

Enhancing Inclusive Learning Management through Video-Based Learning Media to Support SDG 4 for Hearing-Impaired Students

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ABSTRACT

Objective: The study aimed to develop and evaluate video-based learning content integrated into an inclusive Learning Management System (LMS) ELITA to support students with hearing impairment in accessing Biology Learning Video Development courses. Specifically, this study examined the validity of the developed learning media and explored its effectiveness in facilitating the learning process for students with hearing impairment in an inclusive higher education environment. **Method:** The study employed a research and development (R&D) approach using the ADDIE model, which consists of five stages: analysis, design, development, implementation, and evaluation. The research was conducted in July–August 2024 at Universitas Tidar, Central Java, Indonesia. **Results:** The findings showed that the developed video-based learning content integrated into LMS ELITA achieved a highly valid category based on evaluations from both material and media experts. During field implementation, students with hearing impairment were able to participate effectively in the learning activities and demonstrated positive responses toward the use of the inclusive LMS. The developed learning content provided better accessibility to learning materials by presenting information through visual-based media, supporting students with hearing impairment in understanding biological concepts and participating actively in the learning process. These findings indicate that the integration of accessible video-based content into an inclusive LMS can enhance learning experiences for students with hearing impairment. **Novelty:** The study contributes to the development of inclusive digital learning by integrating video-based learning content specifically designed to support students with hearing impairment within an LMS environment. The findings provide empirical evidence that inclusive LMS development can promote equitable learning opportunities and support the implementation of accessible education for students with disabilities.

INTRODUCTION

The inclusion of students with disabilities in higher education has become a key focus of educational policies worldwide (Adams & Brown, 2006; Dumitru, 2023; Filippou et al., 2025; Shaw, 2024). This is because higher education serves as a predictor of rewarding and meaningful employment, while also providing opportunities for career development that positively impact long-term quality of life (Chiu et al., 2021; Magnano et al., 2019; Staupoulou et al., 2023). The number of students entering higher education is also reported to continue to increase along with increasing awareness and identification of the needs of students with disabilities (Kochhar-Bryant et al., 2009). Therefore, the support services for students with disabilities within the university is essential to ensure that their right to equal opportunities in the learning process at higher education institutions is fully realized (Bartolo et al., 2023; Phasha & Mosia, 2017).

Among the students with disabilities, those with hearing impairments face unique challenges in accessing auditory information, which can hinder their learning experiences (Aljedaani et al., 2023; Moustache & Makhoba, 2024). Traditional learning environments, primarily designed for non-disability students, often fail to provide sufficient accommodations for those with hearing disabilities, resulting in limited participation and

engagement in academic activities (Horlin et al., 2024; Masuku et al., 2024). Some of the challenges faced by students with hearing impairments include limited communication, physical environments such as auditory and visual environments, seating arrangements, classroom interactions and activities, and teaching processes and materials (Açar & Demiralp, 2025; Kanwal & Bashir, 2022). The results of the research study also showed that students with hearing impairments face many difficulties caused by the learning methods used by teachers in the classroom, the lack of language interpreters, and teachers' signing to use sign language during learning (6). But apart from that, one of the obstacles faced by students with disabilities is also the lack of awareness among teachers regarding the various needs that students may have, as well as the lack of support when students need lecture notes or slides before lectures (9). This highlights the need for educational technologies and media that are inclusive and accessible to all students, regardless of their abilities.

Higher education institutions should make reasonable and anticipatory adjustments based on students' needs in order to ensure that individuals with disabilities have equal opportunities in the learning process (Ajani & Ntombela, 2025; Campbell, 2023; Chalmers et al., 2026). These adjustments may include providing access to adaptive technology or modifying approaches to learning, teaching, and assessment. The adjustments should also be designed based on the specific needs of individual students and implemented before students begin their study programs.

To facilitate the educational process for students with disabilities, Tidar University is committed to creating an inclusive campus. This is demonstrated by policy support, the establishment of the Disability Service Center (SLD), and the provision of infrastructure to meet the needs of students with disabilities. However, these efforts have yet to fully address the quality of learning services for students with disabilities. This is evident in the planning and implementation of learning processes, which have not adequately considered the unique characteristics and needs of these students.

One of the technological supports available at Tidar University to support all courses including the Biology Learning Video Development course is the implementation of a Learning Management System (LMS) called ELITA which can be accessed at <https://elita.untidar.ac.id/>. Over the years, the number of visits to ELITA has steadily increased, indicating its significant role in enhancing learning at Tidar University. However, while ELITA has been successfully used to support the learning process, the content provided has not been specifically designed to accommodate the needs of students with hearing impairments. Therefore, it is essential to optimize ELITA to be more inclusive, addressing the challenges faced by students with disabilities.

Video-based learning media, which integrates both visual and textual components, has emerged as a promising solution to address the needs of students with hearing impairments (Cheng et al., 2024; Farhan & Razmak, 2022; Khasawneh, 2023). By offering visual aids such as captions, sign language interpretation, and clear explanation and imagery, these videos can enhance comprehension and engagement among hearing-impaired students (Ghannam et al., 2026; Hatami & Chegini, 2024; Mgendi et al., 2024). Research suggests that multimedia learning environments, when properly designed, can improve the retention of information and facilitate deeper understanding by leveraging the visual strengths of students with hearing impairments and significantly improved the academic self-concept of adolescents with hearing impairments who attend public schools. As such, video-based learning media has the potential to create more equitable learning opportunities for students with hearing impairments in higher education (Khomyshak, 2024; Rutledge Ph D, 2025).

This study focuses on the development of video-based learning media specifically designed to the needs of students with hearing impairments in college settings. The research explores how these media can be effectively integrated into inclusive learning management

system (LMS) environments in the Biology Learning Video Development course. By doing so, this study aims to contribute to the growing body of research on inclusive education and digital accessibility for students with disabilities. Moreover, the use of LMS is in line with the needs of students in the millennial era who want easy access to materials anytime and anywhere (Jayanthi et al., 2023; McHaney, 2023).

The implementation of video-based learning media for hearing-impaired students not only supports educational equity but also promotes the broader goals of inclusivity and diversity in higher education. As institutions increasingly adopt digital learning technologies, it is essential to ensure that these tools are accessible to all students, particularly those with disabilities. By developing and evaluating accessible video content, this research seeks to enhance the academic success and participation of students with hearing impairments in higher education.

RESEARCH METHOD

Research design

This study employed a research and development (R&D) design using the ADDIE instructional design model, which consists of five systematic stages: Analysis, Design, Development, Implementation, and Evaluation. The R&D approach was selected because this study aimed to develop, validate, and evaluate video-based learning content integrated into the inclusive Learning Management System (LMS) ELITA to support students with hearing impairment in the Biology Learning Video Development course. The ADDIE model was applied to ensure that the developed learning media met both pedagogical requirements and accessibility considerations for students with hearing impairment.

The research was conducted in July–August 2024 at Universitas Tidar, Central Java, Indonesia. The development process focused on creating nine video-based learning contents for the Biology Learning Video Development course. Each stage of the ADDIE model was systematically implemented, beginning with identifying students' learning needs, designing learning content and media specifications, developing video materials, implementing the developed media in the learning process, and evaluating the quality and feasibility of the product. The stages of the research and development process are presented in Figure 1.

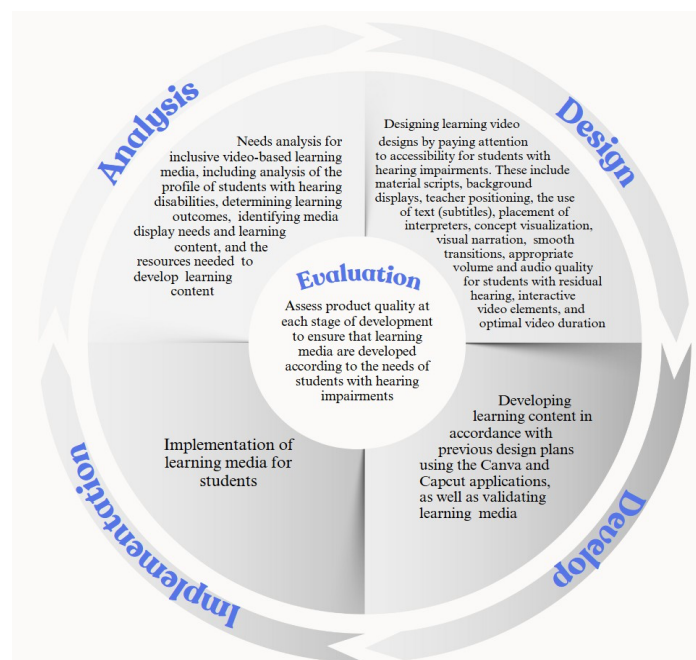


Figure 1. The steps of research and development of video-based learning media

The R&D design was considered appropriate because this study aimed not only to produce learning media but also to evaluate its validity and usability in supporting inclusive learning. Through this approach, the developed video-based learning content was expected to provide accessible learning resources that accommodate the needs of students with hearing impairment.

Research participants

The participants of this study consisted of media and material experts, as well as undergraduate students enrolled in the Biology Learning Video Development course at Universitas Tidar. The participants were selected using purposive sampling because they were directly involved in evaluating and implementing the developed video-based learning media.

The expert participants consisted of three validators with expertise in biology learning media and educational materials. These experts were involved in assessing the quality, relevance, presentation, accessibility, and technical aspects of the developed video content. In addition, the participants included seventh-semester undergraduate students from the Biology Education Study Program who were enrolled in the Biology Learning Video Development course.

The involvement of experts and students allowed researchers to obtain comprehensive information regarding the validity, feasibility, and practical implementation of video-based learning content integrated into the inclusive LMS ELITA, particularly for supporting students with hearing impairment during the learning process.

Research instruments

The research instruments used in this study consisted of field observation sheets, questionnaires, interview guidelines, and validation sheets for material and media experts. These instruments were developed to collect data during the needs analysis, product validation, and implementation stages of the ADDIE model.

Field observation sheets, questionnaires, and interview guidelines were used during the analysis stage to identify learning needs, accessibility challenges, and students' requirements in the Biology Learning Video Development course. Meanwhile, validation sheets were used by material and media experts to evaluate the eligibility of the developed video-based learning content.

The assessment conducted by material experts focused on several aspects, including content relevance, material accuracy, presentation quality, language clarity, and typography. Meanwhile, media experts evaluated the media aspects, including function and benefits, visual and audio quality, accessibility features, and typography. The validation instrument used a five-point Likert scale ranging from 1 (bad), 2 (not good), 3 (moderate), 4 (good), to 5 (very good).

The instruments were designed to determine whether the developed learning media fulfilled pedagogical, technical, and accessibility requirements for inclusive biology learning.

Data analysis techniques

Data collection was conducted through observation, interviews, questionnaires, and expert validation. The collected data were analyzed descriptively to determine the validity and feasibility of the developed video-based learning content integrated into LMS ELITA.

The validation data obtained from material and media experts were analyzed by calculating the total score and percentage for each assessment indicator. The percentage score was calculated using the following formula:

Table 1. Media eligibility criteria

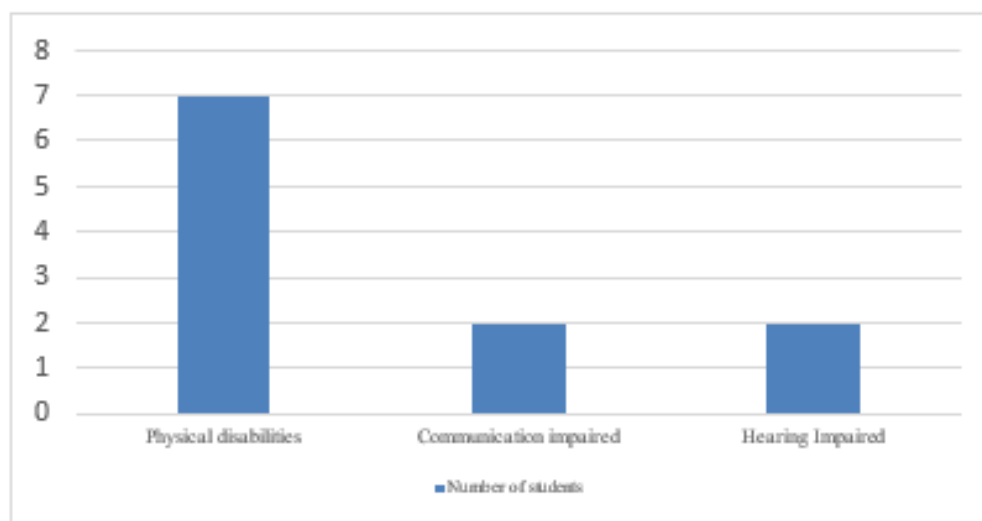
No.	Rating (P) in %	Criteria
1	$85 < P \leq 100$	Highly Valid
2	$70 < P \leq 85$	Valid
3	$55 < P \leq 70$	Moderate
4	$40 < P \leq 55$	Less Valid
5	$P \leq 40$	Invalid

The implementation data obtained from field observations and student responses were analyzed descriptively to identify the effectiveness and practicality of the developed learning media. The analysis focused on students' participation, responses, and ability to engage with video-based learning content through the inclusive LMS ELITA. Through these analysis procedures, the researchers evaluated whether the developed media was valid, feasible, and capable of supporting students with hearing impairment in accessing biology learning materials.

RESULTS AND DISCUSSION

Results

At this stage, a needs analysis for developing learning media for students with disabilities was conducted. The analysis revealed that Tidar University currently has 11 students with disabilities distributed across seven study programs: Management, Accounting, Animal Husbandry, Law, Indonesian Language and Literature Education, English Language Education, and Biology Education. The types of disabilities include physical impairments, communication disorders, and hearing impairments. Specifically, students with disabilities in the Biology Education program are currently limited to those with hearing impairments. Complete data on the number of students with disabilities is presented in Figure 2.

**Figure 2.** Number of disabled students at Tidar University

An analysis of the profile of hearing-impaired student in the Biology Education Study Program revealed that she is unable to hear with the right ear, while her left ear has a hearing range of 40-60 dB. This condition makes herself difficult to fully engage in lecture activities. To handle these conditions, she has relied primarily on the limited hearing from the left ear and focusing on the lecturer's lip movements during explanations. However, during the COVID-19 pandemic, these challenges intensified as the use of masks prevented students from reading lips, making it impossible for hearing impaired students to receive the

information conveyed by the lecturer. Their limited hearing often impedes the learning process, as they must focus on lip-reading, especially when the lecturer speaks too quickly or with unclear articulation. As a result, students frequently struggle to fully grasp the context of the discussion.

Moreover, an analysis of the curriculum and learning outcomes indicates that in the course on developing biology instructional videos, students learn how to create videos for biology education. They are also taught how to develop scenarios, film video content, process videos using editing software, and publish the final product. Currently, the primary learning resource is limited to PowerPoint slide presentations, while the Elita LMS platform serves as a tool for submitting assignments and quizzes. Although the number of visits to Elita continues to rise, there is an urgent need to optimize the platform by developing inclusive content to better accommodate the learning needs of students with hearing impairments.

Design phase results

Based on the needs analysis, several designs were developed at this stage. First, Semester Learning Plan is developed based on the needs of students with disabilities. a biology video learning course module as teaching material, a storyboard for disability-friendly learning videos in the biology video learning course, and audio elements to support both non-disabled students and deaf students with residual hearing. Additionally, a disability-friendly assessment instrument was designed for the biology video learning course. These designs aim to create a more inclusive learning environment that accommodates diverse student needs.

Develop phase results

At the development stage, the inclusive learning video plan is implemented. The creation of the learning videos begins with compiling content according to the storyboard, followed by editing to integrate video clips of teachers and sign language interpreters, as well as adding narration, audio elements, and visual effects. Before finalizing, the videos are reviewed by sign language instructors to ensure the content and delivery meet the needs of students with hearing impairments. After this review, material and media experts assess the videos to determine the feasibility and quality of the learning media. The final version of the video is shown in Figure 3.



Figure 3. Examples of learning video development results on videography concept

Implementation phase results

The implementation stage begins once the development phase produces learning video content that is considered feasible by experts. During this stage, the RPS, modules, learning videos, and assessment instruments applied in the odd semester of the 2024/2025 academic year, using the Elita LMS. The RPS was uploaded at the first meeting, while the learning

videos were uploaded for each session, aligned with the topics outlined in the learning plan. The optimized interface of the Elita LMS which has been optimized through the development of inclusive video-based learning content is shown in Figure 4. When used in the field, students with hearing impairment were able to participate effectively in learning and gave very positive feedback on the LMS.

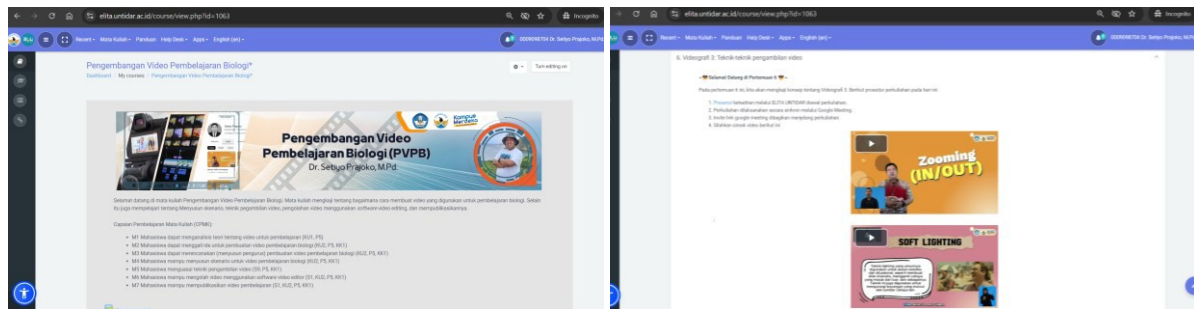


Figure 4. Elita LMS page showing learning video content

Evaluation phase results

The evaluation stage is carried out during the process of developing learning video media to improve the final quality of the learning video. The assessment of the feasibility based on material experts and media experts is shown in Table 2 and Table 3.

Table 2. Results of the eligibility of learning videos based on assessments by material experts

No.	Indicator	Assessment Results (%)			Rata-rata (%)	Criteria
		Ahli 1	Ahli 2	Ahli 3		
1	Relevance of material	91.11	91.11	91.11	91.11	Highly Valid
2	Presentation of material	93.33	93.33	93.33	93.33	Highly Valid
3	Language and Typography Aspects	96.67	96.67	96.67	96.67	Highly Valid
Overall Assessment					93.70	Highly Valid

Table 3. Results of the eligibility of learning videos based on assessments by media experts

No.	Indicator	Assessment Results (%)			Rata-rata (%)	Criteria
		Ahli 1	Ahli 2	Ahli 3		
1	Functions and benefits	100	90	100	96.67	Highly Valid
2	Visual Media	96.67	83.33	93.3	91.10	Highly Valid
3	Audio Media	100	90	90	93.33	Highly Valid
4	Typography	100	86.67	100	95.56	Highly Valid
Overall Assessment					94.16	Highly Valid

Based on Table 2, the results of the validator's assessment of the material aspect obtained a percentage of 93,70% and based on the validation criteria, the score indicates that the product developed is highly valid. According to material experts, the material presented in the learning media is in accordance with the learning outcomes of the course. The breadth and depth of the material have also been adjusted to the learning objectives. The good learning media should facilitate the achievement of learning objectives and be designed for students' needs and environmental conditions (Daryanes et al., 2023; Fatchurahman et al., 2022; Febrina & Setiawan, 2024). In addition, the material presented is also accurate, in accordance with the facts, and consistent with scientific or pedagogical knowledge.

In addition to adapting the material to the student's development level, the material delivered through learning videos is also equipped with examples to clarify the material.

Examples play a crucial role in teaching and learning, particularly facilitate concept acquisition, promote student engagement in various types of reasoning, and help instill new ideas while reinforcing existing knowledge (Bhardwaj et al., 2025). The appropriate use of examples has also been reported to trigger cognitive processes such as association of features with specific cases, recalling similar situations, and preparing heuristics or mental constructs for interpreting larger phenomena.

Based on the results of the validation that has been carried out on the video-based learning media, which is seen from four aspects of the assessment, namely the function and benefits, visual media, audio media, and typography aspects, the results from the media aspect obtained a percentage of 94,16%. Based on the validation criteria, the score indicates that the product developed is highly valid. Media experts noted that the video-based media not only enhances the delivery of educational content for students in general but is particularly beneficial for students with hearing impairments. The media's visual and typographic elements, as well as sign language translators help compensate for auditory deficiencies, offering a clearer and more accessible learning experience. This aligns with the specific needs of hearing-impaired students, who often face challenges with traditional learning methods due to their inability to process auditory information effectively.

Discussion

The development of video-based learning content integrated into the inclusive Learning Management System (LMS) ELITA demonstrates the importance of adapting digital learning environments to accommodate diverse learning needs, particularly for students with hearing impairments. The findings of this study indicate that accessibility barriers experienced by students with hearing impairments are not only caused by limitations in auditory perception but are also influenced by the availability of appropriate instructional resources. Therefore, the development of inclusive learning media is essential to provide equal opportunities for students with disabilities to actively participate in higher education.

The needs analysis revealed that students with hearing impairments in the Biology Education Study Program experienced difficulties in accessing auditory information during conventional learning activities. The student's dependence on residual hearing and lip-reading strategies indicates that traditional learning approaches may not fully accommodate students with hearing impairments. These challenges became more apparent during the COVID-19 pandemic when the use of masks limited students' ability to read lecturers' lip movements. This finding supports previous studies emphasizing that students with hearing impairments require accessible learning environments that provide alternative representations of information beyond auditory communication.

The development of inclusive video-based learning content through the ADDIE model provides a systematic approach to overcoming these challenges. The design of learning videos incorporated visual explanations, sign language interpretation, audio support, and structured learning materials to ensure accessibility for students with different abilities. This approach is consistent with the principles of Universal Design for Learning (UDL), which emphasizes providing multiple means of representation and engagement to support learner diversity.

The feasibility evaluation conducted by material and media experts confirmed that the developed learning videos met high-quality standards. Based on the assessment by material experts, the developed learning content obtained an overall validity score of 93.70%, categorized as highly valid. Specifically, the relevance of the material achieved a score of 91.11%, the presentation of material obtained 93.33%, and language and typography aspects received the highest score of 96.67%. These results indicate that the developed videos

successfully presented accurate, relevant, and appropriately structured biological learning materials.

The high validity score from material experts suggests that the content development process successfully aligned the learning materials with the expected learning outcomes of the Biology Learning Video Development course. The relevance aspect demonstrates that the material was appropriate with the course objectives, while the presentation aspect indicates that the sequence and organization of concepts supported students' understanding. Furthermore, the language and typography assessment showed that the learning videos provided clear and accessible information. Previous studies have emphasized that effective learning media should not only contain accurate content but also consider students' learning characteristics and environmental conditions to facilitate the achievement of learning objectives (Daryanes et al., 2023; Fatchurahman et al., 2022; Febrina & Setiawan, 2024).

The use of examples within the learning videos also contributed to the effectiveness of the developed media. Examples help students connect theoretical concepts with concrete situations, facilitate conceptual understanding, and stimulate cognitive processes such as reasoning and knowledge construction (Bhardwaj et al., 2025). This aspect is particularly important for students with hearing impairments because visual examples provide additional support in interpreting biological concepts that may otherwise be difficult to understand through verbal explanations alone.

In addition to material validity, the media evaluation results also demonstrated a highly valid category. The assessment by media experts obtained an overall score of 94.16%, indicating that the developed learning videos were highly feasible from the media perspective. The assessment results showed that the function and benefits aspect obtained 96.67%, visual media obtained 91.10%, audio media obtained 93.33%, and typography obtained 95.56%. These results demonstrate that the developed media successfully integrated technical quality and accessibility features required for inclusive learning.

The high score in the function and benefits aspect (96.67%) indicates that experts considered the developed videos capable of supporting learning objectives and improving accessibility for students with hearing impairments. Meanwhile, the visual media score (91.10%) confirms that visual components were appropriately designed to support information processing. The inclusion of sign language interpreters, visual illustrations, and clear text representation helped compensate for students' auditory limitations. Furthermore, the audio media score (93.33%) indicates that the developed videos remained beneficial not only for students with hearing impairments who still possess residual hearing but also for students without disabilities.

The typography assessment score of 95.56% highlights the importance of readable text presentation in inclusive learning media. Clear typography, appropriate text size, and organized visual layouts support students in accessing information independently. These findings reinforce previous research stating that multimedia learning becomes more effective when visual and verbal elements are systematically combined to support learners' cognitive processes.

The implementation of the developed media through LMS ELITA further demonstrated its practical value. During field implementation, students with hearing impairments were able to participate effectively in learning activities and provided positive responses toward the inclusive LMS environment. This finding indicates that accessibility-oriented digital learning resources can reduce barriers experienced by students with disabilities and promote more meaningful engagement in academic activities.

Overall, this study demonstrates that video-based learning content integrated into an inclusive LMS can effectively support students with hearing impairments in biology education. The combination of pedagogical quality, accessibility features, and digital

learning integration represents an important contribution to inclusive higher education. The novelty of this study lies in developing biology learning videos that are not only focused on content delivery but are specifically designed to ensure accessibility and active participation of students with hearing impairments. Therefore, this research provides practical implications for universities and educators in developing inclusive digital learning systems that promote equal access and learning opportunities for all students.

CONCLUSION

Fundamental Finding: This study demonstrates that the development of video-based learning content integrated into the inclusive Learning Management System (LMS) ELITA effectively supports students with hearing impairments in accessing Biology Learning Video Development courses. The findings reveal that the developed learning videos achieved a highly valid category based on assessments from both material and media experts. The material expert validation obtained an overall score of 93.70%, while the media expert validation obtained an overall score of 94.16%, indicating that the developed product met high standards in terms of content relevance, material presentation, language, visual design, audio components, typography, and functional aspects. The implementation of the developed learning media also showed that students with hearing impairments were able to participate effectively in learning activities and provided positive responses toward the inclusive LMS environment. These findings indicate that integrating accessible video-based learning content with LMS technology can reduce learning barriers and provide equitable learning opportunities for students with hearing impairments. **Implication:** The findings provide evidence that inclusive digital learning environments can be developed through the integration of accessible multimedia content and Learning Management Systems. Higher education institutions and lecturers should consider students' diverse learning needs when designing instructional media, particularly for students with disabilities who experience barriers in accessing conventional learning resources. The implementation of video-based learning content with accessibility features, such as visual explanations, sign language interpretation, and supportive audio elements, can serve as an effective strategy to promote inclusive and student-centered learning. This study provides practical recommendations for universities in optimizing LMS platforms not only as administrative learning tools but also as accessible learning environments that support equal participation for all students. **Limitation:** This study was conducted within one educational context, namely the Biology Education Study Program at Universitas Tidar, with a limited number of participants involved in the validation and implementation stages. Therefore, the findings may not be directly generalized to other study programs, institutions, or types of disabilities. Furthermore, this study primarily evaluated the validity and feasibility of the developed learning media but did not measure its long-term effectiveness in improving students' academic achievement, learning independence, or engagement over an extended period. **Future Research:** Future studies are recommended to involve larger numbers of participants from various educational institutions and different types of disabilities to examine the broader applicability of inclusive LMS-based learning media. Further research may also investigate the effectiveness of accessible video-based learning content through experimental or longitudinal approaches to measure its impact on learning outcomes, student engagement, and academic independence. In addition, future studies could explore the integration of emerging technologies, such as artificial intelligence, automated captioning, interactive multimedia, and adaptive learning systems, to further enhance accessibility and support the development of inclusive higher education.

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AUTHOR CONTRIBUTIONS

Setiyo Prajokoa: Conceptualization, methodology, investigation, data curation, formal analysis, writing original draft, and visualization. **Shefa Dwijayati Ramadani:** Supervision, validation, writing review and editing, and project administration. **Weni Anggraeni:** Conceptualization, methodology, supervision, validation, writing review and editing, and resources. All authors have read, reviewed, and approved the final version of the manuscript and agree to be accountable for all aspects of the work.

CONFLICT OF INTEREST STATEMENT

The authors declare no conflicts of interest.

STATEMENT ON THE USE OF AI OR DIGITAL TOOLS IN WRITING

AI tools were used only for language editing, grammar improvement, and discussion support. The authors take full responsibility for all aspects of the research and the final content of the manuscript.

REFERENCES

- Açar, D., & Demiralp, C. (2025). Inclusive education for hearing impairment: Teacher perspectives, strategies and the role of educational technologies. *Adiyaman University Journal of Educational Sciences*, 15(1), 412–447. <https://doi.org/10.17984/adyuebd.1594722>
- Adams, M., & Brown, S. (2006). *Towards inclusive learning in higher education: Developing curricula for disabled students*. Routledge. <https://doi.org/10.4324/9780203088623>
- Ajani, O. A., & Ntombela, S. (2025). Advancing inclusive education in higher education: Challenges and opportunities in preparing pre-service teachers to support students with disabilities. *International Journal of Management, Knowledge and Learning*, 14(1). <https://doi.org/10.53615/2232-5697.14.25-41>
- Aljedaani, W., Krasniqi, R., Aljedaani, S., Mkaouer, M. W., Ludi, S., & Al-Raddah, K. (2023). If online learning works for you, what about deaf students? Emerging challenges of online learning for deaf and hearing-impaired students during COVID-19: A literature review. *Universal Access in the Information Society*, 22(3), 1027–1046. <https://doi.org/10.1007/s10209-022-00897-5>
- Bartolo, P. A., Borg, M., Callus, A.-M., De Gaetano, A., Mangiafico, M., Mazzacano D'Amato, E., Sammut, C., Vella Vidal, R., & Vincent, J. (2023). Aspirations and accommodations for students with disability to equitably access higher education: A systematic scoping review. *Frontiers in Education*, 8, 1218120. <https://doi.org/10.3389/feduc.2023.1218120>
- Bhardwaj, V., Zhang, S., Tan, Y. Q., & Pandey, V. (2025). Redefining learning: Student-centered strategies for academic and personal growth. *Frontiers in Education*, 10, 1518602. <https://doi.org/10.3389/feduc.2025.1518602>

- Campbell, S. (2023). *Supporting disabled students in higher education: The reasonable adjustments handbook*. Routledge. <https://doi.org/10.4324/9781003223962>
- Chalmers, K., Irons, A., & Phippen, A. (2026). Reasonable adjustment supporting special educational needs and disabilities: The case for digital skills. In *The digital student* (pp. 143–168). Elsevier. <https://doi.org/10.1016/B978-0-443-34057-4.00006-7>
- Cheng, S., Cheng, H., Su, S., Ming, L., Masud, S., Wang, Q., & Huang, Y. (2024). Motion design principles for accessible video-based learning: Addressing cognitive challenges for deaf and hard of hearing learners. *arXiv*. <https://arxiv.org/abs/2410.00196>
- Chiu, M.-S., Xiong, W., & Kuan, P.-Y. (2021). Graduates' career success predicted by mathematical and affective abilities, effective higher-education learning and economic contexts: A bioecological positivity to success model. *Journal of Education and Work*, 34(3), 313–330. <https://doi.org/10.1080/13639080.2021.1931668>
- Daryanes, F., Darmadi, D., Fikri, K., Sayuti, I., Rusandi, M. A., & Situmorang, D. D. B. (2023). The development of articulate storyline interactive learning media based on case methods to train student's problem-solving ability. *Heliyon*, 9(4). <https://doi.org/10.1016/j.heliyon.2023.e15082>
- Dumitru, C. (2023). Inclusion of students with disabilities in higher education. In *The Palgrave handbook of global social change* (pp. 1–29). Springer. https://doi.org/10.1007/978-3-030-87624-1_400-1
- 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>
- Fatchurahman, M., Adella, H., & Setiawan, M. A. (2022). Development of animation learning media based on local wisdom to improve student learning outcomes in elementary schools. *International Journal of Instruction*, 15(1), 55–72. <https://doi.org/10.29333/iji.2022.1514a>
- Febrina, V., & Setiawan, D. (2024). Analysis of the use of learning media on the learning interest of learning science students and environmental themes. *Jurnal Penelitian Pendidikan IPA*, 10(8), 5702–5709. <https://doi.org/10.29303/jppipa.v10i8.7497>
- Filippou, K., Acquah, E. O., & Bengs, A. (2025). Inclusive policies and practices in higher education: A systematic literature review. *Review of Education*, 13(1), e70034. <https://doi.org/10.1002/rev3.70034>
- Ghannam, A., Nahas, L., Dashash, M., & Alzoubi, H. (2026). Effectiveness of sign language-based cartoon oral health education among hearing-impaired children in Damascus City, Syria: A randomized controlled trial. *International Journal of Paediatric Dentistry*, 36(1), 129–139. <https://doi.org/10.1111/ipd.70035>
- Hatami, M., & Chegini, M. (2024). Enhancing digital content accessibility for the hearing impaired through AI-driven visual representations. In *2024 10th International Conference on Artificial Intelligence and Robotics (QICAR)* (pp. 322–328). <https://doi.org/10.1109/QICAR61538.2024.10496621>
- Horlin, C., Hronska, B., & Nordmann, E. (2024). I can be a "normal" student: The role of lecture capture in supporting disabled and neurodivergent students' participation in higher education. *Higher Education*, 88(6), 2075–2092. <https://doi.org/10.1007/s10734-024-01201-5>
- Jayanthi, K., Priya, M. S., Saranya, S., Gomathi, R., & Sam, D. (2023). E-learning as a desirable form of education in the era of Society 5.0. In *Advances in distance learning in times of pandemic* (pp. 23–51). Chapman and Hall/CRC. <https://doi.org/10.1201/9781003322252-2>

- Kanwal, A., & Bashir, R. (2022). Classroom dynamics in government special education institutions for students with hearing impairment in Punjab-Pakistan. *Journal of Development and Social Sciences*, 3(3), 867–878. [https://doi.org/10.47205/jdss.2022\(3-III\)81](https://doi.org/10.47205/jdss.2022(3-III)81)
- 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>
- Khomyshak, O. (2024). Video-based learning in the digital age: Challenges and opportunities. *Information Technologies and Learning Tools*, 104(6), 14. <https://doi.org/10.33407/itlt.v104i6.5854>
- Kochhar-Bryant, C., Bassett, D. S., & Webb, K. W. (2009). *Transition to postsecondary education for students with disabilities*. Corwin Press.
- Magnano, P., Santisi, G., Zammitti, A., Zarbo, R., & Di Nuovo, S. (2019). Self-perceived employability and meaningful work: The mediating role of courage on quality of life. *Sustainability*, 11(3), 764. <https://doi.org/10.3390/su11030764>
- Masuku, K. P., Khumalo, G., & Moroe, N. (2024). Barriers and facilitators to inclusive education for learners who are deafblind: A scoping review. *Education Sciences*, 14(10), 1072. <https://doi.org/10.3390/educsci14101072>
- McHaney, R. (2023). *The new digital shoreline: How Web 2.0 and millennials are revolutionizing higher education*. Taylor & Francis. <https://doi.org/10.4324/9781003447979>
- Mgendi, J. C., Bali, T., & Sungwa, R. (2024). Enhancing engagement of hearing-impaired pupils in inclusive Tanzanian classrooms through teaching and learning materials. *Ta'dib*, 27(1), 247–264. <https://doi.org/10.31958/jt.v27i1.12553>
- Moustache, H. M. T. E., & Makhoba, M. (2024). Educators' experiences of teaching learners with hearing loss in inclusive classrooms. *South African Journal of Childhood Education*, 14(1), 1358. <https://doi.org/10.4102/SAJCE.v14i1.1358>
- Phasha, N., & Mosia, P. A. (2017). Access to curriculum for students with disabilities at higher education institutions: How does the National University of Lesotho fare? *African Journal of Disability*, 6(1), 1–13. <https://doi.org/10.4102/ajod.v6i0.257>
- Rutledge, F. (2025). Enhancing digital accessibility for deaf or hard of hearing learners: Innovative strategies for inclusive education. *Developmental Disabilities Network Journal*, 5(1), 8. <https://doi.org/10.59620/2694-1104.1122>
- Shaw, A. (2024). Inclusion of disabled higher education students: Why are we not there yet? *International Journal of Inclusive Education*, 28(6), 820–838. <https://doi.org/10.1080/13603116.2021.1968514>
- Stauropoulou, A., Sardianou, E., Malindretos, G., Evangelinos, K., & Nikolaou, I. (2023). The effects of economic, environmentally and socially related SDGs strategies of banking institutions on their customers' behavior. *World Development Sustainability*, 2, 100051. <https://doi.org/10.1016/j.wds.2023.100051>

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