

Effectiveness of Interactive Educational Websites in Enhancing Learning Outcomes for Learners with Severe Hearing Impairments: A Systematic Review

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Abstract

This study aims to systematically review the effectiveness of interactive educational websites in teaching various skills and knowledge to individuals with severe hearing impairments. Adopting a systematic review methodology based on PRISMA guidelines, a comprehensive search was conducted across multiple international and regional databases, including Scopus, Web of Science, Google Scholar, and selected Arabic databases. The initial search yielded 300 studies, of which 48 met the inclusion criteria and were included in the final qualitative synthesis.

The findings indicate that interactive web-based learning environments significantly enhance academic achievement, engagement, motivation, and skill development among learners with severe hearing impairments. The results further highlight that the effectiveness of these platforms is strongly influenced by instructional design quality, particularly in terms of visual clarity, multimedia integration, accessibility features (such as captioning and sign language), and interactive feedback mechanisms. Moreover, learners generally demonstrate positive perceptions toward such environments, although challenges such as cognitive overload, design inconsistencies, and limited accessibility features remain.

The review concludes that interactive educational websites represent a powerful tool for promoting inclusive education, provided that they are designed based on pedagogical principles and accessibility standards such as Universal Design for Learning (UDL).

Keywords: Interactive Educational Websites, Web-Based Learning, Hearing Impairment, Instructional Design, Accessibility

1. Introduction

In recent years, the rapid advancement of information and communication technologies (ICT) has significantly transformed educational systems, leading to the emergence of digital learning environments that extend beyond traditional classroom boundaries and enable more flexible, learner-centered education. Among these developments, interactive educational websites have become a central component of web-based learning, providing integrated environments that combine multimedia elements such as text, images, videos, simulations, and interactive assessments. These environments facilitate continuous interaction between learners, content, and instructors, thereby promoting active engagement and deeper knowledge construction (Al-Azawei et al., 2016).

The significance of such environments becomes particularly pronounced when addressing the educational needs of individuals with severe hearing impairments. Traditional instructional approaches, which rely heavily on auditory communication, often create barriers that limit access to information and reduce learning effectiveness for deaf and hard-of-hearing students (Kushalnagar et al., 2010). In contrast, interactive web-based platforms provide alternative communication channels through visual representations, captioned content, and sign language integration, which align more closely with the cognitive and perceptual characteristics of this population (Hashim et al., 2013; Joy & Gundmi, 2024).

A growing body of empirical research has demonstrated the effectiveness of interactive and e-learning environments in enhancing learning outcomes among Learners with Severe Hearing Impairments. Niksiar (2025) and Alves et al. (2025) reported significant improvements in learners' engagement, motivation, and academic performance within authentic e-learning environments. Al-Quran (2023) found that educational software based on sign language contributes to improved academic achievement and self-learning skills. Moreover, interactive web-based learning models have been shown to positively influence learning outcomes (Ratnawulan et al., 2021; Rahmawati et al., 2023), highlighting the critical role of interactivity in supporting both skill acquisition and conceptual understanding.

In addition to effectiveness, several studies emphasize that the success of these environments is strongly influenced by their design characteristics. Key elements such as visual clarity, structured interfaces, multimedia integration, and immediate feedback are essential for supporting learning among deaf students (Al-Osaimi et al., 2009; Kent, 2015). The application of Universal Design for Learning (UDL) principles further enhances accessibility and inclusivity in digital learning environments (Al-Azawei et al., 2016).

Despite the growing volume of research, the existing literature remains fragmented across different technological approaches, educational contexts, and methodological designs. While

some studies focus on specific tools or interventions, others address general aspects of e-learning without adequately considering the unique needs of individuals with severe hearing impairments. Furthermore, inconsistencies in findings and variations in study designs make it difficult to draw comprehensive conclusions regarding the overall effectiveness of interactive educational websites.

Therefore, there is a clear need for a systematic synthesis of the available evidence to provide a more coherent understanding of how and to what extent interactive educational websites support learning for this population. In response to this need, the present study adopts a systematic review approach based on PRISMA guidelines to analyze and synthesize findings from 48 selected studies. Accordingly, this review seeks to answer the following central question: What is the effectiveness of interactive educational websites in teaching different skills or knowledge to people with severe hearing impairments?

2. Literature review

Interactive web-based learning environments play a significant role in improving educational outcomes for learners with Severe Hearing Impairments. Platforms integrating multimedia elements, sign language, and structured activities enhance academic achievement, motivation, and self-directed learning skills (Niksiar, 2025; Alves et al., 2025; Al-Quran, 2023). Interactivity is identified as a central pedagogical component rather than a supplementary feature, as it facilitates multiple forms of engagement, including learner–content, learner–learner, and learner–instructor interaction (Balda & El-Gamal, 2011; Jaffal et al., 2019). Multimedia and interactive features improve cognitive processing and knowledge retention, particularly for learners who rely on visual input (Shadiev et al., 2020; Marschark et al., 2011).

Well-structured navigation, visual clarity, and usability are essential for ensuring meaningful learning experiences (Kent, 2015; Kushalnagar et al., 2010). Accessible features, including captioning, visual hierarchies, and adaptive interfaces, are particularly critical for learners with hearing impairment, as they directly influence comprehension and engagement (Hashim et al., 2013; Cavender et al., 2009).

Learners' perceptions of interactive and online learning environments are generally positive, with students valuing flexibility, autonomy, and the ability to control their learning pace (Aljedaani et al., 2021, 2022). Nevertheless, challenges such as e-learning fatigue, cognitive overload, and variability in instructional quality remain evident (Rodrigues et al., 2022; Borgia et al., 2019). Research suggests that simplifying content and incorporating visual supports can mitigate these challenges and enhance understanding (Fajardo et al., 2014).

Innovations such as microlearning, virtual classrooms, and interactive applications contribute to more personalized and adaptive learning experiences, although their effectiveness depends on the integration of accessibility features (Alsadoon & Turkestani, 2020).

3. Materials and Methods

Systematic reviews systematically identify, evaluate, and synthesize research using transparent and replicable procedures, minimizing bias compared to narrative reviews. This approach is particularly suitable for emerging fields with dispersed evidence. This study employs a systematic review to assess the effectiveness of interactive educational websites for individuals with severe hearing impairments, aiming to consolidate findings across diverse contexts.

3.1 PRISMA Framework

This systematic review follows the PRISMA (Preferred Reporting Items for Systematic Reviews and Meta-Analyses) guidelines, which provide a standardized framework to enhance transparency, completeness, and methodological rigor in systematic reviews (Page et al., 2021). The use of PRISMA ensures that the review process—including study identification, screening, eligibility assessment, and inclusion—is clearly documented and reproducible (Moher et al., 2009).

3.1.1 Resources

A comprehensive literature search was conducted using Scopus, Web of Science, Google Scholar, and selected Arabic databases to ensure broad international and regional coverage. Scopus served as the primary source due to its extensive multidisciplinary indexing, while Web of Science complemented it with high-impact and foundational studies. Google Scholar was used to capture grey literature and recent publications, and Arabic databases were included to incorporate regional perspectives. This multi-database strategy ensured a comprehensive and balanced evidence base on the effectiveness of interactive educational websites for learners with severe hearing impairments.

3.1.2 Systematic Review Process

The systematic review process consists of three key stages: identification, screening, and eligibility (see Figure 1).

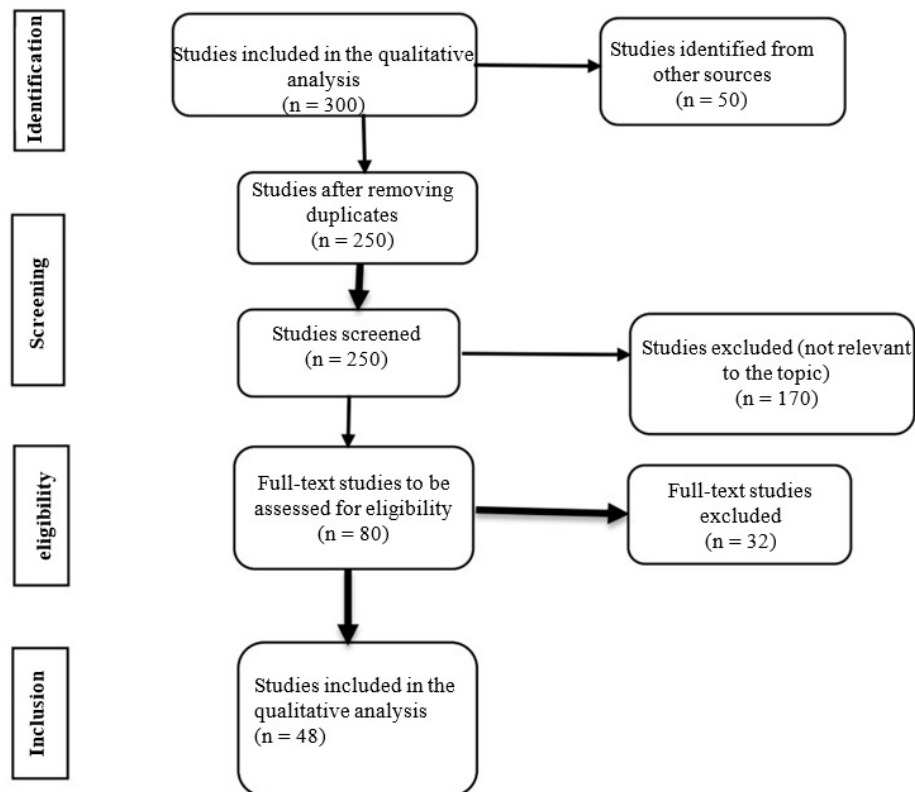


Figure 1: PRISMA (Preferred Reporting Items for Systematic Reviews and Meta-Analyses)

3.1.3 Identification

In the initial phase, relevant keywords for the search process were carefully identified in both English and Arabic to ensure comprehensive coverage of international and regional research related to interactive educational websites and hearing impairments. This stage involved identifying synonyms, related terms, and variations of the main concepts—such as interactive learning, web-based learning, e-learning, deaf learners, and hearing impairment—to broaden the scope of the search and maximize the retrieval of relevant studies. The keyword selection process was guided by the central research question and refined through the use of academic thesauri, previously used keywords in related studies, and automated keyword suggestions provided by databases such as Scopus and Web of Science. Additionally, commonly used terms in the literature on deaf education and educational technology were incorporated to ensure conceptual accuracy and coverage.

The finalized search strategy employed Boolean operators (AND, OR), phrase searching, truncation, wildcard symbols, and field-specific codes to improve search precision and recall. To ensure the inclusion of regional research, equivalent Arabic keywords "التعلم الإلكتروني" (at-ta'allum al-iliktirōnī) OR "المواقع التعليمية التفاعلية" (al-mawāqī' at-ta'līmiyyah at-tafā'uliyyah) OR "التعلم عبر الويب" (at-ta'allum'abra al-web) AND "الصم" (aṣ-ṣumm) OR "الإعاقة السمعية" (al-i'āqah as-sam'iyyah) were used in searches conducted within Arabic databases such as Dar Al Mandumah and the Egyptian Knowledge Bank (EKB).

The complete search strings applied across the selected databases are presented in Table 1.

Table 1. Research Strings Used in Database Searches

Database	Search String	Filters Applied
Scopus	("interactive learning" OR "interactive website*" OR "web-based learning" OR "e-learning" OR "online learning" OR "digital learning" OR "virtual learning environment*" OR "learning management system*" OR LMS OR "multimedia learning" OR "technology-enhanced learning") AND ("hearing impairment" OR deaf OR "hard of hearing" OR "hearing loss" OR "hearing disability" OR "students with hearing impairment")	Years: 2000–2025; Language: English; Subject Areas: Education, Social Sciences, Psychology
Web of Science (WoS)	TS=("interactive learning" OR "web-based learning" OR "e-learning" OR "online learning" OR "digital learning" OR "virtual learning environment*" OR "multimedia learning" OR "technology-enhanced learning") AND TS=("hearing impairment" OR deaf OR "hard of hearing" OR "hearing loss" OR "hearing disability")	Years: 2000–2025; Language: English; Subject Areas: Education, Social Sciences, Psychology
Google Scholar	allintitle: ("interactive learning" OR "e-learning" OR "online learning" OR "web-based learning" OR "digital learning") AND ("deaf" OR "hearing impairment" OR "hard of hearing" OR "hearing loss") OR ("interactive education" AND "students with hearing impairment")	Years: 2000–2025; Language: English; Subject Areas: Education, Social Sciences, Psychology
Google (General Search)	"interactive learning" + "deaf students" / "hearing impairment education" / "online learning for hard of hearing" / "web-based learning hearing loss" / "digital education for students with hearing impairment"	Years: 2000–2025; Language: English; Subject Areas: Education, Social

Database	Search String	Filters Applied
		Sciences, Psychology
Arabic Databases (Dar Al Mandumah / EKB)	"التعلم الإلكتروني" (at-ta'allum al-iliktirōnī) OR "التعلم الرقمي" (at-ta'allumar-raqamī) OR "التعلم عبر الإنترنت" (at-ta'allum'abra al-internet) OR "المواقع التعليمية" (al-mawāqi' at-ta'līmiyyah at-tafā'uliyyah) OR "بيئات التعلم الافتراضية" (bī'āt at-ta'allum al-iftirāḍiyyah) AND "الصمم" (aṣ-ṣumm) OR "ضعاف السمع" (ḍi'āf as-sam') OR "الإعاقة السمعية" (al-i'āqah as-sam'iyyah) OR "فقدان السمع" (faqdān as-sam')	Years: 2000–2025; Language: Arabic & English; Subject Areas: Education, Social Sciences, Psychology

Accordingly, search strings for Scopus, Web of Science, Google Scholar, and selected Arabic databases were developed in March 2026 after identifying all relevant keywords in both English and Arabic (see Table 1). These databases were selected due to their advanced search capabilities, comprehensive indexing of peer-reviewed literature, and multidisciplinary coverage, particularly in the fields of education, educational technology, and special education.

The initial search process resulted in a total of 300 records identified across multiple databases. Specifically, Scopus yielded 120 articles, while Web of Science (WoS) contributed 85 articles. In addition, a manual search using similar keywords in Google Scholar resulted in 45 additional records. Furthermore, searches conducted in selected Arabic databases, including Dar Al Manduma, contributed 50 additional studies.

3.1.4 Screening

The second stage of the systematic review involved screening the records retrieved during the identification phase. After removing duplicate records, 250 unique studies remained for the screening process. These studies were initially evaluated based on their titles and abstracts to determine their relevance to the research topic. During this stage, 170 articles were excluded for several reasons, including lack of relevance to interactive educational websites, absence of focus on learners with severe hearing impairments, or failure to address learning outcomes or educational effectiveness. Additionally, some studies were excluded because they focused on unrelated technologies or general e-learning contexts without specific consideration of learners with severe hearing impairments.

Table 2. Inclusion and Exclusion Criteria

Criteria	Included Studies	Excluded Studies
Document Type	Empirical research articles and systematic reviews	Conference papers, book chapters, editorials, and full books
Language	English and Arabic publications	Publications in other languages
Study Focus	Interactive educational websites, e-learning, web-based learning for deaf or hearing-impaired learners	Studies not related to hearing impairment or not focused on interactive/web-based learning
Outcomes	Studies measuring learning outcomes, skills development, engagement, or effectiveness	Studies without clear educational outcomes or effectiveness measures
Methodology	Empirical, experimental, quasi-experimental, or mixed-methods studies	Conceptual papers or studies with unclear methodology

3.1.5 Eligibility

At this stage, the full texts of the screened articles were retrieved and carefully reviewed in detail. A total of 80 full-text articles were assessed for eligibility based on the predefined inclusion and exclusion criteria. Each study was examined to ensure its alignment with the research objectives, with particular focus on whether it addressed the effectiveness of interactive educational websites or e-learning environments for individuals with hearing impairments.

As a result of this process, 32 articles were excluded for multiple reasons, including lack of direct relevance to learners with hearing impairment; focus on other disability groups without specific analysis of hearing impairment; absence of interactive or web-based learning components; reliance on traditional or non-digital instructional methods; insufficient empirical evidence or purely theoretical discussions; unclear, weak, or unreported methodology; small or non-representative samples; duplication across databases; limited accessibility of full texts; publication types such as editorials, opinion papers, or abstracts without full studies; outcomes unrelated to educational effectiveness or learning performance; lack of measurable results; and studies not published within the specified time frame or language criteria.

3.1.6 Quality Assessment

To ensure the credibility and methodological rigor of the included studies, a quality assessment was conducted using adapted criteria based on established appraisal frameworks, including the Critical Appraisal Skills Programme (CASP) and the Joanna Briggs Institute (JBI) tools. Each study was evaluated according to several key criteria, including research design appropriateness, validity and reliability of data collection instruments, and the relevance and transparency of reported findings. The assessment process aimed to ensure that only methodologically sound studies contributed to the final synthesis. The evaluation revealed variation in the quality of the included studies, with 48 studies classified as high quality.

3.1.7 Data Extraction and Analysis

Following the quality assessment, a systematic data extraction process was conducted to collect key information from each included study. The extracted data included author(s), year of publication, country, study context, sample characteristics, research design, type of technology or used platform, and the main findings related to learning effectiveness. This process ensured consistency across studies and facilitated meaningful comparison. The extracted data were then analyzed using a thematic synthesis approach, consistent with integrative review methodologies (Whittemore & Knafl, 2005).

Through iterative analysis, patterns, similarities, and differences across the studies were identified. The synthesis resulted in the emergence of four main themes:

1. Effectiveness of interactive and web-based learning environments
2. Design features of accessible and inclusive educational platforms
3. Learners' perceptions, engagement, and user experience
4. Supporting technologies and digital learning approaches

Each theme was clearly defined and aligned with the central research question, providing a comprehensive analytical framework for interpreting the findings of the systematic review.

Table 3 presents a structured overview of the studies that examined the effectiveness of interactive and web-based learning environments.

Table 3: Effectiveness Studies

Author & Date	Objective	Method	Sample	Key Findings
Niksiar (2025)	Evaluate effectiveness of authentic e-learning	Experimental	Deaf students	Significant improvement in

Author & Date	Objective	Method	Sample	Key Findings
	for deaf learners			engagement and academic performance
Alves et al. (2025)	Assess impact of e-learning environments	Experimental	Deaf learners	Enhanced motivation and learning outcomes
Al-Quran (2023)	Measure effectiveness of sign-language-based software	Experimental	Hearing-impaired students	Improved achievement and self-learning skills
Ratnawulan et al. (2021)	Examine interactive web-based learning effectiveness	Experimental	Students with disabilities	Positive impact on learning outcomes
Rahmawati et al. (2023)	Evaluate web-based learning in higher education	Experimental	Deaf students	Improved understanding and engagement
Mingsiritham et al. (2020)	Assess MOOC-based learning effectiveness	Experimental	Hearing-impaired learners	Development of life skills
Abu Zeid et al. (2020)	Evaluate hypermedia program effectiveness	Experimental	Deaf students	Significant skill development
Abdel Aziz (2019)	Evaluate Adobe Illustrator for deaf learners	Experimental	Hearing-impaired students	Improved practical skills
Rizk et al. (2015)	Develop fashion design skills	Case study	Deaf students	Enhanced technical skills

Author & Date	Objective	Method	Sample	Key Findings
Al-Kharbawi&Qanuna (2015)	Evaluate educational website effectiveness	Experimental	Students	Improved learning performance
Balda & El-Gamal (2011)	Evaluate proposed website	Experimental	University students	Improved practical skills
Jameh et al. (2020)	Develop interactive website for fashion design	Experimental	University students	Improved design skills
Anwar et al. (2024)	Evaluate STEM-based workshop effectiveness for deaf education	Experimental	STEM learning	Improved engagement and conceptual understanding
Astuti et al. (2023)	Examine interactive web-based learning for deaf students	Experimental	Web-based learning	Enhanced learning outcomes and interaction
Means et al. (2010)	Evaluate effectiveness of online learning practices	Review	Online learning	Online learning improves performance compared to traditional methods
Shadiev et al. (2020)	Review effectiveness of e-learning environments	Review	E-learning	Multimedia and interactivity enhance learning outcomes
Utami et al. (2025)	Systematic review of online learning for learners with	Review	Online learning	Positive impact on achievement

Author & Date	Objective	Method	Sample	Key Findings
	hearing impairment			and engagement

Table 4 summarizes the studies addressing design and accessibility in interactive and web-based learning environments.

Table 4: Design & Accessibility Studies

Author & Date	Objective	Method	Focus	Key Findings
Al-Azawei et al. (2016)	Apply UDL in e-learning	Review	Accessibility	Enhances inclusivity
Al-Osaimi et al. (2009)	Define UI requirements	Design study	Interface	Visual clarity critical
Hashim et al. (2013)	Develop e-learning for deaf students	Development	Platform design	Visual content improves learning
Kent (2015)	Explore accessibility in e-learning	Review	Accessibility	Inclusive design essential
Kushalnagar et al. (2010)	Study accessibility barriers	Empirical	Online learning	Accessibility impacts outcomes
Zhang et al. (2006)	Multimedia learning effectiveness	Experimental	Multimedia	Improves understanding
Sung et al. (2016)	Mobile learning effectiveness	Meta-analysis	Mobile learning	Positive learning impact
Wu et al. (2012)	Review mobile learning	Review	Technology	Supports flexible learning
Rowel et al. (2021)	Develop e-learning	Development	Deaf learners	Improves accessibility

Author & Date	Objective	Method	Focus	Key Findings
	platform			
Luangrungruang&Kokaew (2022)	Identify learning styles	Model	Personalization	Supports adaptive learning
Alsadoon& Turkestani (2020)	Explore virtual classrooms for learners with hearing impairment	Review	Virtual classrooms	Accessibility features are essential for effectiveness
Alshawabkeh et al. (2021)	Investigate online technologies for deaf students	Empirical	Assistive technology	Enhances accessibility and learning experience
Borgia et al. (2019)	Improve e-learning experience for deaf students	Conceptual	Usability	Design improvements reduce barriers
Cavender et al. (2009)	Develop assistive technologies for deaf users	Experimental	Mobile accessibility	Assistive tools improve communication and access
Glasser et al. (2019)	Examine speech recognition challenges for deaf users	Analytical	Accessibility	Limitations in current technologies affect usability
Yazçayır (2023)	Study instructional design for e-learning of	Qualitative	Instructional design	Effective design enhances accessibility and

Author & Date	Objective	Method	Focus	Key Findings
	deaf students			learning

Table 5 presents an overview of studies examining learners' perceptions, experiences, and engagement within interactive and online learning environments.

Table 5: Perception & Experience Studies

Author & Date	Objective	Method	Sample	Key Findings
Aljedaani et al. (2021)	Explore perceptions of online learning	Survey	Deaf students	Positive but with challenges
Aljedaani et al. (2022)	Compare learning experiences	Quantitative	Students	Barriers in engagement
Gehret & Elliot (2025)	Examine perceptions of e-learning	Mixed methods	Deaf learners	Positive attitudes toward multimedia
Rodrigues et al. (2022)	Study e-learning fatigue	Quantitative	Deaf students	Fatigue affects engagement
Farhan & Razmak (2022)	Compare assistive interfaces	Experimental	Mixed disabilities	Improved usability
Joy & Gundmi (2024)	Explore teaching strategies	Qualitative	Educators	Need for visual strategies
Khasawneh (2023)	Evaluate video learning	Experimental	Deaf students	Video enhances comprehension
Beal-Alvarez & Cannon (2014)	Technology intervention research	Review	Deaf learners	Technology supports learning
Marschark	Study	Review	Deaf students	Positive impact of tech

Author & Date	Objective	Method	Sample	Key Findings
et al. (2011)	technology use in deaf education			integration
Domagała-Zyśk (2013)	E-learning for disabilities	Review	Disabled learners	Inclusion improves outcomes
Fajardo et al. (2014)	Evaluate easy-to-read texts for deaf learners	Experimental	Content design	Simplified texts improve comprehension
Farhan & Razmak (2022)	Compare assistive e-learning interfaces	Experimental	User experience	Improved usability enhances engagement
Lang (2002)	Examine higher education experiences of deaf students	Review	Academic experience	Accessibility influences achievement
Mathew & Peiris (2026)	Explore augmented reality for deaf education	Experimental	Emerging technology	AR enhances engagement and interaction
Richardson et al. (2004)	Study academic attainment in deaf students	Empirical	Learning outcomes	Engagement linked to achievement
Youssef (2011)	Develop instructional design for interactive website	Experimental	User interaction	Interactive design improves engagement and skills

4. Findings

The present systematic review provides a comprehensive synthesis of 48 studies examining the effectiveness of interactive educational websites and digital learning environments for individuals with severe hearing impairments. The following findings demonstrate that such environments play a crucial role in improving learning outcomes.

4.1 Effectiveness of Interactive and Web-Based Learning

The findings from the effectiveness-oriented studies (Table 3) provide strong and consistent evidence that interactive web-based learning environments significantly enhance educational outcomes for learners with hearing impairment. The studies demonstrate that the integration of multimedia, sign language, and structured digital activities leads to measurable improvements in both academic performance and learner engagement. Niksiar (2025) reports significant gains in engagement and academic achievement within authentic e-learning environments, while Alves et al. (2025) identifies enhanced motivation and overall learning outcomes. Al-Quran (2023) shows that sign-language-based software contributes to improved academic achievement and the development of self-learning skills, highlighting the importance of visually accessible instructional design.

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Research focusing on interactive web-based learning further confirms its effectiveness in promoting comprehension and engagement. Studies by Astuti et al. (2023), Ratnawulan et al. (2021), and Rahmawati et al. (2023) demonstrate that interactive features—such as visual content, guided activities, and feedback mechanisms—lead to improved understanding, higher levels of participation, and better learning outcomes. In addition, Anwar et al. (2024) shows that interactive STEM-based environments enhance conceptual understanding and engagement, while Mingsiritham et al. (2020) highlights the broader impact of MOOC-based learning in developing life skills alongside academic competencies. These findings indicate that interactivity facilitates not only knowledge acquisition but also the development of transferable skills.

The effectiveness of these environments is particularly evident in applied and skill-based learning contexts. Abu Zeid et al. (2020) demonstrate that hypermedia-based instruction

significantly improves technical skills, while Abdel Aziz (2019) reports enhanced practical competencies through the use of digital design tools such as Adobe Illustrator. Likewise, Rizk et al. (2015) shows that interactive learning approaches contribute to the development of fashion design and pattern-making skills. Complementary evidence from studies on educational websites further supports these outcomes. Al-Kharbawi and Qanuna (2015), Balda and El-Gamal (2011), and Jameh et al. (2020) all report improvements in both learning performance and practical skill development, emphasizing the value of structured, interactive platforms in facilitating step-by-step learning and repeated practice.

At a broader level, review-based studies reinforce the effectiveness of interactive and web-based learning. Means et al. (2010) conclude that online learning environments can outperform traditional instruction in terms of learner performance, while Shadiev et al. (2020) highlight the role of multimedia and interactivity in enhancing cognitive processing and knowledge retention. Furthermore, Utami et al. (2025) confirm through a systematic review that online learning environments positively influence both achievement and engagement among learners with hearing impairment. These findings collectively establish that the effectiveness of such environments is grounded in their ability to present information through multiple modalities and support active learner involvement.

Overall, the evidence across these 17 studies demonstrates that interactive web-based learning environments are highly effective in improving cognitive, behavioral, and skill-based outcomes. Their impact is driven by the integration of multimedia, interactivity, and structured instructional design, alongside the flexibility of web-based delivery. These features are particularly beneficial for learners with hearing impairment, as they support visual processing, enable repeated engagement with content, and foster greater autonomy in the learning process.

The effectiveness of interactive web-based learning is further confirmed. Astuti et al. (2023), Ratnawulan et al. (2021), and Rahmawati et al. (2023) demonstrate that interactive features—such as visual content, guided activities, and feedback mechanisms—lead to improved understanding, higher levels of participation, and better learning outcomes. Anwar et al. (2024) shows that interactive STEM-based environments enhance conceptual understanding and engagement, while Mingsiritham et al. (2020) highlights the broader impact of MOOC-based learning in developing life skills alongside academic competencies.

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4.2 Design, Accessibility, and Instructional Quality

The findings from design and accessibility studies (Table 4) demonstrate that the effectiveness of interactive and web-based learning environments is fundamentally determined by the quality of instructional design rather than the mere presence of technology. Core design elements—such as usability, structured navigation, visual clarity, and coherent multimedia integration—are consistently identified as essential for achieving meaningful learning outcomes (Al-Osaimi et al., 2009; Kent, 2015; Kushalnagar et al., 2010).

The literature further emphasizes that effective web-based learning environments must be intentionally designed to align with the cognitive and perceptual characteristics of learners with hearing impairment. Studies on multimedia and mobile learning (Zhang et al., 2006; Sung et al., 2016; Wu et al., 2012) demonstrate that well-integrated visual and interactive elements enhance understanding, support flexible learning, and improve knowledge retention. Similarly, Rowel et al. (2021) highlight that purpose-built e-learning platforms significantly improve accessibility when they incorporate user-centered design principles, while Luangrungruang and Kokaew (2022) show that adaptive systems tailored to learners' styles enhance personalization and learning efficiency.

These findings are reinforced by inclusive design frameworks, particularly Universal Design for Learning (UDL), which advocate for multiple means of representation, engagement, and expression (Al-Azawei et al., 2016). Development-based studies (Hashim et al., 2013; Alshawabkeh et al., 2021) demonstrate that platforms emphasizing visual content, interactive features, and structured interfaces significantly enhance comprehension and engagement. In addition, Alsadoon and Turkestani (2020) stress that virtual learning environments must incorporate accessibility features—such as captioning and visual support—to ensure their effectiveness for learners with hearing impairment.

Research on assistive technologies and interface design further underscores the importance of accessibility-oriented solutions. Cavender et al. (2009) show that mobile assistive technologies improve communication and access, while Glasser et al. (2019) highlight the limitations of existing speech recognition systems for deaf users, emphasizing the need for alternative, visually

driven interfaces. Complementary evidence from Alshwabkeh et al. (2021) indicates that the integration of assistive technologies within online platforms enhances usability and overall learning experience.

Studies addressing usability challenges reveal that poorly designed environments can significantly hinder learning. Borgia et al. (2019) identify persistent barriers related to interface complexity and lack of accessibility features, while Yazçayır (2023) emphasizes that inadequate instructional design limits the effectiveness of e-learning for learners with hearing impairment.

The evidence across the studies included in Table 4 demonstrates that high-quality instructional design, grounded in accessibility principles and supported by adaptive and assistive technologies, is essential for creating effective and inclusive web-based learning environments. Such environments must prioritize visual communication, user-centered design, and flexible interaction to ensure equitable learning opportunities for learners with hearing impairment.

4.3 Learners' Perceptions, Engagement, and Challenges

Learners with hearing impairment generally exhibit positive attitudes toward interactive and online learning environments, particularly when these environments are visually rich, flexible, and user-centered. Empirical evidence shows that learners value features such as autonomy, accessibility, and multimedia integration. Aljedaani et al. (2021, 2022) report overall positive perceptions of online learning despite the presence of certain engagement barriers, while Gehret and Elliot (2025) highlight strong learner preferences for multimedia-based instructional formats. These findings are further supported by broader research on technology integration, which confirms that digital tools enhance learning experiences and support cognitive engagement (Beal-Alvarez & Cannon, 2014; Marschark et al., 2011).

This positive perception is closely linked to the flexibility of web-based learning environments, particularly their ability to support self-paced and asynchronous learning. Such modes allow learners to revisit materials, control the pace of instruction, and engage with content repeatedly, which is essential for processing visually presented information. Studies focusing on accessibility and inclusion (Domagała-Zyśk, 2013; Lang, 2002; Richardson et al., 2004) further emphasize that when learning environments are accessible and well-structured, they contribute to improved academic achievement and more equitable educational experiences.

At the level of instructional strategies and learning tools, several studies highlight the importance of aligning content delivery with learners' needs. Khasawneh (2023) demonstrates that video-based learning significantly enhances comprehension, while Joy and Gundmi (2024) emphasize the necessity of adopting visually oriented teaching strategies to support effective learning. Similarly, Farhan and Razmak (2022) show that assistive and user-centered interfaces improve usability and engagement, confirming that well-designed technological environments can enhance both access and interaction. Emerging technologies also play a role in shaping learner

experience, as Mathew and Peiris (2026) demonstrate that augmented reality applications increase engagement and provide immersive learning experiences.

In addition, research on content design and cognitive accessibility highlights the importance of simplifying information and enhancing visual clarity. Fajardo et al. (2014) show that easy-to-read textual materials significantly improve comprehension for learners with hearing impairment, while Youssef (2011) demonstrates that interactive instructional design enhances both engagement and skill development. These findings indicate that clarity, structure, and interactivity are essential components of effective learning environments.

Despite these positive outcomes, several studies identify critical challenges that may limit the effectiveness of online learning. Rodrigues et al. (2022) highlight e-learning fatigue as a significant factor that negatively affects engagement, while Aljedaani et al. (2022) point to persistent barriers in interaction and participation. These challenges are often linked to inadequate instructional design, excessive cognitive load, or insufficient adaptation to learners' needs.

The findings demonstrate that learners' perceptions and experiences are shaped by a combination of flexibility, accessibility, instructional quality, and technological design. While interactive and web-based learning environments offer substantial benefits in terms of engagement, autonomy, and comprehension, their effectiveness depends on careful alignment with learners' cognitive and sensory characteristics. When these conditions are met, such environments can significantly enhance both the learning experience and educational outcomes for learners with hearing impairment.

5. Discussion

This systematic review synthesizes evidence from 48 studies to examine the effectiveness of interactive educational websites and web-based learning environments for learners with hearing impairment. The analysis reveals that effectiveness emerges from the convergence of four interrelated dimensions: interactivity, instructional design, accessibility, and learner engagement.

A central conclusion is that interactivity functions as a core pedagogical mechanism rather than a purely technical attribute. The consistent improvements in academic achievement, motivation, and engagement reported across experimental studies (Niksiar, 2025; Alves et al., 2025; Al-Quran, 2023) can be explained by the capacity of interactive environments to support active learning processes. Through structured activities, feedback loops, and multimodal representation, learners are not passive recipients of information but active participants in knowledge construction. This aligns with constructivist and multimedia learning theories, which posit that learning is enhanced when individuals interact with content, reorganize information, and receive immediate feedback (Zhang et al., 2006; Shadiev et al., 2020). The effectiveness observed in both academic and applied contexts—including design and vocational domains (Abu Zeid et al.,

2020; Abdel Aziz, 2019; Rizk et al., 2015)—further indicates that interactivity supports not only conceptual understanding but also procedural and experiential learning.

However, attributing these outcomes solely to interactivity would be misleading. The findings clearly demonstrate that instructional design quality is the primary factor mediating the relationship between technology and learning outcomes. Core design principles—such as usability, visual clarity, structured navigation, and coherence of content—are consistently identified as essential for effective learning (Al-Osaimi et al., 2009; Kent, 2015; Kushalnagar et al., 2010). Interactivity yields positive results only when embedded within well-structured instructional systems that align with learners' cognitive and perceptual characteristics. This explains why platforms incorporating guided activities, progressive task sequencing, and clear visual hierarchies outperform those that merely digitize content without pedagogical adaptation.

Accessibility emerges as a foundational dimension that underpins both design and effectiveness. For learners with hearing impairment, access to information is inherently mediated by visual communication. Features such as captioning, sign language integration, visual scaffolding, and intuitive interfaces are not supplementary enhancements but essential requirements. The application of inclusive design frameworks, particularly Universal Design for Learning (Al-Azawei et al., 2016), reinforces the need to provide multiple means of representation and engagement. Empirical and development-based studies (Hashim et al., 2013; Alshawabkeh et al., 2021) demonstrate that accessible environments significantly enhance comprehension and participation. Conversely, limitations in accessibility—whether due to inadequate interface design or reliance on auditory-based technologies—can hinder learning, as highlighted in studies addressing usability barriers and technological constraints (Borgia et al., 2019; Glasser et al., 2019; Yazçayır, 2023).

The role of learner experience further contextualizes these findings. Positive perceptions of interactive and web-based learning environments are consistently associated with flexibility, autonomy, and visual richness (Aljedaani et al., 2021, 2022; Gehret & Elliot, 2025). These characteristics align closely with the needs of learners with hearing impairment, who benefit from the ability to control learning pace, revisit materials, and engage repeatedly with content. Self-paced and asynchronous learning modes, in particular, support deeper cognitive processing and reduce the pressure associated with real-time instruction (Rowel et al., 2021; Means et al., 2010). At the same time, the challenges identified—such as e-learning fatigue and reduced engagement (Rodrigues et al., 2022)—highlight the importance of balancing interactivity with cognitive load and ensuring that learning environments remain user-centered and manageable.

The findings also underscore the significance of delivery formats and technological configurations in shaping learning outcomes. Web-based environments offer diverse modes of delivery, including asynchronous platforms, synchronous virtual classrooms, blended models, and microlearning approaches. Each mode presents distinct advantages and limitations. Asynchronous and self-paced formats are particularly effective for learners with hearing

impairment, as they allow repeated exposure and individualized pacing. Microlearning approaches further support comprehension by breaking complex content into manageable units, thereby reducing cognitive overload. In contrast, synchronous environments require careful integration of accessibility features, such as captioning and sign language interpretation, to ensure equitable participation (Alsadoon& Turkestani, 2020).

At a systemic level, the findings indicate that interactive educational websites contribute to a broader transformation in educational practice. These environments integrate content delivery, interaction, and assessment within unified digital systems, enabling continuous feedback, personalization, and data-driven decision-making (Utami et al., 2025; Mingsiritham et al., 2020). This integration supports a shift from teacher-centered to learner-centered models, where learners actively engage with content, monitor their progress, and develop self-regulation skills. For educators, these platforms enhance instructional flexibility and provide new opportunities for monitoring performance and delivering targeted support.

Despite these advantages, several challenges remain. Issues such as cognitive overload, inconsistent design quality, and insufficient integration of accessibility features can limit the effectiveness of interactive platforms (Borgia et al., 2019; Yazçayır, 2023). Additionally, learners may experience challenges such as e-learning fatigue if instructional design and content delivery are not carefully managed (Rodrigues et al., 2022).

Emerging technologies present promising opportunities for advancing the field. Innovations such as augmented reality, adaptive learning systems, and advanced multimedia platforms offer new possibilities for creating immersive, personalized, and interactive learning experiences (Mathew & Peiris, 2026). However, their effectiveness will depend on maintaining alignment with accessibility principles and learner needs. Without such alignment, technological innovation risks introducing new barriers rather than resolving existing ones.

6. Conclusion

This systematic review provides robust and converging evidence that interactive web-based learning environments are highly effective in enhancing educational outcomes for learners with hearing impairments. Across effectiveness-oriented studies, interactive platforms that integrate multimedia, sign language, and structured activities consistently demonstrate significant improvements in academic achievement, motivation, and self-directed learning skills. These findings confirm that interactivity is not merely a technological enhancement but a core pedagogical mechanism that facilitates deeper cognitive processing, engagement, and knowledge construction. This is particularly critical for deaf learners, for whom visually rich and interactive environments compensate for the absence of auditory input and support meaningful learning.

The review further highlights that the success of interactive educational websites is fundamentally dependent on the quality of instructional design and accessibility. Well-designed environments—characterized by clear visual organization, structured navigation, multimedia

integration, and inclusive design principles—are more effective in supporting comprehension and engagement. Accessibility features such as captioning, sign language integration, and adaptive interfaces are not optional components but essential conditions for equitable learning. In this regard, the application of frameworks such as Universal Design for Learning reinforces the importance of designing flexible and inclusive environments that accommodate diverse learner needs.

In addition, the findings emphasize the importance of aligning technological features with pedagogical strategies. The integration of different web page types (static, dynamic, and application-based), as well as diverse learning formats (e.g., microlearning, simulations, and browser-based applications), contributes to creating comprehensive and adaptive learning environments. Similarly, the use of appropriate learning modes—particularly asynchronous and self-paced approaches—enhances learner autonomy, reduces cognitive load, and allows for repeated engagement with content, which is especially beneficial for deaf learners.

Learners' perceptions further support these conclusions, as deaf and hard-of-hearing students generally report positive attitudes toward interactive and online learning environments, valuing their flexibility, visual clarity, and opportunities for independent learning. However, the review also identifies important challenges, including cognitive overload, inconsistent design quality, and the risk of e-learning fatigue. These issues underscore the need for careful instructional planning, appropriate media selection, and continuous evaluation of learning environments to ensure their effectiveness.

Moreover, the findings demonstrate that interactive educational websites have a transformative impact on the broader educational process. They support a shift toward more learner-centered approaches by integrating content delivery, interaction, and assessment within a unified digital environment. They also enhance teachers' roles by enabling more effective monitoring, feedback, and personalized instruction, while simultaneously improving students' engagement, independence, and skill development.

Looking ahead, emerging technologies such as augmented reality, mobile learning, and advanced digital platforms offer promising opportunities to further enhance learning experiences for deaf learners. However, their successful implementation requires a continued emphasis on accessibility and pedagogical alignment to avoid introducing new barriers. The expansion of virtual classrooms and online systems reflects an ongoing digital transformation in education, but these environments must be carefully designed to ensure inclusivity.

In conclusion, interactive educational websites represent a powerful and scalable approach to inclusive education for individuals with hearing impairments. Their effectiveness depends on the integration of interactivity, instructional design quality, accessibility, and pedagogical coherence. When these elements are thoughtfully aligned, such environments have the potential to significantly improve learning outcomes, foster learner autonomy, and bridge persistent educational gaps for deaf and hard-of-hearing students.

7. Implications

The findings of this review carry significant implications for educational practice, instructional design, and future research, particularly in the context of inclusive and technology-enhanced learning. From an instructional design perspective, there is a clear need to move beyond surface-level integration of multimedia toward a more intentional and pedagogically grounded design approach. Interactive educational should be developed based on principles that prioritize visual communication, structured content organization, and cognitive load management. This includes the careful sequencing of learning tasks, the use of visual scaffolding techniques, and the integration of interactive elements that directly support learning objectives rather than merely enhancing presentation. In this context, interactivity should be purposeful, guiding learners through progressive stages of understanding rather than overwhelming them with excessive stimuli.

Accessibility must also be positioned at the core of the design process. The consistent evidence across the reviewed studies indicates that features such as captioning, sign language support, visual annotations, and customizable interfaces are essential for ensuring equitable access to learning. Therefore, adopting frameworks such as Universal Design for Learning (UDL) is not optional but necessary for developing inclusive digital environments. Moreover, accessibility should be embedded from the initial stages of design rather than retrofitted after development.

At the level of educational practice, there is a pressing need to equip educators with the skills required to design and implement interactive digital learning experiences tailored to deaf learners. This includes training in multimedia design, accessibility standards, and the pedagogical use of technology. Additionally, educational institutions should consider integrating interactive websites into formal curricula, particularly in skill-based and visually oriented disciplines, where such platforms have demonstrated strong effectiveness.

From a research perspective, the review highlights several important directions for future investigation. There is a need for more rigorous experimental studies with larger and more diverse samples to strengthen the evidence base. Longitudinal research is also essential to examine the sustainability of learning outcomes and the long-term impact of interactive environments. Furthermore, emerging technologies such as augmented reality, artificial intelligence, and adaptive learning systems offer promising opportunities for enhancing personalization and engagement, yet their application in deaf education remains underexplored. Finally, comparative studies across different cultural and educational contexts would provide valuable insights into how contextual factors influence the effectiveness of interactive learning environments.

8. Limitations

While this systematic review provides a comprehensive synthesis of the existing literature, several limitations must be acknowledged to contextualize the findings and guide future

research. First, although the review employed a multi-database search strategy, it is possible that some relevant studies were not captured, particularly those published in non-indexed journals or grey literature sources. This limitation is inherent in systematic reviews that rely on database coverage and may result in partial representation of the research landscape. Second, the inclusion of studies published only in English and Arabic introduces a potential language bias, which may have excluded relevant contributions from other linguistic contexts. Given the global nature of research on disability and e-learning, future reviews would benefit from incorporating studies published in a wider range of languages. Finally, it is important to note that not all included studies focused exclusively on interactive educational websites; some addressed broader e-learning environments or related technologies. While this broader scope enriches the analysis, it may also introduce variability in how “effectiveness” is conceptualized and measured.

References

1. Abdel Aziz, Iman. (2019). The Effectiveness of Using Adobe Illustrator in Teaching Fashion Design Skills to Girls with Hearing Impairments. *Journal of Architecture, Arts and Humanities*, 4(14), 51–63. https://mjaf.journals.ekb.eg/article_25768.html
2. Abu Zeid, Wafia Mohamed Wajih, Abdel Halim, Assem, Ahmed El-Sayed, Hesham, Najm El-Din, Ahmed Hosni Khattab, and Abdel Hamid, Amal Hosni Mohamed. (2020). The Effectiveness of a Hypermedia Program for Developing Knowledge and Skills in Industrial Skirt Pattern Making for the Deaf. *Journal of Home Economics*, 36(2), 127–150. https://jhe.journals.ekb.eg/article_116384.html
3. Al-Azawei, A., et al. (2016). Universal design for learning. *Computers in Human Behavior*, 61, 39–48. <https://doi.org/10.1016/j.chb.2016.03.028>
4. Aljedaani, W., et al. (2021). Deaf students’ perspectives on online learning. *Education Sciences*, 11(11), 712. <https://doi.org/10.3390/educsci11110712>
5. Aljedaani, W., et al. (2022). If online learning works for you, what about deaf students? *Scientific Reports*, 12. <https://doi.org/10.1038/s41598-022-13542-1>
6. Al-Kharbawi, Reda Mohamed Mohamed, and Qanuna, Samia Ahmed Mohamed. (2015). The Effectiveness of Building an Online Educational Website for Teaching a Fashion Design Technique through Sketching. *Journal of the World of Education*, 16(50), 1–33. <http://search.mandumah.com/Record/851175>
7. Al-Osaimi, A., et al. (2009). User interface requirements for e-learning for deaf children. <https://doi.org/10.1145/1836029.1836036>
8. Al-Quran, R. M. (2023). The effectiveness of an educational software based on sign language in improving distance learning achievement and self-learning skills of hearing-impaired students at the University of Jordan. *Jordanian Journal of Educational Sciences*, 8(1, Suppl. 2), 821. <https://www.jaesjo.com/index.php/jaes/article/download/1099/923>
9. Alsadoon, E., & Turkestani, M. (2020). Virtual classrooms for hearing-impaired students. <https://doi.org/10.18662/rrem/12.1sup2/240>

10. Alshawabkeh, A. A., Woolsey, M. L., & Kharbat, F. F. (2021). Using online information technology for deaf students. *Heliyon*, 7(5), e06915. <https://doi.org/10.1016/j.heliyon.2021.e06915>
11. Alves, R. F., Pereira, L. S., & Teixeira, A. (2025). The effectiveness of an authentic e-learning environment for deaf learners. *Applied Sciences*, 15(3), 1568. <https://doi.org/10.3390/app15031568>
12. Anwar, R., et al. (2024). Effectiveness of STEM-based workshop for deaf education. *Heliyon*. <https://doi.org/10.1016/j.heliyon.2024.e20439>
13. Astuti, E. Y., et al. (2023). Interactive web-based learning for deaf students. <https://doi.org/10.17977/um005v7i12023p171>
14. Balda, Ahmed Mohamed Ahmed, and El-Gamal, Ahmed Fathi Abdullah. (2011). The Effectiveness of Using a Proposed Website in Equipping Students of the Faculty of Specific Education with Some Practical Skills. *Egyptian Journal of Science Education*, 14(1), 197–218. <http://search.mandumah.com/Record/82>
15. Beal-Alvarez, J., & Cannon, J. (2014). Technology intervention research with deaf learners. *American Annals of the Deaf*, 158(5), 486–505. <https://doi.org/10.1353/aad.2014.0002>
16. Borgia, F., Bianchini, C., & de Marsico, M. (2019). Towards improving the e-learning experience for deaf students. <https://arxiv.org/abs/1911.13231>
17. Cavender, A., et al. (2009). Mobile assistive technologies for deaf users.
18. Domagała-Zyśk, E. (2013). E-learning for students with disabilities.
19. Fajardo, I., et al. (2014). Easy-to-read texts for deaf learners. *Journal of Deaf Studies and Deaf Education*, 19(4), 531–545. <https://doi.org/10.1093/deafed/enu028>
20. Farhan, W., & Razmak, J. (2022). A comparative study of an assistive e-learning interface among students with and without visual and hearing impairments. *Disability and Rehabilitation: Assistive Technology*, 17(4), 431–441. <https://doi.org/10.1080/17483107.2020.1786733>
21. Gehret, A. U., & Elliot, L. B. (2025). Perceptions of e-learning by deaf and hard-of-hearing students using asynchronous multimedia tutorials. *Educational Technology Research and Development*, 73(3), 1921–1949. <https://doi.org/10.1007/s11423-025-10476-z>
22. Glasser, A., Kushalnagar, K., & Kushalnagar, R. (2019). Speech recognition challenges for deaf users. <https://arxiv.org/abs/1909.01176>
23. Hashim, H., Tasir, Z., & Mohamad, S. K. (2013). E-learning environment for hearing impaired students. *Turkish Online Journal of Educational Technology*, 12(4), 67–70. <https://eric.ed.gov/?id=EJ1018030>
24. Jameh, Hassan Hussein, El-Ghamgham, Sarah Abdullah Saleh, Youssef, Souad Abdullah, and El-Gazzar, Mohamed Mohamed Ahmed. (2020). A Proposed Interactive Educational Website for Developing Fashion Design Skills among Female University

- Students in the Kingdom of Saudi Arabia. *Educational Technology – Studies and Research*, (43), 449–477. https://journals.ekb.eg/article_173344.html
25. Joy, S., & Gundmi, A. (2024). E-learning strategies implemented by instructors for individuals with hearing impairment. *Indian Journal of Otolaryngology and Head & Neck Surgery*, 76(4), 3140–3145. <https://doi.org/10.1007/s12070-024-04630-x>
26. Kent, M. (2015). Disability and e-learning accessibility. *Journal of Educational Technology Systems*, 44(1), 28–45. <https://doi.org/10.1177/0047239515588161>
27. Khasawneh, M. A. S. (2023). The use of video as media in distance learning for deaf students. *Contemporary Educational Technology*, 15(2), ep418. <https://doi.org/10.30935/cedtech/13012>
28. Kushalnagar, P., et al. (2010). Accessibility in online learning for deaf students. *Journal of Deaf Studies and Deaf Education*, 15(2), 123–135. <https://doi.org/10.1093/deafed/enp017>
29. Lang, H. G. (2002). Higher education for deaf students. *Journal of Deaf Studies and Deaf Education*, 7(4), 267–280. <https://doi.org/10.1093/deafed/7.4.267>
30. Luangrungruang, T., & Kokaew, U. (2022). E-learning model to identify the learning styles of hearing-impaired students. *Sustainability*, 14(20), 13280. <https://doi.org/10.3390/su142013280>
31. Marschark, M., et al. (2011). Technology use in deaf education. *American Annals of the Deaf*.
32. Mathew, R., & Peiris, R. L. (2026). Augmented reality for deaf students in education. <https://arxiv.org/abs/2604.00856>
33. Means, B., et al. (2010). Evaluation of evidence-based practices in online learning. <https://www2.ed.gov/rschstat/eval/tech/evidence-based-practices/finalreport.pdf>
34. Mingsiritham, K., & Chanyawudhiwan, G. (2020). Experiment of online learning resources (MOOC) to develop life skills for hearing-impaired students. *International Journal of Emerging Technologies in Learning*, 15(3), 242–249. <https://doi.org/10.3991/ijet.v15i03.12059>
35. Niksiar, N. (2025). The effectiveness of an authentic e-learning environment on deaf learners. *Applied Sciences*, 15(3), 1568. <https://doi.org/10.3390/app15031568>
36. Rahmawati, Y., Kurniawan, D., & Pramono, S. E. (2023). The interactive web-based learning in online learning for blind and deaf students in higher education. *International Journal of Instructional Technology and Educational Studies*, 4(2), 45–56. <https://journal2.um.ac.id/index.php/icsar/article/view/31922>
37. Ratnawulan, T., Ridwan, P. G., Suryana, Y. B., Anisah, E. Y., & Mahmud, E. (2021). The effect of interactive web-based learning (IWL) model on learning outcomes of students with visual impairment and students with hearing impairment. *Journal of ICSAR*, 5(2), 46–53. <https://distantreader.org/stacks/journals/icsar/icsar-17611.pdf>
38. Richardson, J. T. E., et al. (2004). Academic attainment in deaf students. *Studies in Higher Education*. <https://doi.org/10.1080/0307507042000190780>

39. Rizk, Mohamed Abdel-Shafi, Zalat, Atef Ibrahim, and Metwally, Rania Abdel-Moneim. (2015). Developing Fashion Design and Pattern Drawing Skills for Students in Schools for the Deaf and Hard of Hearing (A Case Study). *Journal of Specific Education Research*, (37), 539–564. <https://doi.org/10.21608/mbse.2015.140535>
40. Rodrigues, F. M., et al. (2022). E-learning fatigue in deaf and hard-of-hearing students. *Scientific Reports*. <https://doi.org/10.1038/s41598-022-13542-1>
41. Rowel, M. M. K., Gunasekara, A. D. A. I., Uwanthika, G. A. I., & Wijesinghe, D. B. (2021). An e-learning platform for hearing impaired children. <http://ir.kdu.ac.lk/bitstream/handle/345/5207/9.pdf>
42. Shadiev, R., et al. (2020). Review of e-learning effectiveness. *Educational Technology Research and Development*, 68, 1–25. <https://doi.org/10.1007/s11423-019-09703-3>
43. Sung, Y. T., et al. (2016). Effects of mobile learning. *Computers & Education*, 94, 252–275. <https://doi.org/10.1016/j.compedu.2015.11.008>
44. Utami, I. S., et al. (2025). Online learning for students with hearing impairment: A systematic review. *TEM Journal*, 14(2), 1762–1770. <https://doi.org/10.18421/TEM142-74>
45. Wu, W. H., et al. (2012). Mobile learning review. *Computers & Education*, 59(2), 817–827. <https://doi.org/10.1016/j.compedu.2012.03.016>
46. Yazçayır, G. (2023). Teachers' instructional design for e-learning of deaf students. *International Journal of Online and Multimedia Education Studies*. <https://www.ijonmes.net/index.php/ijonmes/article/view/342>
47. Youssef, Ahmed Shaaban Mohamed. (2011). A Proposed Instructional Design for an Interactive Website in Social Studies and Its Impact on Developing Critical Thinking and Some Electronic Communication Skills Among Seventh-Grade Students in Basic Education. *Journal of the Educational Society for Social Studies*, (31), 14–105. <http://search.mandumah.com/Record/87323>
48. Zhang, D., et al. (2006). Interactive multimedia learning. *Information Systems Research*, 17(2), 129–139. <https://doi.org/10.1287/isre.1060.0086>