The perils of AI notwithstanding, there is a substantial number of benefits for d/Deaf and hard of hearing students. Many of the benefits and applications are similar to those for other students, and a few are unique to d/Dhh students. In general, AI can impact communication, language, literacy, and other academic content areas as well as social-emotional development and social interactions.

One critical advantage is the improvement of access to communication via real-time captioning and/or speech to text translations. Captioning, driven by AI, has been shown to increase classroom participation and to provide access to any information delivered via speech or the auditory mode (Alkahtani, 2024; Coy et al., 2025). That this type of access also increases motivation, interest, and engagement should not be underestimated.

The potential for improving the verbal (spoken) language proficiency and its subsequent effects on all other academic areas should also not be underplayed. The structure of the spoken language can be manipulated to deliver explanations or information in simpler form to enhance or facilitate understanding by the students. If applicable, AI can be designed to improve the speech ability of d/Dhh children and adolescents.

The use of AI and sign language has also generated novel and innovative outputs. For example, the translations of sign language into text or spoken language facilitate communication with non-signers and can be a benefit for inclusive settings (Coy et al., 2025). To promote inclusion as well as language development and instructional content delivery, the AI models can translate spoken language or print text into *animated sign language avatars*. Chatbot (e.g., Chat GPT) can provide explanations or additional clear information via the use of signs. It is possible that the sign language avatars can assist with interpreting needs. In essence, to facilitate communication between d/Dhh students and non-signing teachers, investigators and innovators are combining computer vision, machine translation, and 3D avatars (Coy et al., 2025).

Children who are d/Deaf and hard of hearing often struggle to access language and communication in the early stages of development, which can hinder cognitive development. If Chat GPT could be part of their use, here are some possibilities:

- *Visual and language support (for children who recognize text)*

Artificial intelligence can translate speech into text in real time (speech-to-text), which would make it easier for children to follow communication. AI can provide explanations in simple language or visual metaphors, making understanding more accessible.

- *Sign language support*

As mentioned, there is research and development of software that uses artificial intelligence to recognize and generate sign language via cameras and avatars (Alkahtani, 2024; Coy et al., 2025). This would allow affected children to interact through their primary modality -visual-motor.

- *Knowledge development through interactive tasks*

Artificial intelligence can offer games, tasks, and logic exercises adapted for use without sound, with a focus on visual attention, spatial orientation, and semantic networks. This provides a constant learning partner for children.

- *Bridge to Inclusion*

We have mentioned the benefits of AI for inclusive settings (e.g., Coy et al., 2025). The d/Dhh child can communicate more easily with peers and teachers with the help of Bridge to Inclusion (a textual and visual bridge), which reduces isolation and encourages social cognition and interactions.

## Examples and Prototypes

AI could be designed as an interactive digital teacher for children, with a special emphasis on linguistic and cognitive development, visual materials, and, where possible, integration with sign language. At the request of the educator, Chat GPT can prepare a functional concept (high level) for a digital interactive tutor adapted to d/Dhh children, plus practical steps for the pilot, measurement indicators, and an example of a teaching activity that can be immediately implemented in a prototype:

**1. Summary objective**

Goal: to improve the early language-cognitive development and inclusion of d/Dhh children through a multimodal, visually-oriented digital tutor that integrates:

- real-time text transcripts,
- visual/animated representations of sign language (avatar or video),
- interactive visual tasks and games adapted to the child's level.

**2. Key System Components**

- *User Interface (UI)*

- Tablet/PC application with large, clear visuals; child-friendly buttons and interactions.
- Parent/Teacher access with a dashboard to track progress.

- *Speech and text support*

- Speech-to-text for teacher communication (real-time display as text + sentence highlighting).
- Toggle for plain language.

- *Sign language*

- Two choices: (A) professional translator videos for teaching content; (B) animated avatar for dynamic responses (if we choose an avatar, we work in collaboration with sign language linguists).

- *Interactive exercises and games*

- Visual sequences, word → picture mapping, story building from pictures, spatial logic puzzles, memory games, etc.
- Adaptive difficulty level (AI model monitors performance and adjusts tasks).

- *Assessment and monitoring*

- Standardized story comprehension tests, percentage accuracy, reaction time, vocabulary tests — all automatically logged.
- Dashboard with trends and recommendations.

- *Privacy and ethics*

- Local processing of sensitive data whenever possible; coding; parental consent; absence of advertising.
- Inclusion of the d/Deaf community and certified interpreters in development.

**3. Educational approach (how to teach)**

- Basis: multimodal input/output (image + text + sign).
- Focus on: receptive language (comprehension), expressive language (communication), cognitive skills (working memory, visual-spatial attention).
- Methods: short lessons (5–10 minutes), frequent repetitions, scaffolded tasks, and storytelling.

**4. Technical architecture**

- Student: mobile/web app (React Native) for tablets.
- Backend: API for managing content, users and analytics.
- ML/modules: STT (local or cloud), NLP for generating simplified explanations, adaptive model for weight adjustment. (Speech-to-text (STT) is an essential component for creating voice-powered experiences that delight users. A subset of automatic speech recognition (ASR), STT algorithms enable the application of text-based natural language processing (NLP) techniques to a user's intentions. This makes speech-to-text perfect for use cases such as generating video captions, transcribing meetings, and converting voice to plain text for analysis.
- Character module: integrated video library +/− avatar engine/ Separate development or existing SDK - The Android Software Development Kit (SDK) is a collection of tools, libraries, and documentation that developers use to create applications for devices running the Android operating system. It provides a complete development environment for building, testing, and debugging Android applications.

**5. Pilot study (design proposal)**

- Objective: to test acceptability, usability, and impact on vocabulary/ comprehension.
- Participants: 20–40 d/Dhh children, divided into experimental and control groups (if possible).
- Duration: 8–12 weeks, 3 sessions of 10–15 minutes each.
- Metrics: increase in number of words understood, improvement in story scores (pre/post), engagement (time used), parent/teacher satisfaction.
- Analysis: simple pre/post design (paired t-test or Wilcoxon if distribution is not normal) for main language metrics.

**6. Success metrics**

- % vocabulary increase (pre → post).
- Accuracy improvement in story comprehension tasks.
- Average training time and task completion rate.
- User satisfaction (parent/teacher survey).

**7. Assess resources and partners**

- Experts needed: sign language linguists, special educator, developer, ML engineer, UX designer, audiologist/therapist.
- Initial budget (depending on avatar and ML integrations).

**8. Example of a 10-minute lesson (a concrete scenario that AI can immediately prototype on any topic)**

- Here is an example of a topic: "Toy and cat" — goal: 8 new words + understanding of a short story.
- Introduction (1 minute) — Large illustration of a cat and a toy; word shown visually + text + video of a sign language interpreter (10–12 s).
- Word presentation (3 minutes) — 8 words: cat, toy, ball, sleep, run, window, eat, calm. For each: picture + text + 2 s sign + short animation (if possible). Game: click on the picture that shows the word you see in the sign.
- Story (3 minutes) — A simple sentence is read (text + signs + comic-style pictures): "The cat looks at the ball and starts running." Each sentence is followed by a simple question with a choice of picture (receptive test).
- Memory game (2 minutes) — Pairs of pictures (matching) that test memory of concepts.
- Short evaluation & feedback — The system shows three metrics: accuracy, time, and recommendation for the next lesson.

**9. Ethics, inclusion, and continuous evaluation**

- Involve members of the local d/Deaf community in all phases: from design, testing to finalization.
- Mandatory accessibility assessment (specific requirements for sign language).
- Regular content revisions by certified translators.

**10. Suggested steps - Chat GPT can make these artifacts:**

- MVP specification (10–12 pages) detailing functionality and minimum requirements. A Minimum Viable Product is the simplest version of a product or feature that can be released to early adopters. It includes only the core functionalities necessary to meet initial user needs and gather feedback for future development.
- Interactive wireframe prototype (series of screens and flows: initial screen, lesson, task, dashboard).
- The first 10-minute lesson is delivered in a directly deliverable format (texts, storyboard for pictures, script for sign language interpreter).
- Pilot study plan with details for ethics, measurements, and analysis.

If desirable, for example, start with a wireframe and prototype of a lesson, AI will instantly generate it and sketch out a preliminary UI flow (description + series of screens).

GPT can provide a text-graphic representation (description + arrangement of elements) to present a clear vision of how the application should look and function.

Wireframe - The flow through the app provides a home screen where one can choose beginner lessons for learners (e.g., Lesson 1: Toy and Cat; Lesson 2: My Room, or Lesson 3: On the Playground).

The child, together with a teacher, proceeds through lessons that GPT generates immediately on demand. Everything takes place in a dynamic format: Word presentation, Mini-game, find the word, Story (comic style), Memory game, End of lesson and instructions for the next lesson.

Prototype of the lesson "Toy and cat". The goal can be selected: Learn to pronounce and/or write 8 words (cat, toy, ball, sleep, run, window, eat, calm).

Structure (10 minutes):

Introduction – presentation of the topic (picture of a cat + sign + text).

Presentation of each word (picture + text + sign).

Mini-game "find the word".

Short story in a comic book (3–4 sentences).

Comprehension questions.

Memory game (matching pairs).

Feedback and praise.

**General Background Discussion**

The use of specific software and technology, similar to AI, to improve the education of d/Dhh individuals has been described in previous research (some of which has been mentioned previously in this commentary). For example, what artificial intelligence proposes as screen drawings, as visual sketches (wireframe images), to get a sense of the real appearance of the application through a programmed dynamic classroom for children who are d/Dhh, has been proposed by Hasanbegovic and Sinanovic (2007), Hasanbegovic (2008), and Hasanbegovic and Mahmutovic (2014).

Hasanbegovic (2008) offered multimodality as the basis of computer-programmed lessons for learning language and literacy through an application (combining images, sign language, text, and sound, if possible, which provides better support than monomodal methods), and AI currently offers the same approach for teaching children who are d/Dhh (see, e.g., Alkahtani, 2024; Coy et al., 2025). Aldemir *et al*. (2023), through a systematic review and meta-analysis of vocabulary interventions for d/Dhh children and adolescents, consolidated the evidence on interventions aimed at expanding vocabulary. The researchers showed that structured, targeted vocabulary technologies and programs produce measurable improvements. An intervention that combined traditional language education with information technology (Hasanbegovic & Sinanovic, 2007) monitoring of spoken language found a significant increase in sentence length, number of words, and pragmatic abilities. This approach supports the use of technology + visual/alternative means of communication (sign, symbol, image) to improve the language and literacy of children who are d/Dhh. A discussion on the development and improvement of syntax in children with the help of modern technology can be found in Hasanbegovic and Mahmutovic (2014).

For a number of d/Dhh children, AI-generated content needs to be visually supported, including the use of a signed language. Holmer *et al*. (2017) in their experimental study showed that computer programs that include sign language can improve reading in children who know sign; practical evidence that digital content with signs works to improve literacy (also, see Alkahtani, 2024).

A review of early interventions directed at parents emphasized the importance of early, family-centered support and multimodal strategies in the first months/years of life. This points to the usefulness of structured programs for language development (Wright et al., 2021). A good resource for practical standard solutions can be found in Karger (2020). There is a practical report/policy brief summarizing evidence and recommendations for the design of digital educational materials available to d/Dhh students (WCAG + multimodality, meta-support for strategic use of visuals). Curtis et al. (2022) provided a taxonomy of high-tech AAC solutions, useful for technology selection (e.g., avatar vs. video translator) and understanding the implications/limitations.

## Conclusion

If teachers and students are adequately prepared, the use of AI is truly transformative and will create efficient lessons and equitable learning environments. We believe that d/Dhh students via AI can improve their cognitive, language, and literacy skills and, equally as important, participate as creative-critical thinkers in the current society. However, students need a balanced, thorough treatment of AI by their teachers.

At present, a number of teacher education programs are not performing well in preparing teachers in the use of AI (e.g., Weiner & Lake, 2025, April). As indicated in this manuscript, there are several sources that have contributed to teachers' fears, ranging from lack of understanding and clarity on how to use AI and incorporate in their lessons to their concerns about misuse, bias, reduction of interactions, and loss of professional identity and authority. These concerns are similar to those expressed during the advent of the computer and the internet. In essence, these concerns need to be addressed through in-service and recurring workshops, buttressed by clear district or school policies. Students also need to be aware of the positives and negatives regarding AI with well-planned and organized instructional lessons.

With adequate preparation and ongoing institutional support, the use of AI in the education of d/Deaf and hard of hearing students should produce enormous transformational benefits. We should not neglect to harness the power of this technology for improving the cognitive, educational, and social skills of students, especially students who are d/Deaf and hard of hearing.

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