Gamification and Inclusion: A Systematic Review on the Use of Gamified Technologies in Deaf Education

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Abstract: This research analyzed 13 recent studies on the use of digital technologies in the education of deaf students. The objective was to understand these tools' impact on this group's inclusion and learning. The results indicate that Information and Communication Technologies (ICTs), such as games and online platforms, have effectively improved the communication, engagement, and academic performance of deaf students. The review identified several promising tools and pedagogical strategies but also highlighted the need for more research in different contexts. The conclusions reinforce the importance of ICTs as a valuable resource for inclusive deaf education, offering recommendations for future research and pedagogical practices.

Keywords: deaf education; digital technologies; inclusion; gamification; systematic review.

Gamificação e Inclusão: Uma Revisão Sistemática sobre o Uso de Tecnologias Gamificadas na Educação de Surdos

Resumo: Esta pesquisa analisou 13 estudos recentes sobre o uso de tecnologias digitais na educação de estudantes surdos. O objetivo foi compreender o impacto dessas ferramentas na inclusão e no aprendizado desse público. Os resultados indicam que as Tecnologias da Informação e Comunicação (TICs), como jogos e plataformas online, têm sido eficazes em melhorar a comunicação, o engajamento e o desempenho acadêmico de estudantes surdos. A revisão identificou diversas ferramentas e estratégias pedagógicas promissoras, mas também destacou a necessidade de mais pesquisas em diferentes contextos. As conclusões reforçam a importância das TICs como um recurso valioso para a educação inclusiva de surdos, oferecendo recomendações para futuras investigações e práticas pedagógicas.

Palavras-chave: educação de surdos; tecnologias digitais; inclusão; gamificação; revisão sistemática.

1. Introduction

Education for the deaf in Brazil began in 1857 with the founding of the Imperial Institute for the Deaf-Mute, initiated by French professor Herbert Huet. Although this was a historic milestone, for many years the institution operated more as an asylum for the deaf rather than providing a comprehensive formal education. It was only in the 20th century that education for the deaf underwent significant transformations, with the recognition of Brazilian Sign Language (Libras) and the advocacy for rights (Brito, 2013).

For many years, schools for deaf students prioritized the development of oral and written language, using typing and signs as auxiliary tools, with sign language recommended only for those who did not meet oralist goals (Brito, 2013; Fernandes *et al.*, 2014). Over time, this approach has evolved, and today Sign Language (SL) is recognized as the primary language of the deaf, with each country having its own distinct SL (Hoffmeister; Karipi e Kourbetis, 2022).

The inclusion of people with disabilities in education entails guaranteeing the right to access knowledge and social interaction within educational environments.

Institutions such as schools and universities play a crucial role in providing equal learning opportunities for all students, regardless of their physical or mental characteristics (Garzotto e Gonella, 2011; Pontes; Furlan Duarte e Pinheiro, 2020). In this context, accessibility in games is fundamental to ensure that everyone, including individuals with disabilities, can enjoy the benefits that games offer for human development (Mendes *et al.*, 2019; Naidon; Bernardi e Cordenonsi, 2023).

Motivated by the importance of including deaf students, this study seeks to answer the following question: "Which technological tools have proven effective in the academic training of these students?" To answer this question, we conducted a Systematic Literature Review (SLR), a rigorous methodology that allows us to critically analyze previous studies and synthesize their results.

2. Methodology

The methodology used for this research was SRL, for which we used articles from the last five years in the period from 2019 to 2024. We chose articles in English, to have a more comprehensive view of the different parts of the world.

Based on the research question, the SRL protocol was divided into (i) Planning, (ii) Database definition, (iii) Execution, with study identification, selection, and extraction, (iv) Summarization, and (v) Finalization of the Review. Based on the structuring of the methodology, we used the application State of Art (StArt)* Tool (Fabbri *et al.*, 2016; Fabbri *et al.*, 2012; Hernandes *et al.*, 2012). to assist us in this SRL, which was based on the systematic mapping indicated in the work of (Kitchenham *et al.*, 2009; Kandlhofer e Steinbauer, 2016; Moreira e Lima, 2023; Sendacz; Isotani e Lima, 2022), According to the researchers, SRL aims not only to aggregate all existing evidence on a research question but also to support the development of evidence-based guidelines for professionals.

2.1. Planning

In this section, we present the protocol for the systematic literature review (SLR) conducted to investigate the effectiveness of technological tools in teaching sign language to deaf or hard-of-hearing students. We outline the research plan, including the databases used, the inclusion and exclusion criteria for the studies, and the StArt application, which assisted in conducting the SLR. The aim is to provide a detailed guide for researchers interested in replicating this study. For this investigation, we formulated the following three research questions:

RQ1 What are the most effective pedagogical practices for including deaf students in traditional learning environments?

RQ2 How do audiovisual resources, in addition to technological tools, contribute to the learning of deaf students?

RQ3 What are the best communication strategies to facilitate interaction between deaf and hearing students?

The search string used for this study was: "(gamification `OR` game* `OR` 'serious games' `OR` 'serious game' `OR` 'video game') `AND` (teach `OR` learn) `AND` (Deaf `OR` LIBRAS `OR` 'Brazilian Sign Language')", locating 403 articles. The articles selected for this Systematic Literature Review were collected from three databases, including: (i) Scopus, (ii) Web of Science, and (iii) Science Direct. These databases were chosen due to their recognized relevance in the dissemination of high-quality scientific articles in various areas of knowledge.

*StArt (State of the Art through Systematic Review) developed by the Software Engineering Research Laboratory of the Federal University of São Carlos (UFSCAR). Access link: <http://lapes.dc.ufscar.br/tools/start_tool>.

To ensure the rigor of the selection of articles, inclusion, and exclusion criteria were defined based on systematic review methodologies (Kitchenham *et al.*, 2009). Inclusion Criteria (IC) specify the essential characteristics that studies should present to be considered relevant to the research, such as the type of publication, the period of publication and the population studied. On the other hand, exclusion criteria (EC) delimited the characteristics that would prevent the inclusion of a study in the review, such as the absence of quantitative data or the use of inadequate methodologies.

To ensure the rigor of the review, five inclusion criteria (IC) and five exclusion criteria (EC) were established. These criteria were essential for selecting relevant studies and standardizing the review process:

IC1: Addresses with the search string;
IC2: Studies in English;
IC3: Full peer-reviewed papers published in journals and conferences;
IC4: Theoretical or practical studies;
IC5: Articles from the last five years 2019 to 2024.

EC1: Secondary studies;
EC2: Grey literature;
EC3: Short papers;
EC4: Outside selected dates;
EC5: Out of scope.

Based on the definitions of the databases and the IC and EC, systematic and careful searches were carried out to ensure that the articles included in this SRL were relevant and up-to-date on the topic of interest. The Scopus database returned 224 articles (56%), Web of Science returned 32 articles (8%), and finally, Science Direct returned 147 articles (36%), as we can see in Figure 1.

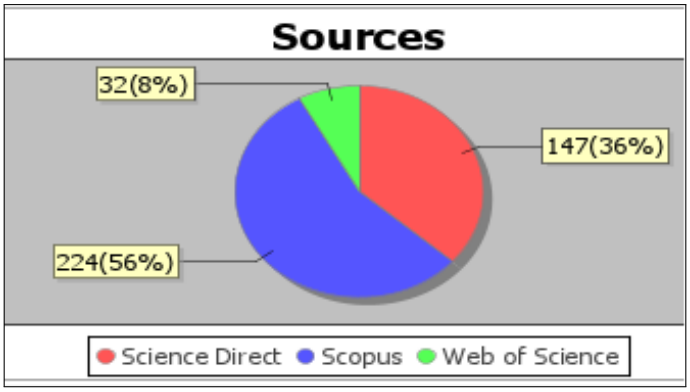
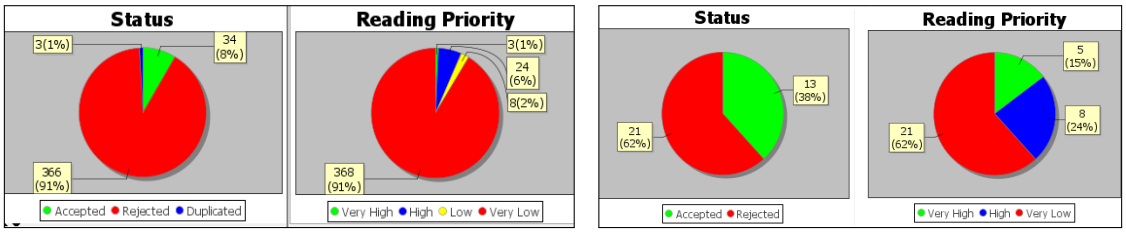


Figure 1. Graph representing the distribution of articles collected from three research sources: Scopus (56%), Web of Science (8%) e Science Direct (36%).

Among the 403 articles initially identified, we performed a careful analysis of titles, abstracts, and keywords to verify their suitability to the scope of the research. Articles that did not address the topic of academic training of deaf students or that were related to areas such as health and software engineering were excluded. After this first filtering stage, 34 articles were selected for in-depth analysis, with the help of the StArt tool. Figure 2(a) illustrates the distribution of articles: 8% were accepted, 1% were duplicated and 91% were rejected. The selected articles were ranked in order of reading priority, as shown in Figure 2(b), to optimize the analysis process.

2.2. Execution

In the extraction phase, all 34 articles were read in full. From the 13 accepted articles, the following were extracted: 11 characteristics for analysis. Six of these characteristics were multiple-choice and represented by colored circles, as illustrated in



(a) Selection Chart (b) Extraction Chart

Figure 2. Selection stage (read status and priority) and extraction stage (read status and priority).

Figure 3. In this figure, blue circles represent the population, green circles represent the type of research, red circles represent the method, yellow circles represent the type of analysis, white circles represent the evaluation, and orange circles represent how the data were obtained. The remaining five characteristics were open-ended: the conception of gamification, the description of the objectives, the country of publication, the context of application, and the technologies used in the article; therefore, they are not included in this comparison chart.

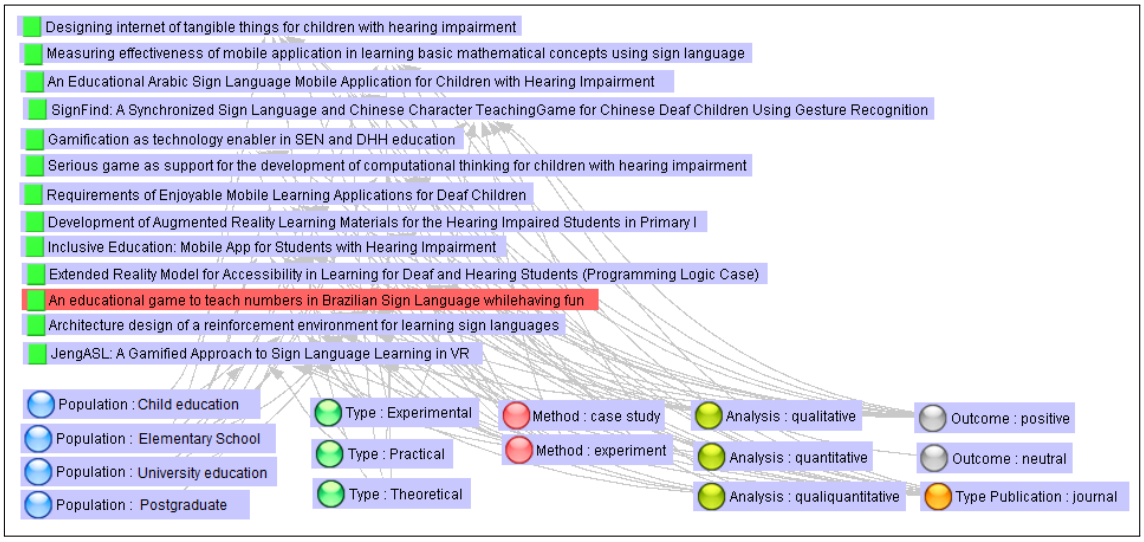


Figure 3. Graph representing the association between the article and the completed search form for each article accepted in the extraction phase.

For example, article ID 225, highlighted in Figure 3, has the following characteristics: it observes postgraduate students using a mathematics application and is classified as an experimental study that incorporates both qualitative and quantitative analysis. The evaluation of the application's use was positive, indicating that the experience gained through a game can serve as a valuable tool in the inclusive process. For all other articles, the same characteristic-filling analysis was applied to populate the database used for data verification. These works are summarized and explained in detail in the following sections.

2.3. Summarization

In the summarization stage, we perform data visualization. Of the 13 articles accepted in this phase, they were developed in various parts of the world, as shown in Figure 4. The colors represent the number of articles: one article is represented by

lilac, while a maximum of two articles is shown in purple. Colombia had the most accepted studies, with two articles published in 2020 and 2021. Brazil was represented by one article among those selected and accepted in the extraction phase. Despite the representation from several regions, no studies from the African and Oceania continents were identified during the extraction phase.

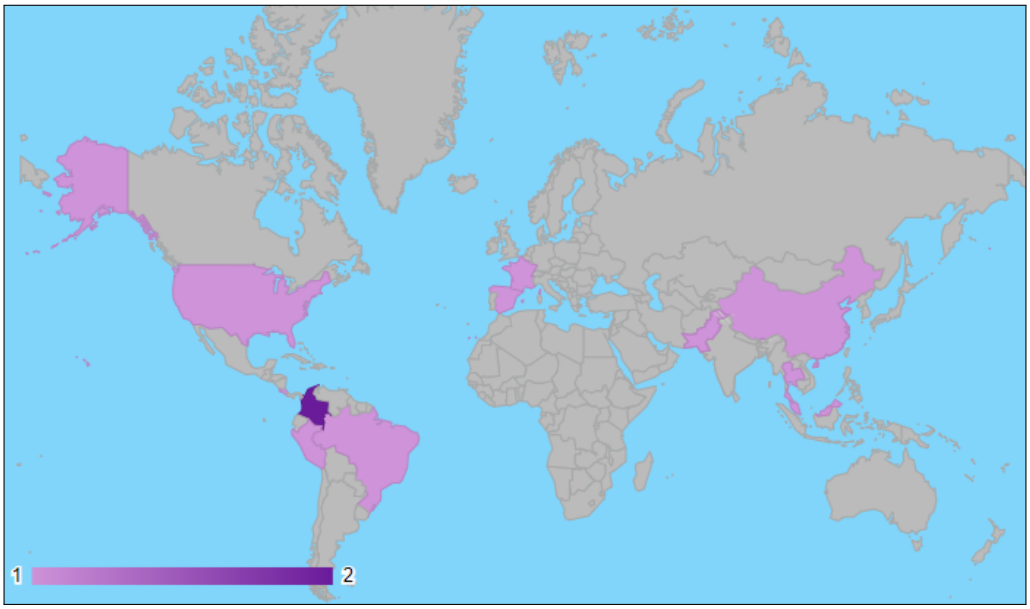


Figure 4. World map showing the number of accepted papers by country.

Table 1 brings important data from each of the 13 articles and a brief summary of each article. Each column represents data from the article: (a) Authors, (b) Year of publication, (c) Country, (d) Reading Priority (e) Gamification Tools, and (f) Summary.

3. Results

This section presents the results from the analysis of the works included in this SLR. A detailed discussion will follow, focusing on the summary provided in Table 1 for each of the 13 articles reviewed.

The reviewed studies address the use of technological tools and gamification to improve the learning of deaf students in different countries and educational contexts. In Brazil, (Pontes; Furlan Duarte e Pinheiro, 2020), they developed the gamification tool MatLIBRAS, combining basic arithmetic operations and numerical signs in Brazilian Sign Language. The study with 38 postgraduate students demonstrated that the tool promoted good results in the participation and learning of the students involved. In France, (Chan; Santally e Whitehead, 2022) conducted a study with eight elementary school students, two Special Education teachers, and 14 parents, to identify the literacy difficulties of deaf students and their gaming preferences. The research resulted in the development of a game inspired by HyperCard, which can be played on different devices and was well received by students, especially those who preferred time-limited games.

In China, (Nie *et al.*, 2022) developed the educational game SingFind, aimed at children aged 5 to 7, who practiced Chinese sign language and writing characters through interaction with game elements. The game, which involves using the camera to recognize signs, has proven to be effective in promoting student learning and engagement. The study by (Hashim *et al.*, 2024) in Malaysia investigated the requirements for the use of gamified applications in learning for deaf children based on their daily needs and experiences.

Table 1. Theoretical framework summarizing the 13 articles accepted in the SRL extraction phase

AUTHORS	YEAR	COUNTRY	READING PRIORITY	GAMIFICATION TOOLS	SUMMARY
Pontes et al.	2020	Brasil	Very High	MatLIBRAS	The use of games provides greater engagement and good relationships between players, helping hearing-impaired students to learn.
Chan et al.	2022	França	High	App inspired by "HyperCard"	The use of gamification as a learning resource can positively affect students' understanding and level of achievement.
Nie et al.	2022	China	Very High	SignFind	Play increases the fun of learning and make children more willing to perform learning tasks.
Hashim et al.	2024	Malaysia	Very High	KoTBAM and PopSignTest	The use of gamification can potentially improve learning for deaf children.
Segura et al.	2023	Spain	High	AMixed Reality pp	The use of a gamified environment can improve creative writing skills and interactive learning activities, strengthening the understanding and development of creativity in problem-solving and finding solutions.
Shaw et al.	2023	USA	Very High	JengASL	The use of gamification and virtual reality can make learning sign language more enjoyable and motivating.
Ploylim and Michel	2023	Thailand	Very High	AR-Book	The use of ICT can benefit not only students but also their parents in promoting the teaching of sign language, thus contributing to the promotion of inclusion and equality in education.
Mohammad et al.	2022	Arabia	High	MySign	The use of gamification can cause a paradigm shift in the learning and communication process of deaf people.
Naranjo-Zeled on et al.	2021	Costa Rica	High	SL learning reinforcement Tool	The use of technology becomes a great option to achieve the goal of learning sign language.
Boza-Chua and Andrade-Arenas	2022	Peru	High	unknown	Gamification can bring benefits and possibilities to the learning of students with hearing impairments.
Cano et al.	2020b	Colombia	High	unknown	The use of the Internet of Tangible Things can aid child development, especially in children with hearing impairments, through tangible interactions connected to the Internet.
Cano et al.	2020a	Colômbia	High	Perdi-Dog	The use of gamification allows the development of a set of related skills in children, such as problem-solving and decision-making.
Parvez et al.	2019	Pakistan	High	unknown	The use of assistive technology can improve the learning and understanding ability of deaf children.

The KoTBAM and PopSignTest applications were used by 13 children aged 7 to 12, with PopSignTest considered more fun and effective by the children, highlighting the importance of gamification for engagement and learning.

In the study by (Segura; Osorio e Zavala, 2023), in Spain, they investigated the use of Mixed Reality and Immersive Virtual Reality applications with 30 university students, of which 6 were deaf. The results showed that 77% of the participants considered the software innovative and motivating, indicating that these technologies can facilitate the learning of deaf and hearing students by placing them as active participants in virtual environments. In the United States, (Shaw *et al.*, 2023) explored the use of interactive virtual reality for teaching American Sign Language with the JengASL app. The study involved 8 college students and used gesture recognition and 3D hand models, resulting in a significant increase in student interest and effort, demonstrating the effectiveness of virtual reality for teaching sign languages.

In Thailand, (Ploylim e Michel, 2023) developed AR-Book, a learning media tool for teaching Thai Sign Language to primary school students. Rated as satisfactory for both classroom teaching and self-study, the tool has contributed to promoting inclusion and equity in education and is an effective option for independent learning.

Authors (Mohammad; Tamimi e Abuamara, 2022) in Saudi Arabia developed the Android application *MySign* for teaching Arabic Sign Language. The study, which involved 10 first-grade elementary school students, compared gamified learning with traditional methods and concluded that using the application resulted in better interaction, communication, and learning between deaf and hearing students.

In Costa Rica, (Naranjo-Zeledón *et al.*, 2021) created the SL Learning Reinforcement app with the support of speech-language pathologists to facilitate sign language learning among higher education students. The results demonstrated the app's effectiveness in teaching sign language, promoting better understanding and use of the language. In Peru, (Boza-Chua e Andrade-Arenas, 2022) developed prototype applications using Android Studio, aimed at promoting an inclusive educational environment for students with hearing impairments. With the participation of 40 people, including parents and students with and without hearing impairments, the study showed that the applications were well-received and effective in promoting inclusive interaction among students.

Authors (Cano *et al.*, 2020b) conducted two studies in Colombia. The first analyzed the use of the Internet of Tangible Things with early childhood education children, observing positive responses, but insufficient to draw definitive conclusions about the benefits of this approach (Cano *et al.*, 2020b). The second study designed a serious game, Perdi-Dogs, for children aged 7 to 11, which demonstrated significant improvements in learning, planning and decision-making skills, and motivation to play (Cano *et al.*, 2020a). Finally, (Parvez *et al.*, 2019) in Pakistan developed an app for teaching basic mathematics to children with hearing impairments, which was used by 195 students. The experimental group that used the app demonstrated superior performance compared to the control group, highlighting the importance of assistive technology in the education of deaf children.

4. Discussion

The studies included in this RSL converge on the conclusion that the use of technologies, especially games, has a positive impact on the teaching and learning process of deaf students. The results indicate significant improvements in several areas, such as the development of cognitive skills, motivation to learn, and academic performance. The analysis of the 13 selected articles reinforces the idea that technology can be a valuable resource to promote inclusion and equity in deaf education.

QP1 The studies analyzed in this RSL reveal that the implementation of gamified environments has proven to be a promising strategy for the inclusion of deaf students. Studies such as that of (Chan; Santally e Whitehead, 2022), (Shaw *et al.*, 2023), and (Segura; Osorio e Zavala, 2023) pointed out that gamification contributes to more engaging and effective learning, providing deaf students with opportunities to develop skills such as writing, problem-solving, and critical thinking. In addition, gamification can foster autonomy and collaboration among students, making the teaching-learning process more dynamic and enjoyable.

QP2 The COVID-19 pandemic has exposed the need for innovative teaching resources to meet the needs of students with hearing impairments. In this context, research by (Ployjiw e Michel, 2023) demonstrated that the use of AR-Book, an augmented reality tool, can be an effective solution for teaching sign language. The results of the study, obtained through Student's t-test, indicated a significant improvement in students' learning after using AR-Book. Similarly, (Parvez *et al.*, 2019) found that the mobile application they developed provided deaf students with a

more dynamic and effective learning experience, thanks to visual and interactive resources, such as videos and images, which facilitate the understanding of mathematical concepts.

QP3 The study by (Cano *et al.*, 2020b) demonstrated that the Internet of Tangible Things can create more inclusive environments, providing more equitable access to information and social interaction for children with and without special needs. On the other hand, (Segura; Osorio e Zavala, 2023) showed that Mixed Reality has the potential to transform communication between deaf and hearing students. Despite the initial difficulties encountered by deaf students, the research showed that the majority of participants (about 80%) demonstrated good acceptance of the tool, indicating that Mixed Reality can be an effective strategy to promote inclusion and improve learning.

4.1. Recommendations

After analyzing the 13 articles and answering the research questions, we developed a set of recommendations to assist teachers in using ICTs with deaf students. Figure 5 presents an info-graphic with practical suggestions for increasing student engagement and participation.

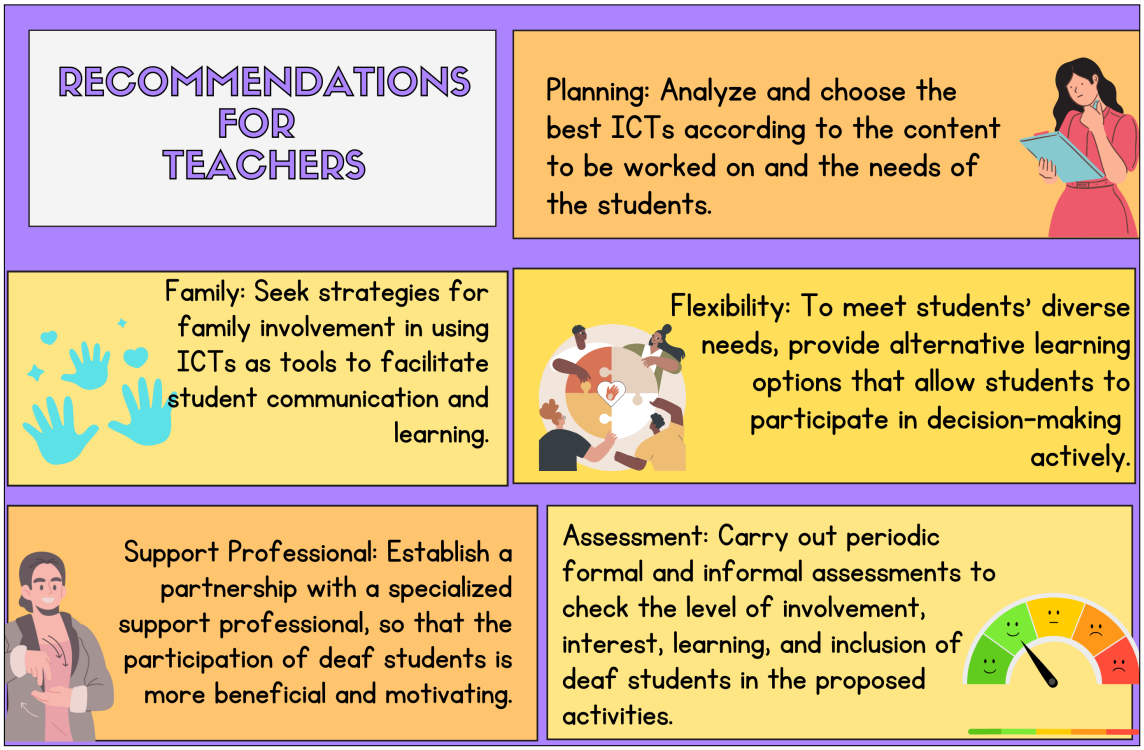


Figure 5. Graph Recommendations for Teachers.

4.2. Limitations

The lack of studies in the African and Oceanic continents in this SLR restricts the generalization of the results to the global context. The predominance of research in the American continent can lead to a Eurocentric view of the topic, disregarding the specificities of other cultural and educational contexts. This gap limits the understanding of the impact of ICTs on the education of deaf students in regions with distinct socioeconomic and political realities. Additionally, the lack of a more detailed analysis of cultural and educational differences between countries prevents a deeper understanding of

the impact of ICTs on the education of deaf students. It's crucial to recognize that digital resources, technological infrastructure, and educational policies vary greatly between countries, impacting ICT usage and outcomes.

5. Conclusions

This research, conducted through a systematic literature review, aimed to analyze the contributions of technological tools to the academic training of deaf students and the promotion of inclusion in learning environments. From a sample of 13 articles, we identified that ICTs have been used in various ways to facilitate communication between deaf and hearing students, as well as to promote the development of linguistic and cognitive skills. The results suggest that the use of gamified environments can be an effective strategy to increase the engagement of deaf students and improve their academic performance, particularly in the development of writing and creativity.

A key limitation is socioeconomic inequality, hindering universal access to ICTs in education. To address this, we created a practical guide with five suggestions for teachers to effectively integrate ICTs, covering activity planning, assessment, and collaboration. This tool helps teachers implement ICTs by identifying their needs and solutions. We plan to expand the guide's dissemination to Support Centers for People with Specific Needs (NAPNEs) to reach more educators.

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