MAKING THOUGHT VISIBLE: BLENDING GENERATIVE ARTIFICIAL INTELLIGENCE AND VISUAL COGNITION THEORY FOR INNOVATIVE RESOURCES IN DEAF EDUCATION[1]

Zviditeľnenie myslenia: prepojenie generatívnej umelej inteligencie a teórie vizuálneho vnímania pre inovatívne zdroje vo vzdelávaní žiakov so sluchovým postihnutím

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Abstract: *Generative artificial intelligence (GenAI) is an innovative educational resource for deaf students, promoting the connection between visual cognition, digital literacy, and creative thinking. This project explores the potential of GenAI to promote Portuguese as a Second Language (PL2) and Portuguese Sign Language (PSL) skills, integrating text, images and gestures in a multisensory way. Adopting a bilingual socio-anthropological approach, the project Artificial intelligence in promoting critical and creative thinking skills in deaf students was first implemented through the training course 'Making Thought Visible', equipping teachers and interpreters with the skills to create inclusive pedagogical resources and generate meaningful images to illustrate curricular content. Participants analyzed the ethical foundations of artificial intelligence (AI), visual cognition, the production of visual narratives, and pedagogical innovation with digital tools through structured stages. Preliminary results suggest increased motivation and participation among deaf students, supporting the hypothesis that AI can effectively facilitate intermodal learning processes. Critical training among professionals was essential for the conscious use of these technologies. The study also suggests that AI can contribute to the development of a visual epistemology of learning, challenging traditional concepts and broadening the scope of expression, cognition, and culture in bilingual education.*
Key words: *deaf education, generative artificial intelligence, visual cognition, Portuguese language, portuguese sign language.*

Abstrakt: *Generatívna umelá inteligencia (GenAI) predstavuje inovatívny vzdelávací zdroj pre žiakov so sluchovým postihnutím, ktorý podporuje prepojenie medzi vizuálnym vnímaním, digitálnou*

[1] Prijaté do redakcie/Paper submitted: 03. 08. 2025

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gramotnosťou a kreatívnym myslením. Tento projekt skúma potenciál GenAI na podporu zručností v portugalčine ako druhom jazyku (PL2) a portugalskom posunkovom jazyku (PSL) integrujúc text, obrazy a gestá multisenzorickým spôsobom. S využitím bilingválneho socioantropologického prístupu bol projekt "Umelá inteligencia na podporu kritického a kreatívneho myslenia u žiakov so sluchovým postihnutím" najskôr implementovaný prostredníctvom školiaceho kurzu "Zviditeľnenie myslenia," ktorý vybavil učiteľov a tlmočníkov zručnosťami na vytváranie inkluzívnych pedagogických zdrojov a generovanie zmysluplných obrazov na ilustráciu obsahu kurikula. Účastníci analyzovali etické základy umelej inteligencie (UI), vizuálne vnímanie, produkciu vizuálnych naratívov a pedagogické inovácie s digitálnymi nástrojmi prostredníctvom štruktúrovaných etáp. Predbežné výsledky naznačujú zvýšenú motiváciu a účasť medzi žiakmi so sluchovým postihnutím, čo podporuje hypotézu, že UI môže efektívne uľahčiť intermodálne vzdelávacie procesy. Kritická príprava odborníkov bola nevyhnutná pre vedomé používanie týchto technológií. Štúdia tiež naznačuje, že UI môže prispieť k rozvoju vizuálnej epistemológie učenia, spochybňujúc tradičné koncepty a rozširujúc rozsah expresie, kognície a kultúry v bilingválnom vzdelávaní.
Kľúčové slová: *vzdelávanie žiakov so sluchovým postihnutím, generatívna umelá inteligencia, vizuálne vnímanie, portugalčina, portugalský posunkový jazyk.*

Introduction

In contemporary educational contexts, the integration of artificial intelligence (AI) into pedagogical practices has opened up transformative possibilities—particularly in the field of Deaf education, where visual cognition plays a foundational role. Visual cognition refers to the process through which individuals perceive, interpret, and mentally manipulate visual stimuli, encompassing attention, memory, reasoning, and problem-solving skills mediated by visual input (Arnheim, 2004; Hall et al., 2017). For deaf learners, visual processing is not merely a compensatory strategy for hearing loss, but a primary cognitive modality that structures their interaction with the world. Consequently, educational approaches for deaf students must privilege and enhance visual channels of communication and comprehension.

Generative Artificial Intelligence (GenAI) has emerged as a particularly promising tool in this endeavor. Its capacity to generate meaningful, context-specific visual representations from linguistic prompts enables a deeper exploration of semiotic translation between written Portuguese, Portuguese Sign Language (PSL), and visual imagery (Luckin et al., 2016; Habib et al., 2024). This intermodal translation fosters what may be called a visual epistemology—a way of knowing rooted in imagery, gesture, and spatial reasoning. By aligning with the bilingual socio-anthropological model of Deaf education (Skliar, 1998; Vieira, 2022), AI-supported pedagogies can significantly enhance the linguistic autonomy and critical-creative capacities of deaf students.

Central to this innovation is the concept of multimodality, which acknowledges that meaning is constructed through the interplay of various modes—verbal, visual, gestural, spatial, and digital (Jewitt, 2008). Multimodal educational design ensures that students engage with knowledge through multiple, synchronized sensory pathways. In the case of deaf learners, the triad of text–image–gesture becomes a dynamic framework for inclusive instruction, enabling deeper comprehension, engagement, and expression.

Finally, these innovations contribute to the development of inclusive pedagogical practices, which aim to create equitable learning environments that accommodate diverse learners. Inclusive pedagogy is not limited to accessibility but involves actively designing content that resonates with students' linguistic, cultural, and cognitive profiles (Holmes et al., 2019). GenAI, when critically applied, supports the differentiation of curriculum, allowing educators to tailor resources in ways that are visually, cognitively, and emotionally meaningful.

This article explores the intersection of these four key concepts—visual cognition, AI in Deaf education, multimodality, and inclusion—to demonstrate how pedagogical innovation can be both technologically grounded and ethically responsive.

AI, Text, Image, and Gesture: A New Educational Grammar

The metaphor "Making Thought Visible" encapsulates a conceptual and pedagogical ambition: to enable, through Generative Artificial Intelligence (GenAI), processes of expression, symbolization, and comprehension that are truly accessible to deaf learners. At the heart of this ambition lies a clear epistemological stance: visuality is not merely a support for learning, but a constitutive mode of knowledge. For deaf students, thought is often structured visually and gesturally, rather than phonetically or auditorily. Therefore, educational practices that center on text-image-gesture triads reflect not only inclusive aims but also neurological and cognitive realities (Arnheim, 2004; Marschark & Knoors, 2014).

In this context, "making thought visible" becomes more than a metaphor—it becomes a pedagogical imperative. Through the use of AI tools capable of generating visual content from linguistic prompts, educators can mediate complex ideas via personalized, visually salient resources. These resources not only aid in comprehension but also support linguistic and metalinguistic development by encouraging transitions between different semiotic codes (Luckin et al., 2016). When deaf students are invited to articulate concepts through gesture, text, and image, they are not simply consumers of content—they become epistemic agents within a multimodal learning ecology (Jewitt, 2008).

This pedagogical ecology aligns with theories of visual cognition, which posit that visual processing is not just a substitute for auditory learning, but a distinct cognitive pathway in its own right. For deaf learners, visual perception is more than compensatory; it is often the primary channel through which attention, memory, and categorization are organized (Hall et al., 2017). In this view, GenAI-based tools function as mediators of meaning, not only translating abstract verbal ideas into concrete images, but also activating spatial and affective dimensions of learning that are critical for engagement and retention. Moreover, these tools enable customization—a key factor in inclusive education. Deaf learners vary widely in their levels of proficiency in Sign Language and written Portuguese, in their use of speech, and in their familiarity with digital technologies. GenAI can assist in adapting content to linguistic level, age, cultural context, and even regional variations of Portuguese

Sign Language (in original Lingua Gestual Portuguesa or LGP), facilitating differentiated instruction and helping to mitigate the risks of exclusion within bilingual educational contexts (Skliar, 1998; Vieira, 2022). The impact of AI is transversal in various domains of daily life, as education is no exception. It is essential to understand the ethical principles of using AI to improve the language skills of deaf students, as the EUD report mentions sign language in an age of AI (Venade, 2025). Sign language is, above all, a visuocorporeal language that is relevant to the design and development of AI, taking into account this idiosyncratic essence.

This capacity for semiotic translation and adaptation also opens the way for a new visual epistemology—a way of knowing grounded in imagery, spatial-temporal reasoning, and embodied expression. As Arnheim (2004) argues, visual perception is not just passive observation but an active form of thought. In education, particularly in deaf education, this has profound implications: if knowledge can be constructed through visual-symbolic forms, then the curriculum itself must shift to accommodate visual literacies and gestural reasoning as legitimate cognitive strategies.

Nevertheless, such potential must be met with critical engagement and ethical responsibility. AI tools are not neutral. They encode the biases of their training data and reflect the assumptions of their designers (Holmes et al., 2019). Teachers and Portuguese Sign Language (PSL) interpreters must therefore be equipped not only with technical know-how but also with a reflective and ethical framework that enables them to evaluate when, how, and why to integrate GenAI tools into their practice. Issues of data privacy, algorithmic representation of deaf culture, and the risk of technological determinism require continuous attention.

In sum, "Making Thought Visible" is both a didactic strategy and a philosophical claim. It asserts that expression is learning that visibility is not auxiliary to knowledge but central to it, and that deaf learners are best served by technologically mediated environments that respect and elevate their visual, gestural, and cognitive identities. The integration of GenAI in deaf education has the potential to radically transform how knowledge is produced, shared, and experienced—but only if implemented with rigor and creativity.

Emerging Hypotheses: Linguistic Autonomy, and Visual Epistemology

Generative Artificial Intelligence (GenAI) has emerged as a promising resource in the education of deaf students, combining visual cognition, digital literacy, and the development of creative thinking, which are fundamental for academic and social progression (Habib et al., 2024; Luckin et al., 2016). Despite the recognition of the importance of visuality in bilingual education for deaf students, supported by PSL as the native language and Portuguese as the second one, reductionist concepts persist that limit images to the status of retinal support, without exploring their potential to build interdiscursive and intermodal learning processes (Marschark & Knoors, 2017; Rodrigues & Lopes, 2022).

This project and the linked training course proposes an approach that considers images as mediators of critical and creative learning, integrating visual cognition as a tool to make thinking visible and foster creativity, motivation, and autonomy in inclusive educational contexts (Dekker et al., 2012; Howard-Jones, 2014). Visual cognition plays a central role in the learning of deaf students, as it is through vision that they construct the world, process linguistic information, and develop cognitive skills. Studies in cognitive neuroscience indicate that visual learning not only compensates for the lack of auditory input but also strengthens brain networks dedicated to spatial reasoning, visual memory, and attention. Images, in this context, should not be seen merely as decorative elements, but as catalysts for the construction of meaning, especially when combined with sign language, which is itself a visual-kinesthetic language.

Recognizing visual cognition as a structuring axis of the curriculum for deaf students also implies the development of pedagogical resources that respect the specific modes of perception and visual expression of this community. The use of AI in teaching Portuguese as a Second Language (PL2) and Portuguese Sign Language (PSL), based on the text-image-gesture triad or the image-gesture-text sequence, creates opportunities for a multisensory and translingual approach to learning. Deaf students benefit from resources that connect clear visual stimuli with accessible linguistic content. With AI, it is possible to generate images adapted to different age and curriculum levels, making content more engaging, personalized, and pedagogically meaningful. This bidirectional relationship between text and image can be further enriched with the mediation of gesture, allowing students to articulate linguistic and visual knowledge in integrated learning experiences that stimulate creativity, association, and critical thinking. Accessibility in learning through technology requires that resources not only be available but also tailored to the specific ways in which deaf students perceive and produce knowledge.

AI can help overcome language barriers by creating bridges between written Portuguese and Sign Language through images and gestures that accompany the content. At the same time, it requires a critical analysis of the visual, cultural, and symbolic quality of the generated images. It is essential to ensure that these images are meaningful to the curriculum, clearly represent concepts, and are visually appealing to children of various ages. An irrelevant or visually confusing image can lead to demotivation, distraction, or conceptual error. In this sense, it is essential that teachers and sign language interpreters are aware of the possibilities and limitations of AI in the context of deaf education. Ongoing training for these professionals should include digital skills, visual thinking, and the ability to critically analyze AI tools.

It is important to understand that AI does not replace pedagogical mediation or knowledge of the specificities of bilingual education, but it can be a powerful ally if used with didactic intention and cultural sensitivity. Understanding the logic behind IAG, the construction of effective prompts, and the critical reading of the generated images is essential to ensuring the pedagogical quality of the materials produced.

The project's objective is to explore how the use of GenAI can promote critical and creative thinking skills in deaf students in teaching Portuguese as second language and Portuguese Sign Language (PSL), reinforcing the text-image-PSL interface and consolidating visually oriented yet multisensory pedagogical practices, in accordance with the socio-anthropological bilingual model, with different legal, ethical, pedagogical, and educational implications (Skliar, 1998; Vieira, 2022).

Through a 30-hour online training course called "Making Thought Visible," the aim was to train a multidisciplinary group of 68 teachers and PSL interpreters from across the country to produce innovative teaching resources. The course "Making Thought Visible" designed for implementing the first phase of the project under the name "Artificial intelligence in promoting critical and creative thinking skills in deaf students", combines theory and practice in an intensive and reflective manner. This training explored, in different stages, the ethical and pedagogical foundations of AI, visual cognition in deaf students, the creative possibilities of AI-powered image generation, and the mediation between PL2, PSL, and images in the context of deaf learning.

With theoretical and practical sessions delivered remotely, this course allowed students to consolidate a multisensory and critical approach to teaching. The content, taught by a multidisciplinary team of teachers, ranged from the fundamentals of neuroscience applied to visual education, to the design of tasks integrating AI and images in reading and writing, to pedagogical planning based on the principles of bilingual education and curricular accessibility. Examples of best practices were also discussed, and GenAI tools for generating clear, relevant images adapted to the age ranges of deaf students were analyzed. Each stage of the course reinforced the understanding that images, when combined with gestures and text, can become powerful cognitive mediators.

The training also offered opportunities for practical experimentation, where teachers created and tested materials, planning activities aligned with the curriculum and focused on developing visual, critical, and creative thinking. This practical dimension allowed for immediate application of the resources in the classroom, strengthening the autonomy of professionals and the motivation of students.

Method

The "Making Thought Visible" course comprised thirteen 2- and 2.5-hour sessions aimed at professionals from multidisciplinary teams working with deaf students at all levels of education (from preschool to secondary school). Given the e-learning attendance regime offered, these professionals enrolled from all over the country. As mentioned above, the trainers involved in this course were both deaf and hearing, and came from a variety of different areas of expertise. The course was mainly attended by special educational needs teachers and PSL interpreters. The first session focused on the ethical considerations of using Generative AI in Deaf Education. It aimed to promote teachers' understanding of, and critical reflection on, the ethical issues involved in using Generative AI

in educational settings with deaf students. The course ensured that Generative AI was applied in a way that respected the principles of equity, privacy, and accessibility, thereby contributing to inclusive education that was adapted to the communication and cultural needs of these students. The second session focused on pedagogical skills for teaching and learning Portuguese as a second language, specifically the theoretical and methodological principles based on the principles of Deaf Education.

The third session focused on pedagogical and didactic skills for teaching and learning PSL, with a specific focus on the impact of images and visual narratives as privileged pedagogical resources in teaching and learning PSL. The following session continued the course with an approach to aesthetic appreciation and visual hermeneutics, focusing on developing analytical and reflective skills to identify aesthetic 'taste' in an integrative visual hermeneutics context. The fifth session focused on applying AI to PL2 teaching in deaf education. This session aimed to understand the assumptions associated with visual language, spatial thinking, problem solving, divergent thinking and cognitive flexibility. The possible practical applications of AI in the design of teaching and learning tools were discussed.

Two sessions (the sixth and eighth) were dedicated to technological skills in Generative AI applied to education, with the aim of understanding how GenAI algorithms work, how they enable teachers to assess the quality of the results generated, and how they help teachers to identify possible errors in the tools used. Knowledge was applied in the design of activities, assessment tools and feedback. The seventh session focused on developing creative skills., particularly in reflecting on how creativity in writing can promote respect for diversity and the inclusion of deaf students. The session also discussed the role of perceptions, attitudes, and self-efficacy in education and writing within inclusive digital learning environments.

The trainers agreed that the theme 'Skills for Inclusion: Promoting Accessibility to Digital Technologies as a Factor for Inclusion, Equity, Autonomy and Skills for the Future' should be included in the training, with the ninth session dedicated to this topic.

The tenth session then addressed content related to skills for innovation from the perspective of bilingual education. This included understanding the processes, resources and strategies of pedagogical innovation, as well as the development of effective planning central to bilingual education for deaf students, in light of current legislation regulating inclusive education in Portugal.

Before the final two sessions of the course, the following session addressed skills for a multimodal approach, specifically focusing on understanding the role of multimodality in inclusive education and in teaching and learning writing processes.

The final sessions were reserved for technological skills in Generative AI applied to education. The focus was on identifying the potential of GenAI in developing reading, writing, creative thinking, and critical thinking skills in deaf

students. There was also a focus on developing teaching and learning proposals based on AI tools, from their design to the processes of materializing and evaluating results. A demonstration was given on how to use AI applications in accordance with the training course objectives.

At the end of the course, the trainees presented a practical application proposal to an audience of deaf students, either in a classroom setting or through individual support. PSL interpreters were asked to plan their work to facilitate interdisciplinary collaboration between interpreters, teachers and students, and to liaise with other professionals, such as speech therapists, depending on the professional situation.

The course received the highest score, and the trainees are looking forward to more advanced training to further their learning. All of the registered trainees attended the course and passed.

All the knowledge acquired through the proposals carried out and documented by the trainees is now undergoing a process of selection and improvement to build a free online resource base, based on the educational experience of the professionals who attended the course, and above all, on the real possibilities of transferability between the theoretical and practical domains. Preliminary results point to an improvement in the motivation of deaf students and the professionals involved in training, greater participation in writing tasks using IAG and the development of interdiscursive visual narratives in students, using poetic, dramatic and narrative text, creating coherent image sequences and mobilizing knowledge of Portuguese and PSL in prompts to generate more meaningful images in the visual cognition process (Ghoul & Othman, 2022).

The methodological design was informed by the theoretical framework outlined in the introduction, integrating visual cognition, multimodality and inclusive pedagogy within the socio-anthropological model of Deaf education. Each session operationalized these principles by combining conceptual reflection with hands-on experimentation, ensuring that the theoretical assumptions about visual learning, multimodal meaning-making and the ethical integration of AI were continuously translated into classroom practice. Activities such as generating images from linguistic prompts, designing multimodal tasks, and creating collaborative resources allowed participants to experience how generative AI can serve as a cognitive mediator, aligning theory with practice. Thus, the course conveyed theoretical knowledge and embodied it through experiential learning, enabling participants to internalize and apply these frameworks in their own professional contexts.

Results of the implementation of the course

We have chosen to include a summary of the results of one of the submitted assessment portfolios here, to illustrate how the task of developing and implementing a pedagogical-didactic proposal in bilingual educational contexts was carried out. One highlight is the feedback that deaf students provided on the activities included in the following proposal:

Proposal: 'The Three Little Pigs' (target audience: deaf preschool children).

These activities are designed to develop linguistic and creative skills in Portuguese Sign Language (PSL), and to integrate technology and Generative Artificial Intelligence into the teaching and learning process.

General objective:

To promote comprehension and expression in Portuguese Sign Language through fun, interactive activities.

Specific objectives:

1. Language: To encourage the use of PSL to narrate stories in a cohesive and expressive manner, and expand vocabulary related to the story of 'The Three Little Pigs' (e.g. pig, house, wolf, straw, wood, brick). Work on sentence construction and narratives in PSL.
2. Cognitive: To develop creativity by proposing alternative endings to the story and stimulate critical thinking by reflecting on the story and creating narrative variations.
3. Technological: To promote the use of artificial intelligence as a tool to support PSL learning, and familiarize students with technologies that visually represent concepts and stories.
4. Social and emotional: To encourage group work to promote collaboration and communication, as well as to reinforce students' self-confidence when presenting stories in LGP.

***Methodological framework of the pedagogical-didactic sequence**:*

Activity 1: Introduction:

The teacher or interpreter presents the video of the story of the 'Three Little Pigs' in PSL (a resource that is available online) and highlights the story's key vocabulary. They also present an AI-generated image, the written word and the PSL gesture (to triangulate concepts) (see Figure 1).

Figure 1 Concept triangulation through AI-generated images

(Source: generated by GenAI)

The prompt taken from the chatbot was: 'Create images for the keywords from the story of the Three Little Pigs (pig, house, wolf, blow, wood, brick).'

Activity 2: Exploring the narrative using GenIA.

An AI platform that allows video editing in PSL (recorded with the students) was used: Canva.

The steps involved were as follows: the students were asked to choose parts of the story and create representative images or scenarios with the support of AI. As they are preschool students and cannot write, they gestured what they wanted and the teacher entered this into the AI (see Figures 2 – 5).

Figure 2 Image of the narrative sequence generated by GenAI. Parts of the narrative are selected by deaf children and signed to an adult.

(Source: generated by GenAI)

The prompt was taken from a chatbot: 'Create an image for the following story: Once upon a time, there were three little pigs who lived with their mother in a house in the forest.'

Figure 3 An image of the narrative sequence generated by GenAI.

(Source: generated by GenAI)

The prompt taken from the chatbot was: 'Create an image for "The youngest pig built a house of straw and then went to rest".'

Figure 4 An image of the narrative sequence generated by GenAI.

(Source: generated by GenAI)

Prompt taken from the chatbot: 'Create an image of the middle pig building a wooden house and then playing with the youngest pig.'

Figure 5 An image of the narrative sequence generated by GenAI.

(Source: generated by GenAI)

The prompt taken from the chatbot was: 'Create an image for "The wolf appeared and blew, and the straw house went up in smoke".'

Images were generated until the end of the narrative using prompts directed at the adult, who then converted them into written Portuguese using a chatbot.

Activity 3: Design an alternative ending to the story of the three little pigs.

Each group created an alternative ending for the story using PSL AI was then used to generate scenarios and/or characters to support the alternative ending (see Figures 6 and 7).

Figure 6 An illustrative image showing an alternative ending to the original story, prompted by gestures and writing from the adult.

(Source: generated by GenAI)

The prompt was taken from a chatbot: 'A three-headed monster appeared, and each head ate a piglet.'

Figure 7 An illustrative image showing an alternative ending to the original story.

(Source: generated by GenAI)

The prompt was taken from a chatbot: 'The wolf fell into the cauldron and the pigs made wolf soup.'

Activity 4 Results presentation

Each group presents their alternative ending to the class using the LGP and images they created.

Activity 5: Reflection and closing

Students discuss the vocabulary they have learnt and reinforce their understanding of the sequence of the original narrative and the alternative endings in PSL.

Questions to support reflection and student comments:

How did AI help with learning new vocabulary, sentence construction, gestural narrative construction, and imagination for different purposes?

Child A: 'It helped because we created images of things we said through gestures.'

Child B: 'It helped because we didn't have to work hard to draw.'

Child C: 'It helped because we could see if what we said was correct and if everyone understood.'

The proposal was evaluated through observation and recording of student participation and fluency when using PSL.

Observation and recording of student participation and fluency when using PSL.

Evaluation of the creativity and cohesion of the alternative endings to the stories presented.

Final reflection by the trainees

In terms of accessibility, AI-based tools make teaching materials more accessible, ensuring that all students, regardless of their level of fluency in PSL, can participate in the activities. Deaf students are empowered by the ability to create and interact with digital content, which generates greater autonomy and stimulates creativity.

Discussion and limitations of the study

Training that focuses on integrating generative artificial intelligence (GAI) into deaf education highlights the importance of combining technology and pedagogy to create inclusive and transformative practices. This approach positions AI as a tool that supports the visibility of thought and can significantly impact the learning of deaf students.

The concept of 'making thought visible' refers to the idea of externalizing mental processes, enabling teachers and students to interact in a clearer and more objective manner. In Deaf Education, generative AI can produce visual resources such as avatars that demonstrate Portuguese Sign Language (PSL), as well as images and scenarios that illustrate complex concepts, thereby

facilitating understanding. This enables teachers, educators and deaf students to transform abstract content into more concrete, visual forms, thereby making learning more accessible. We believe that AI can be used to personalize the diverse learning experiences we provide at school, which is a crucial aspect of inclusive education, particularly for students with special educational needs. AI resources can be used to create visual aids from written instructions, such as images for narratives, explanatory visual materials and real-time translations into PSL.

The integration of interactive avatars in PSL enables students to practice and interact with the content independently.

This training emphasized the role of AI in overcoming certain barriers, such as language and communication barriers, while also celebrating deaf culture.

In short, we conclude that Gen-AI technology should complement, rather than replace, human interaction, the critical role of teachers, and the work of multidisciplinary teams. Furthermore, we conclude that avatars will never replace PSL interpreters or teachers. This training reinforces the idea that AI is not just a technological tool, but also an innovative pedagogical resource. When used intentionally, it can transform deaf education by promoting equal opportunities and greater inclusion.

Given the exploratory nature of this study, it is important to acknowledge its methodological limitations. The evidence gathered is primarily based on qualitative data, including portfolios, reflections and informal feedback from trainees who attended the course. While the participants implemented the proposed activities in real educational contexts with deaf students, this study did not involve direct observation or systematic data collection from the students themselves. Consequently, the reported outcomes, such as increased motivation and engagement, and the development of multimodal resources, reflect the trainees' perceptions and documented experiences as mediators rather than measured effects on learners. This approach is consistent with the initial phase of the project, which aimed to evaluate the transferability of theoretical principles into professional practice.

Future research should complement these qualitative insights with longitudinal and quantitative studies to assess the measurable impact of GenAI on deaf students' linguistic and cognitive development.

Additionally, the course design ensured alignment between the theoretical framework, which is rooted in visual cognition, multimodality, and inclusive pedagogy, and the practical activities developed. Each session applied theoretical concepts through hands-on experimentation, enabling trainees to engage critically with AI tools and consider their ethical use in educational settings. Ethical considerations, including data privacy, representational fairness and the cultural sensitivity of AI-generated images, were explicitly addressed to promote the informed and responsible integration of technology in deaf education.

Acknowledgments
This work was financially supported by Portuguese national funds through the FCT – Foundation for Science and Technology - within the framework of Research Centre on Child Studies of the University of Minho under the reference UID/00317: Research Centre on Child Studies.

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