

DEAVIS (Deaf Visual Interactive Science Learning): A Digital Science Learning Media for Students with Moderate Hearing Impairment

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Keywords

DEAVIS, Digital Learning Media, Inclusive Education, Moderate Hearing Impairment, Multimodal Learning

Abstract

Inclusive education requires learning media that accommodate the needs of students with disabilities, including those with moderate hearing impairment. However, existing learning media often do not adequately integrate visual, textual, and interactive elements to support science learning. This study aimed to formulate a conceptual design of DEAVIS (Deaf Visual Interactive Science Learning), a multimodal digital science learning medium for students with moderate hearing impairment. Using a conceptual approach based on learning needs analysis and relevant literature, this study resulted in a design that integrates visual representations, adaptive text, videos, and interactive features within a structured learning system. The proposed design offers a conceptual digital learning alternative with the potential to support science concept understanding among students with moderate hearing impairment.

INTRODUCTION

Inclusive education seeks to ensure that all students, including those with disabilities, have equal access to education and opportunities to participate actively in learning environments without discrimination. This approach emphasizes not only the presence of students in the same classroom but also the fulfillment of diverse learning needs to support optimal development. Inclusive education reflects a global commitment to providing equitable, meaningful, and accessible education for all learners, including children with disabilities (Taneja-Johansson & Singal, 2025). Furthermore, inclusive education values diversity, addresses

individual learning needs, and fosters a sense of belonging within educational systems (Rapp & Corral-Granados, 2024). Inclusive education also requires the identification of students' learning needs and the provision of appropriate support to ensure meaningful learning participation (Yunitasari et al., 2025). Consequently, learning strategies and instructional media must be adapted to accommodate diverse learner characteristics.

One group that requires particular attention is students with moderate hearing impairment. These students experience limitations in receiving auditory information but still retain residual hearing that can be utilized through appropriate instructional support (Leijen et al., 2021). The level of hearing loss influences how students access information, communicate, and understand learning materials. Unlike students with mild hearing impairment who can generally rely on hearing aids, and students with severe hearing impairment who predominantly depend on sign language, students with moderate hearing impairment require a balanced combination of visual, linguistic, and interactive learning supports (Ahmed & Hasegawa, 2022).

Science learning presents additional challenges for students with hearing impairment because many scientific concepts are abstract, complex, and contain specialized terminology. Previous studies on science education for deaf and hard-of-hearing students have emphasized the importance of visual-based instructional strategies and appropriate learning support to facilitate science learning and concept understanding (Atika et al., 2023). Difficulties in language access and communication often hinder students' understanding of scientific concepts, particularly when learning media are not designed according to their needs (Batanero-Ochaíta et al., 2021). Previous studies have demonstrated that visual elements, such as images, videos, and sign language, can improve learning comprehension among deaf and hard-of-hearing students (González-Afonso et al., 2026). Interactive digital learning environments have also been reported to enhance student engagement and learning motivation (Niksiar et al., 2025).

Advances in educational technology provide opportunities to address these challenges through digital and multimodal learning media. Recent research has highlighted the growing role of educational technologies, including assistive tools, captioning systems, and digital learning platforms, in improving accessibility for deaf and hard-of-hearing learners (Almulhim, 2025). Technologies such as interactive e-learning platforms, educational videos, augmented reality, and virtual reality have shown potential to improve accessibility and learning experiences for students with hearing impairment (Khasawneh, 2023; González-Afonso et al., 2026). A recent systematic review highlighted the importance of designing accessible online learning environments that consider the characteristics and learning needs of students with hearing impairment to maximize learning benefits and reduce barriers to participation (Utami et al., 2025). Previous studies have also reported that accessible support systems play an important role in promoting participation and reducing barriers experienced by students with disabilities in

online learning environments (Lynch et al., 2026). Nevertheless, most existing learning media are designed for deaf learners in general and do not specifically address the transitional learning characteristics of students with moderate hearing impairment, who require a balanced integration of visual representation, adaptive text, and interactive learning activities within a single learning system.

Based on this research gap, this conceptual study proposes DEAVIS (Deaf Visual Interactive Science Learning), a digital science learning medium specifically designed to address the learning needs of students with moderate hearing impairment. DEAVIS integrates visual representations, adaptive text, educational videos, and interactive features to support science learning within an inclusive education context. Therefore, this study aims to formulate a conceptual design of DEAVIS as a multimodal digital science learning medium that accommodates the learning characteristics and needs of students with moderate hearing impairment.

METHODS

This study employed a qualitative approach through a conceptual study aimed at analyzing and synthesizing theories and findings from previous studies to formulate a new conceptual design (Jaakkola, 2020). The study examined relevant literature concerning the characteristics of students with hearing impairment, inclusive education, and multimodal digital learning media. Data sources consisted of Scopus-indexed international journal articles and other scientific references related to the research topic.

The research procedure involved several stages, including identifying learning problems experienced by students with moderate hearing impairment, analyzing learning needs based on student characteristics, and reviewing relevant theories and previous studies. The subsequent stage involved formulating the conceptual design of DEAVIS (Deaf Visual Interactive Science Learning) based on the identified learning needs and theoretical foundations.

Data were analyzed using descriptive qualitative analysis through the processes of reviewing, comparing, integrating, and synthesizing findings from the literature. The results of the analysis were used as the basis for formulating an integrated and adaptive conceptual design of DEAVIS that accommodates the learning characteristics of students with moderate hearing impairment. This approach is consistent with the nature of conceptual studies, which aim to construct new conceptual models or frameworks based on existing theories and previous research findings (Jaakkola, 2020).

RESULTS AND DISCUSSIONS

Characteristics and Learning Challenges of Students with Moderate Hearing Impairment

Students with hearing impairment demonstrate different characteristics depending on the degree of hearing loss. Students with mild to moderate hearing impairment generally retain residual hearing that can be utilized, particularly with the support of hearing aids, allowing the use of verbal language during the learning process. In contrast, students with more severe hearing impairment experience greater limitations in accessing auditory information and therefore rely more heavily on visual forms of communication, such as sign language (Zussino et al., 2022; Bintoro et al., 2023; Rodríguez-Correa et al., 2023). Students with moderate hearing impairment occupy a transitional condition that requires a balance between visual representation, language support, and active learning experiences. These differences indicate that the learning needs of students with hearing impairment cannot be generalized. Students with moderate hearing impairment require learning support that bridges auditory limitations while simultaneously utilizing their residual hearing.

Table 1. Characteristics of Moderate Deaf Students and Learning Needs

Characteristics of Students	Learning Needs	Supporting References
Auditory limitations	Concrete visual representations	Ahmed & Hasegawa (2022)
Visual-dominant learning style	Image-based learning materials	Zussino et al. (2022)
Need for accessible language	Adaptive and simplified text	Jolly et al. (2024)
Need for active engagement	Interactive learning activities	Skyer (2023)

As presented in Table 1, students with moderate hearing impairment demonstrate specific learning needs that should be considered in the design of learning media. These needs include concrete visual representations, accessible language, and opportunities for active engagement during the learning process. Therefore, the conceptual design of DEAVIS incorporates several multimodal components intended to address these learning needs. The visual approach adopted in DEAVIS is strongly supported by previous studies. The conceptual design of DEAVIS indicates that learning media for students with moderate hearing impairment should not rely on a single component. Instead, DEAVIS is proposed as a multimodal learning medium that integrates various forms of information representation. Individuals with hearing impairment tend to depend on visual processing when interpreting information. Visual

representations in the form of images, animations, and videos can help make abstract science concepts more concrete. Previous studies have shown that visual technologies, such as augmented reality (AR) and virtual reality (VR), can improve conceptual understanding and learning engagement through more concrete representations (Al-Ansi et al., 2023; González-Afonso et al., 2026). These findings suggest that digital technologies and learning media have the potential to support students' understanding of scientific concepts.

However, the use of visual elements in learning cannot stand alone. Excessive visualization without adequate language support may increase cognitive load and hinder comprehension. This finding is consistent with studies reporting that high visual complexity can increase cognitive load and interfere with learning processes (Chong et al., 2026). In science education, visualization and simulation are particularly relevant because many scientific concepts are abstract and require concrete representations to facilitate understanding. Visual-based technologies have been shown to support students in understanding complex concepts through more immersive learning experiences (Al-Ansi et al., 2023).

Multimodal Learning Needs of Students with Moderate Hearing Impairment

Differences in the characteristics of students with hearing impairment indicate that their learning needs cannot be treated as homogeneous. Students with moderate hearing impairment require learning support that bridges auditory limitations while simultaneously utilizing their residual hearing. Within DEAVIS, adaptive text functions as a meaning-enhancing component. Text is presented in a simple and structured manner to accommodate students' linguistic abilities. Previous studies have shown that the use of text and captions can improve comprehension and information retention among students with hearing impairment while helping to overcome communication barriers (Jolly et al., 2024). The quality of text presentation is also important, as inaccurate captions may reduce the effectiveness of information delivery (Mével et al., 2022).

The video component in DEAVIS further enhances learning accessibility. Research on multimedia-based e-learning for deaf and hard-of-hearing students has shown that appropriately designed visual and multimedia elements can support learning experiences and accommodate the specific needs of this learner population (Gehret & Elliot, 2025). The presentation of learning materials through visual videos or sign language enables students to access information through communication channels that better suit their needs. Research has demonstrated that multimodal visual elements, including sign language and subtitles, can increase access and participation among students with hearing impairment in digital learning environments (González-Afonso et al., 2026). Recent studies have further emphasized the importance of designing accessible video-based learning environments that address the diverse needs of deaf and hard-of-hearing learners (Chen et al., 2025).

Interactivity within DEAVIS contributes to student engagement. Interactive learning allows students to actively participate through exploration and practice activities. Previous studies have reported that interactive activities in digital environments can enhance motivation, engagement, and learning experiences (Chong et al., 2026). Multimodal learning, which integrates visual, linguistic, and kinesthetic modalities, can support students with hearing impairment in understanding learning materials more effectively because they do not rely on a single form of information representation. Instead, they benefit from a combination of multiple modes of communication and information delivery in constructing understanding (Skyer, 2023; Francisco & Padilla, 2024). Therefore, the integration of various components within DEAVIS reflects a multimodal learning approach that is aligned with the characteristics of students with moderate hearing impairment, making learning more accessible and easier to understand.

Proposed Design of DEAVIS Digital Learning Media

The result of this conceptual study is a proposed design of a digital science learning medium called DEAVIS (Deaf Visual Interactive Science Learning). DEAVIS is designed as a visual and interactive learning medium intended for students with moderate hearing impairment within an inclusive education context. The proposed design is based on the characteristics of students with moderate hearing impairment, who require a balance between the utilization of residual hearing and visual support during the learning process. Unlike students with mild or severe hearing impairment, students with moderate hearing impairment require learning support that can bridge limitations in auditory access while optimizing visual information processing (Zussino et al., 2022; Bintoro et al., 2023; Rodríguez-Correa et al., 2023). These characteristics serve as the foundation for the design of DEAVIS as a learning medium that presents information in a structured, concrete, and easy-to-understand manner.

Conceptually, DEAVIS is designed as an interactive digital learning medium that can be accessed through devices such as laptops, computers, or tablets. The medium adopts a simple learning interface that presents science content through a combination of adaptive text, visual illustrations, animations, supporting videos, and interactive exercises. The selection of a digital format is based on the ability of e-learning media to deliver learning materials in a multimodal and flexible manner while accommodating the needs of students with hearing impairment (Luangrungruang & Kokaew, 2022). The integration of assistive technologies within digital learning environments has also been reported to support learning and accessibility for students with hearing disabilities (Eksasari et al., 2025).

Design Components of DEAVIS

DEAVIS consists of two levels of design, namely the learning structure and the main learning components. The learning structure begins with an orientation page or homepage that serves as the entry point to the learning medium. This page provides information about the learning topic, objectives, instructions, and navigation buttons that guide students to the main content. A clear orientation stage is important because students with hearing impairment require a structured learning sequence to follow information systematically and minimize confusion. In addition to the learning structure, DEAVIS incorporates five main components: visual content, video, adaptive text, interactive activities, and feedback. These components are integrated to support accessible and multimodal science learning for students with moderate hearing impairment.

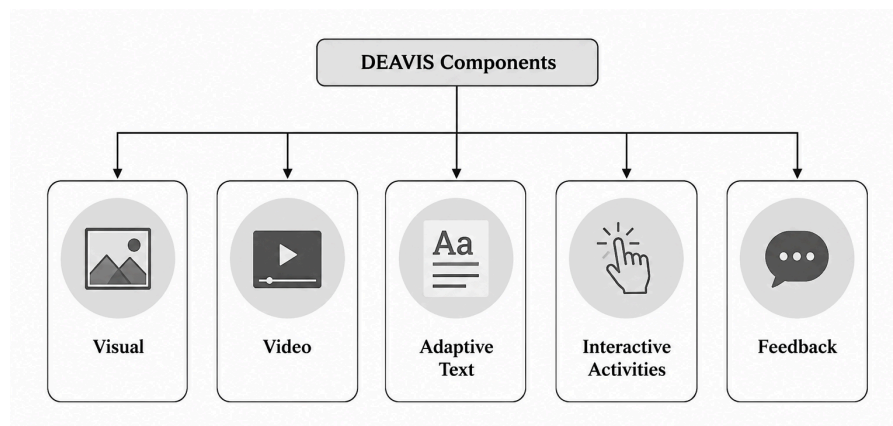


Figure 1. DEAVIS Components

Source: Developed by the authors based on literature analysis.

Figure 1 illustrates the main components of DEAVIS, consisting of visual content, video, adaptive text, interactive activities, and feedback. These components are integrated to support accessible and multimodal science learning for students with moderate hearing impairment. To further explain the educational role of each component, Table 2 summarizes the functions of the DEAVIS components and their theoretical foundations based on previous studies. The integration of these components reflects the application of multimodal learning principles designed to accommodate the learning characteristics of students with moderate hearing impairment.

Table 2. DEAVIS Components and Educational Functions

DEAVIS Component	Function	Supporting References
Visual	Present scientific concepts concretely through images and animations	Al-Ansi et al. (2023); González-Afonso et al. (2026)
Video	Provide explanations supported by sign language	Khasawneh (2023)
Adaptive Text	Facilitate understanding through concise and accessible language	Jolly et al. (2024)
Interactive Activities	Increase student participation and engagement	Chong et al. (2026)
Feedback	Reinforce learning outcomes and motivation	Mayer (2024)

The second component is the presentation of core learning materials through visual representations. In this section, science content is delivered through images, diagrams, process illustrations, and simple animations that present scientific phenomena in a concrete manner. The use of visualization is supported by findings indicating that individuals with hearing impairment tend to pay greater attention to visual stimuli and rely heavily on visual channels when processing information. Concept visualization is particularly important in science education because science materials often involve abstract concepts, cause-and-effect relationships, and processes that may be difficult to understand when presented solely through verbal explanations (Al-Ansi et al., 2023).

The third component is adaptive text. In DEAVIS, text is not presented in lengthy paragraphs but rather in short, structured sentences using simple vocabulary. The text functions as a complement to visual representations rather than as the sole source of information. The use of adaptive text is based on findings indicating that students with hearing impairment often encounter difficulties when learning materials are presented with excessive linguistic complexity. Therefore, the text in DEAVIS is intended to clarify images and animations rather than burden students with complex reading materials (Jolly et al., 2024).

The fourth component is sign language videos and visual explanatory videos that support specific learning materials. These components help bridge students' understanding when images and text alone are insufficient to explain a concept. Previous studies have shown that presenting information through visual formats and sign language can improve accessibility and comprehension among students with hearing impairment (González-Afonso et al., 2026). This is consistent with the Cognitive Theory of Multimedia Learning, which suggests that learning becomes more effective when information is presented through a combination of visual and verbal representations, as individuals process information through visual and verbal/auditory channels (Mayer, 2024).

The fifth component is interactive features, such as multiple-choice quizzes, image-matching activities, process-sequencing tasks, and simple click-based simulations. These features are designed to encourage active participation rather than passive observation. Interactive digital learning environments have been reported to enhance student engagement and learning experiences (Chong et al., 2026). Studies have reported that intelligent learning environments can enhance engagement and support the understanding of abstract concepts among students with hearing impairment (Zhang et al., 2024).

The sixth component is immediate feedback. After completing exercises or quizzes, students receive automatic responses in the form of brief explanations, correctness indicators, or recommendations to review specific materials. This component is important because students with hearing impairment often require concrete and timely learning support to maintain their understanding of the learning content. The seventh component is simple and consistent navigation. DEAVIS is designed with clear buttons, easily recognizable icons, and an uncluttered interface. This design aims to maintain students' visual attention on the learning content. Previous studies have shown that poorly organized visual designs may increase users' cognitive load (Chong et al., 2026).

Proposed Implementation and Learning Flow of DEAVIS

The proposed design illustrates DEAVIS as a digital science learning medium that follows a structured learning sequence. Students begin by accessing the topic page, reviewing the learning objectives, and observing illustrations or animations related to the learning content. They then receive explanations through adaptive text and supporting videos before completing interactive learning activities that conclude with immediate feedback. This learning flow is intended to provide a systematic and accessible learning experience for students with moderate hearing impairment.

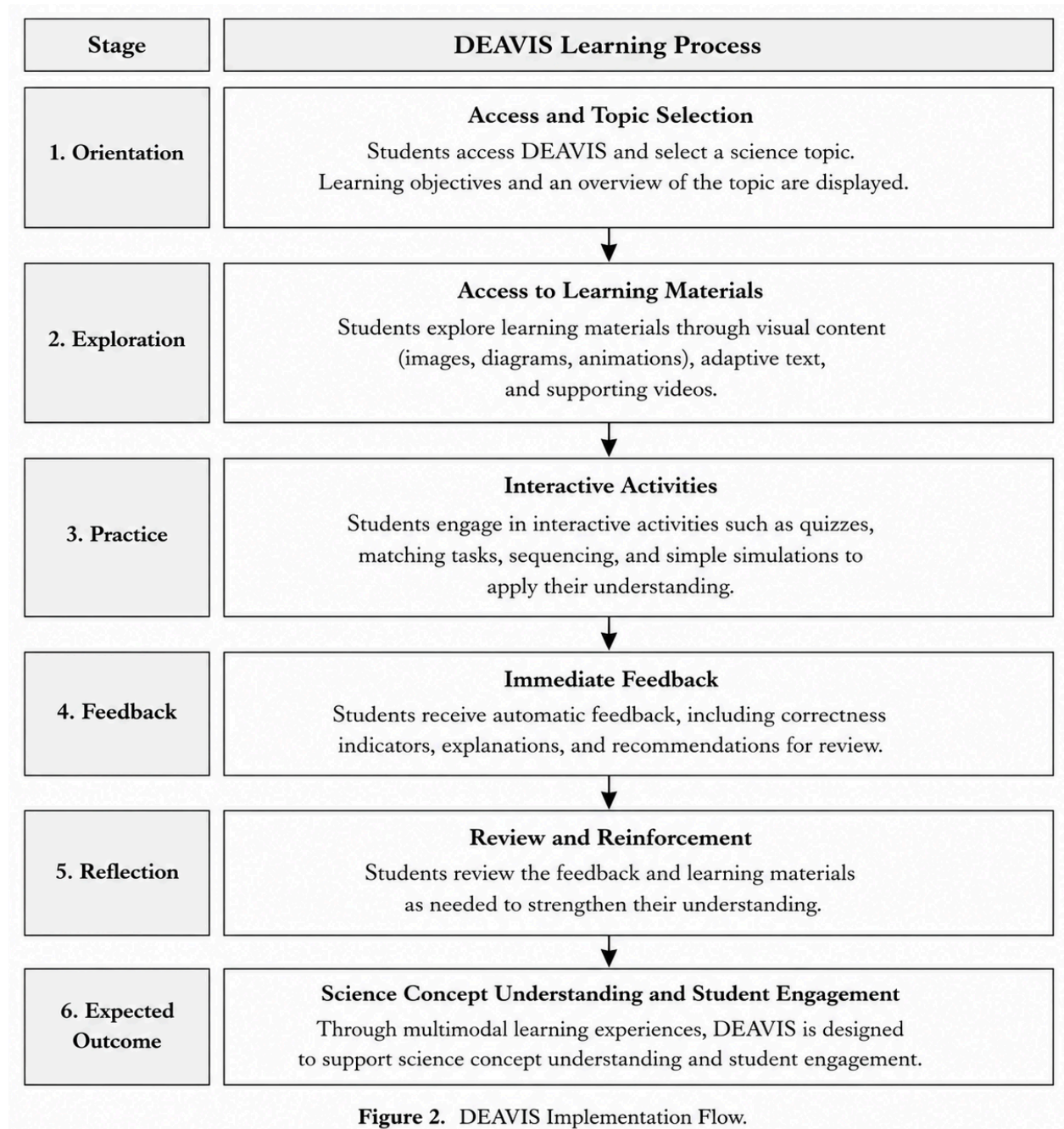


Figure 2 presents the implementation flow of DEAVIS, which illustrates the sequential learning process experienced by students. The flow begins with topic selection and orientation, followed by the exploration of learning materials through visual content, adaptive text, and supporting videos. Students then participate in interactive learning activities, receive immediate

feedback, and review the learning materials as needed. This sequence reflects the integration of multimodal learning components designed to support science concept understanding and student engagement.

The proposed implementation of DEAVIS integrates multiple forms of information representation, including visual elements, text, and interactivity, to facilitate the development of conceptual understanding. Therefore, the multimodal design of DEAVIS is proposed as a suitable approach for addressing the learning needs of students with moderate hearing impairment rather than applying a generalized approach to all categories of hearing impairment. This perspective is consistent with the concept of multimodal transduction, which emphasizes the importance of using multiple modes of communication to improve accessibility and understanding among students with hearing impairment (Skyer, 2023).

Previous studies have shown that multimodal learning, which integrates visual, linguistic, and kinesthetic modalities, can support students with hearing impairment in understanding learning materials more effectively. Rather than relying on a single form of information representation, students benefit from a combination of communication modes that facilitate knowledge construction (Francisco & Padilla, 2024). Therefore, the integration of various components within DEAVIS reflects the application of a multimodal learning approach that aligns with the characteristics of students with hearing impairment, making learning more accessible and easier to understand.

CONCLUSION

This conceptual study concludes that students with moderate hearing impairment are in a transitional condition that requires a balance between the utilization of residual hearing and visual support during the learning process. These characteristics indicate the need for learning media that integrate multiple forms of information representation within a unified system. The proposed design of DEAVIS (Deaf Visual Interactive Science Learning) offers a conceptual solution in the form of a multimodal digital learning medium that combines visual representations, adaptive text, videos, and interactive features in a structured learning environment. The proposed design demonstrates the potential to support science concept understanding among students with moderate hearing impairment in accordance with their learning characteristics. The findings of this study contribute to the field of inclusive digital learning by providing a conceptual framework that may serve as a reference for future learning media design. However, this study remains conceptual in nature; therefore, further research is needed to develop a prototype, conduct expert validation, and examine its implementation in actual learning settings.

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