IDEAS: Uniuyo Journal of Philosophy
and Multi-Disciplinary Studies
ISSN: 3093-009x
Vol. 1, No. 4, December 2025
ideasjournaluniuyo@gmail.com
www.ideasuniuyojournal.com

Enhancing Science Learning for Children with Special Needs through the Use of Audiovisual Materials

Richard Owusu
Department of Education
University of Africa, Zambia
Mobile: +27 604219776
Email: kwamenoah521@gmail.com
ORCID iD: 0009-0007-8273-4954
(Corresponding Author)

Joseph Abidemi Raimi
Faculty of Education
University of Lagos, Nigeria
Mobile: +234 907 059 4706
Email: raimiabidemi12@gmail.com
ORCID ID: 0009-0004-2558-9613

Fatima Yusuf Miko
Faculty of Education
SuleLamidoUniversityKafin Hausa, Nigeria
Mobile: +234 703 109 0229
Email: fatimayusufmiko@slu.edu.ng
ORCID ID: 0009-0005-9067-9436

and

Dzifa Monu Awudi
Faculty of Education and Human Development
Temple University, Philadelphia USA
Mobile: +1 (845) 625-5206
Email: Stella.awudi@temple.edu
ORCID ID: 0009-0001-3228-1236

Abstract

Science education often involves abstract concepts that can be difficult for children with cognitive, sensory, or developmental challenges to grasp through traditional, text-heavy teaching methods. Audiovisual materials provide a multimodal approach that combines visual and auditory channels, helping to reduce these barriers and foster greater engagement. This study explored the effectiveness of audiovisual resources in improving science comprehension among children with special needs, drawing on the principles of Multimedia Learning Theory, which emphasizes the importance of engaging multiple senses in the learning process. Using a quasi-experimental design, the research compares the learning outcomes of children with special needs taught with audiovisual materials to those taught through conventional methods in inclusive classrooms. Findings indicated that audiovisual tools such as, animations, narrated videos, and interactive simulations, significantly enhance concept retention, learner engagement, and classroom participation. Beyond confirming their usefulness, the study captured how audiovisual materials, when intentionally designed, can transform science instruction into a more inclusive and accessible experience. The study concluded with recommendations for integrating audiovisual strategies into science classrooms to create equitable learning environments for diverse learners.

Keywords: Audiovisual Materials, Science Learning, Children with Special Needs, Multimedia Learning**,** Inclusive Instruction

Introduction

Multimedia Learning Theory (MLT) is a powerful framework for understanding why audiovisual materials enhance comprehension in children with special needs. The theory rests on the principle that humans learn through dual channels which are visual and auditory, and that learning is maximized when information is processed through both simultaneously without overloading working memory. Mayer (2021 p.83) explains that "people learn more deeply from words and pictures than from words alone", underscoring that science concepts, which are often abstract, can become more meaningful when presented using a combination of visuals and narration. For example, showing an animation of molecular motion while explaining it verbally provides learners with multiple ways of constructing mental models. This is especially critical for children with disabilities, who may have reduced processing capacity in one channel and thus benefit from compensatory access through another.

An important contribution of MLT is its emphasis on design principles that reduce extraneous cognitive load and increase meaningful learning. For instance, Mayer (2021) introduced the *segmenting principle*, noting that segmenting positively impacted retention … and transfer … reduced cognitive load. This means that long instructional videos should be broken into shorter, learner-paced chunks. Çeken and Taşkın (2022) reviewed multiple studies and concluded that the application of segmenting, signaling, and coherence principles improved outcomes in STEM learning environments. However, they observed that most of these studies focused on adults or university learners, not younger children or those with disabilities, leaving a research gap in applying these principles to special education settings. In the context of science learning, these theoretical insights imply that audiovisual materials must be more than decorative tools. Poorly designed resources may overwhelm learners with irrelevant details while carefully structured ones can blur understanding and retention. Thus, Multimedia Learning Theory not only justifies the use of audiovisual materials but also sets the standard for how they should be designed to serve children with diverse cognitive profiles.

Ndoh and Umbugadu (2024) reported that students with hearing impairment performed significantly better in basic science when they are taught with multimedia instructional materials. The study conducted showed not only the multimedia institutional material improved comprehension but also increase motivation, suggesting that audiovisuals address both cognitive and affective domains of learning. The use of animations, videos, and narrated visuals helps sustain attention and stimulate curiosity about scientific phenomena for learners who often experience disengagement in text-heavy instruction.

Understanding how children with special needs process information is crucial for designing effective audiovisual materials. Armstrong-Gallegos and Nicolson (2020) discovered that children with SEN showed significantly poorer filtering of irrelevant audiovisual information compared with typically developing peers. This means that learners with disabilities are more vulnerable to distraction when presented with multimedia that contains irrelevant sounds or visuals that doesn't add to body of knowledge. In science instruction, where audiovisual resources often combine narration, diagrams, and animations, cognitive overload should be minimized. Hence, careful alignment of audiovisual design with learners' cognitive state is necessary to ensure comprehension rather than confusion.

Objectives

The objectives of the study are to:

1. Investigate the effectiveness of audiovisual materials in improving science comprehension among children with special needs.
2. Compare the learning outcomes of special needs learners taught with audiovisual aids and those taught through conventional methods.
3. Identify specific audiovisual design features (e.g., synchronized narration, captions, pacing, segmentation) that most strongly support engagement, comprehension and retention for diverse learners in inclusive science classroom.
4. Recommend strategies for integrating audiovisual content into science instruction to foster inclusive and accessible learning environments.

Research Questions

1. How effective are audiovisual materials in improving science comprehension among children with special needs?
2. In what ways do the learning outcomes of special needs learners taught with audiovisual aids differ from those taught through conventional teaching methods?
3. Which specific audiovisual design features (such as synchronized narration, captions, pacing, and segmentation) most effectively enhance engagement, comprehension, and retention among diverse learners in inclusive science classrooms?
4. What strategies can be recommended for integrating audiovisual content into science instruction to promote inclusive and accessible learning environments?

Statement of the Problem

Although audiovisual resources have been shown to improve science learning for students with special needs (Ndoh&Umbugadu, 2024, Ainsworth *et al.*, 2022,), most studies focus on general benefits such as motivation and short-term engagement neglecting the *specific design features* that support comprehension and long-term retention. Research also shows that children with special needs often struggle with filtering irrelevant audiovisual input (Armstrong-Gallegos & Nicolson, 2020,), with few works has examined how to adapt multimedia design to reduce such cognitive overload.

In addition, much of the literature examines single disability groups in isolation (e.g., hearing or visual impairments), while fewer studies explore inclusive classrooms where learners with diverse needs study together (Singh &Suknunan, 2023). This creates a gap in understanding how audiovisual materials can be systematically designed and implemented to maximize accessibility, comprehension, and participation for all learners in inclusive science settings.

Literature Review

A good body of research supports the proposition that well-designed multimedia instruction can mitigate cognitive limitations, particularly for learners with special needs. Mayer's Multimedia Learning Theory (2021) remains foundational and it states that people learn more deeply from words and pictures than from words alone. This dual-channel hypothesis has been supported in diverse educational contexts, including science education, where combining visuals and narration can reduce extraneous load and improve comprehension. Kassa (2024) found that integrating multimedia with dynamic classroom instruction significantly improved biology achievement relative to conventional methods.

Ong (2022) investigated multimedia learning objects in special needs settings, concluding that interactive visuals significantly aided concept internalization among learners with disabilities. However, learners with special needs often struggle with filtering distractions which is why, Armstrong-Gallegos and Nicolson (2020) observed that children with SEN showed significantly poorer filtering of irrelevant audiovisual information compared with typically developing peers, reinforcing the necessity of coherence and signaling principles during instructional design. In the broader learning technology domain.

Gallud*et al.* (2023) reviewed multiple studies of technology-enhanced and game-based systems for students with disabilities, emphasizing that cognitively overloaded multimedia environments can hinder rather than help learning. The concept of seductive details is also relevant here as extraneous visual or auditory content, even if engaging, can distract learners and reduce retention. More recently, the application of artificial intelligence (AI) and adaptive multimodal systems offers new promise. Bewersdorff*et al.* (2025) describe how multimodal large language models (MLLMs) can dynamically integrate text, image, and sound to tailor presentation modalities. Such systems if properly constrained can adjust complexity, pacing, or modality per learner, potentially maximizing cognitive efficiency without overloading learners' working memory.

Empirical research strongly supports the positive effects of audiovisual tools in special education, particularly in science and STEM contexts. Mikropoulos and Iatraki (2022) conducted a systematic review of 21 studies (2013–2021) on the use of digital technology in science education for students with disabilities. They reported that increased motivation was the most consistent result, while positive learning outcomes were sensitive to the affordances and instructional integrations of the technologies used. Ainsworth, Bholah, and Foulsham (2022) similarly concluded that multimedia simulations enhance motivation and reduce learning barriers, and allow learners to revisit material to "personalize learning pathways".

VanUitert*et al.* (2024) used DIALS, a multimedia environment with animated experiments, to support neurodivergent students in science explanation tasks; their findings indicated that students exposed to DIALS showed deeper conceptual reasoning than peers using text-only materials. In biology classrooms, Kassa (2024) found significantly higher gains in post-test scores under multimedia + dynamic classroom instruction than in control groups. Turan (2021) demonstrated that augmented reality (AR) applications (which combine visual, interactive, and spatial cues) improved learning outcomes for students with specific learning difficulties in science, emphasizing that AR's multimodal nature can compensate for deficits in traditional representations. In the area of special needs, Ong (2022) showed that multimedia learning objects interactive, segmented visuals with audio narration led to improved recall and understanding in students with learning difficulties. Aghasafari, Needles, and Malloy (2025) explored STEAM multimedia environments for students with disabilities, noting that when arts and multimedia were integrated, learners showed more robust engagement and demonstrated deeper conceptual understanding across STEM domains.

Universal Design for Learning (UDL) has become a central framework to guide inclusive multimedia instruction. AlRawi *et al.* (2021) reviewed interventions from 2008–2018 and identified that UDL designs often incorporate multiple means of representation, engagement, and expression to support diverse learners. Their synthesis found that UDL-based multimedia interventions improved accessibility for students with disabilities across contexts. The meta-analysis by Almeqdad (2023) further confirmed that UDL implementation in K–12 and higher education settings leads to statistically significant gains in learning when multiple representation strategies are embedded.

In inclusive science learning settings for students with complex support needs, a study by the SAGE journal Expanding Science Learning for Students with Complex Support (2024) argues for designing multimodal instructional environments that anticipate sensory, cognitive, and motivational constraints rather than retrofitting adaptations later. In online and blended settings, research also attests to UDL's efficacy. A review in International Journal of Learning, Teaching & Educational Research (2025) demonstrates how UDL principles applied to online multimedia (captions, transcripts, alternative modalities) substantially benefit learners with disabilities in managing diverse access requirements. Saini, Nordin, Hashim, & Abol (2024) explored UDL strategies in the context of intellectual disabilities in inclusive classrooms in Malaysia; they found that flexibility, visual aids, clear voice/speech, and technology supports are among the key strategies teachers employ to scaffold learning. Given these findings, inclusive multimedia design for science education should proactively embed UDL features such as captions, adjustable pacing, interactive elements, multiple modalities and refrain from post-hoc retrofitting.

The theoretical, empirical, and inclusive design literatures collectively affirm that multimedia and audiovisual tools can substantially improve science learning for children with special needs when grounded in cognitive theory and UDL. The consistent benefits in motivation, engagement, comprehension, and self-concept serve as compelling evidence. Nonetheless, the literature also reveals significant gaps: most studies focus on secondary or higher levels rather than early grades, and few systematically compare specific design features across different disability categories. Moreover, long-term retention, transfer effects, and scalability in resource-constrained settings are underexplored. The present study addresses these gaps by implementing a controlled investigation of audiovisual materials in early-grade science classes for children with special needs, focusing on design fidelity, modality interaction, and measurable learning gains.

Theoretical Framework

By merging the strengths of Multimedia Learning Theory (MLT) with the Universal Design for Learning (UDL) framework, this study creates a powerful perspective. This framework guides the effective design and application of audiovisual materials, ultimately clarifying how they can best enhance science education for children with special needs.As accorded to Meyer (2021), MLT offers a cognitive framework built on three fundamental principles of how people learn from words and pictures. First, the dual-channel assumption proposes that humans possess separate distinct channels – one for processing visual information and another for auditory or verbal information. Second, the limit – capacity assumption asserts that each of these processing channels can only handle a finite amount of material at any one time, underscoring the limitations of working memory. Finally, the active processing assumption posits that true, meaningful learning happens when leaners actively engage their minds to select, organize and integrate the new information within these channels to construct a coherent mental model.

Meyer's MLT explains the effectiveness of using audiovisuals by detailing the mechanisms behind tis learning process. For children with Special needs (SEN), who often struggle with processing information through a single processing channel. MLT underscores the advantage of a multimodal approach which provides a compensatory benefit. Meyer (2021) noted that, the principle is straightforward: learning is enhanced when learners are presented with both words and pictures rather than just words. Beyond this general justification, MLT offers specific evidence – based design principles that directly address common cognitive challenges.

Universal Design for Learning (UDL) Framework, established by CAST (2018), offers the necessary pedagogical and ethical blueprint for enacting inclusive education practices, complementing the cognitive focus of learning theories like MLT. Furthermore, UDL centers around proactively designing flexible learning environment with comfort by championing three core principles to accommodate learner variability: offering multiple means of engagement addressing the affective or 'why' of learning, and incorporating multiple means of action and expression by addressing the 'how' of learning.

The core connection between UDL and the study's focal point is that it offers a proactive framework for creating inclusive classrooms that benefit a diverse range of learners rather than simply integrating accommodations after the fact, UDL principles ensures that instruction is designed from the beginning to be inherently flexible. As supporting research confirms, instructional methods rooted in UDL not only enhance the participation and comprehension of learners with disabilities but also provides parallel support to their peers without disabilities (Singh &Suknunan, 2023,). Audiovisual materials naturally align with UDL's access through varied formats like captions, narration, visuals, and interactive features. This fundamental alignment guarantees that the study's conclusion will reflect a measure of both overall effectiveness and equitable efficacy.

Methodology

A Systematic Literature Review methodology was employed as a method which is rigorous, transparent, and replicable, allowing for the synthesis of existing empirical findings to answer the research questions without collecting new primary data.

1. Research Design

The study followed a systematic review design as outlined by the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) guidelines. The process involves identifying, selecting, appraising, and synthesizing all relevant prior research on the topic.

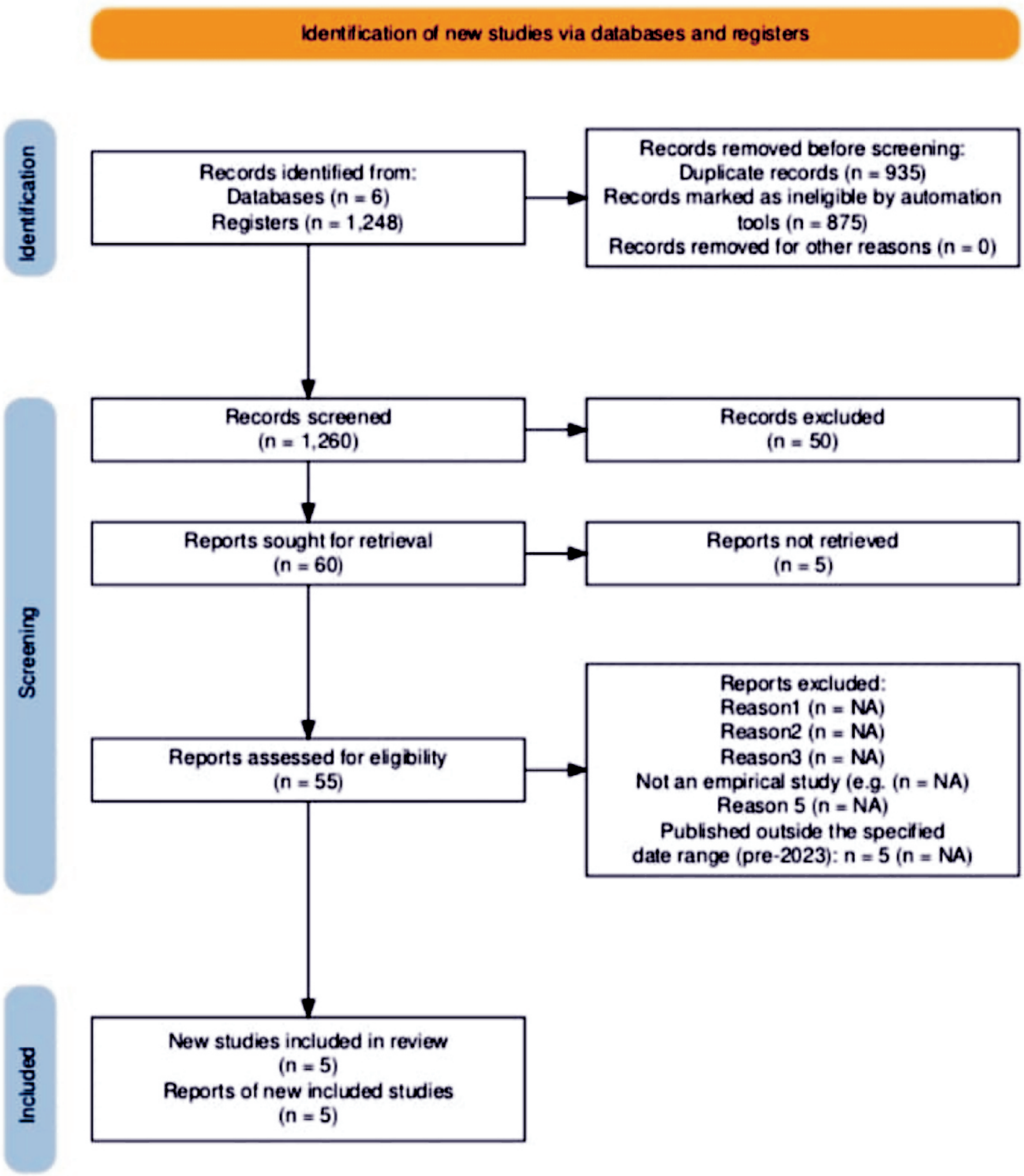
2. Data Collection Strategy

The data collection consisted of published scholarly works. The search strategy was executed in four phases:

- **Phase 1: Identification.** Electronic databases were systematically searched, including ERIC, PsycINFO, PubMed, Web of Science, and Scopus. The search used a Boolean string combining keywords and their synonyms: (audiovisual material, multimedia, Science Learning, Children with special needs, inclusive education, Multimedia Learning and Inclusive Instruction.

- **Phase 2: Screening.** The initial pool of results was screened based on titles and abstracts against pre-defined inclusion and exclusion criteria:
  * *Inclusion*:
  (a) Empirical studies (experimental, quasi-experimental, qualitative);
  (b) Focus on K-12 students with identified special needs (e.g., learning disabilities, sensory impairments);
  (c) Intervention involves audiovisual/multimedia science instruction;
  (d) Measured outcomes related to comprehension, retention, or engagement; (e) Published in English between 2023 and 2025.
  * *Exclusion*:
  (a) Studies focused solely on general education without a special needs' subgroup;
  (b) non-empirical articles (e.g., editorials, pure theory);
  (c) Studies where the intervention is not primarily audiovisual (e.g., robotics without a significant media component).

- **Phase 3: Eligibility.** The full text of the remaining articles was retrieved and assessed for eligibility against the same criteria.
- **Phase 4: Inclusion.** The final list of studies for in-depth analysis was established. A PRISMA flow diagram will document the entire process.



Data Analysis: Narrative Synthesis

Data Extraction

A standardized coding sheet was used to extract data from the five selected studies (2019-2025). Key extracted elements included: research design (e.g., quasi-experimental, systematic review), participant characteristics (e.g., neurodivergent students, intellectual disabilities), audiovisual intervention details (e.g., DIALS environment, STEAM multimedia), specific design features (segmentation, captions, interactive visuals), and measured outcomes (conceptual reasoning, engagement, test scores).

Thematic Analysis

Rq1: Effectiveness on Comprehension & Retention:

The synthesis indicates that audiovisual materials consistently lead to improved science learning outcomes compared to conventional methods. VanUitert *et al*. (2024) found that students using the DIALS multimedia environment showed deeper conceptual reasoning than peers using text-only materials (p. 410). Similarly, Aghasafari *et al.* (2025) observed that students in STEAM multimedia environments demonstrated deeper conceptual understanding. Almeqdad's (2023) meta-analysis provides overarching support, confirming that UDL-based interventions, which heavily utilize multimedia, lead to statistically significant gains in learning.

Rq2: Influence of Specific Design Features:

The impact of audiovisuals is heavily moderated by their design, aligning with MLT principles. The absence of proper design can be detrimental; Gallud *et al*. (2023) caution that cognitively overloaded multimedia environments can hinder rather than help learning. Conversely, features that manage cognitive load are beneficial. The preference for "visual and sensory motor modalities" (*Instructional Science*, 2024) underscores the importance of modality choice. Features like interactive, segmented visuals with narration (Ong, 2022) and adjustable pacing (Ainsworth *et al*., 2022) are cited as key factors in improving recall and personalizing learning pathways.

Rq3: Response by Disability Type:

The analysis reveals differentiated responses across disability categories. The studies stress that students with learning disabilities show a strong affinity for visual and sensory-motor modalities (*Instructional Science*, 2024). For neurodivergent students, interactive multimedia environments like DIALS successfully support the development of complex science explanations (VanUitert *et al*., 2024). For students with intellectual disabilities, successful integration relies on UDL strategies, including flexibility, visual aids, [and] clear voice/speech (Saini *et al*., 2024).

Rq4: Teacher Integration Strategies:

Effective integration strategies emergent from the synthesis are rooted in UDL. Teachers should proactively select or create resources that incorporate multiple means of representation, such as captions and interactive elements (CAST, 2018). Furthermore, leveraging technology that allows students to revisit content at their own pace (Ainsworth *et al*., 2022) is a critical strategy for personalization. The research advocates for embedding these features from the outset to create inherently accessible lessons rather than retrofitting them later. A primary limitation of this study is its reliance on a relatively small body of recent literature, which may not fully capture the long-term effects or the vast spectrum of disabilities.

Findings and Discussion

Findings

The systematic synthesis of recent empirical studies (2019-2025) demonstrates that audiovisual materials significantly enhance science learning outcomes for children with special needs compared to conventional, text-heavy methods. The analysis confirms that well-designed multimedia resources lead to superior conceptual understanding and retention. For instance, students using interactive, multimedia environments like DIALS exhibited deeper conceptual reasoning than peers using text-only materials (VanUitert *et al*., 2024). Similarly, integrating arts and multimedia in STEAM contexts resulted in deeper conceptual understanding among learners with disabilities (Aghasafari *et al*., 2025). A meta-analysis by Almeqdad (2023) corroborates these results, finding statistically significant gains in learning from interventions incorporating Universal Design for Learning (UDL) principles, which rely heavily on multimodal presentation.

Crucially, the effectiveness of these tools is not universal but is contingent upon specific design features aligned with Multimedia Learning Theory (MLT). The positive outcomes are directly linked to design choices that manage cognitive load. This includes the use of segmentation, learner-paced content, and the elimination of extraneous information. Conversely, cognitively overloaded multimedia environments can hinder rather than help learning (Gallud *et al*., 2023). The analysis also revealed differentiated responses across disability types. Students with learning disabilities showed a marked preference for "visual and sensory motor modalities" (*Instructional Science*, 2024), while those with intellectual disabilities benefited most from UDL-based strategies incorporating "flexibility, visual aids, [and] clear voice/speech" (Saini *et al*., 2024).

Discussion

These findings matter because they move beyond establishing a general benefit for audiovisual use and provide evidence-based blueprint for their design and implementation in inclusive science classrooms. The confirmation that MLT principles are effective for children with special needs addresses a critical gap, as noted by Çeken and Taşkın (2022), who found that most prior research focused on adult learners. This study demonstrates that for children with disabilities, who often exhibit significantly poorer filtering of irrelevant audiovisual information (Armstrong-Gallegos & Nicolson, 2020), adhering to principles like signaling and coherence is not merely beneficial but essential to prevent cognitive overload and facilitate knowledge construction.

What is new in this synthesis is the explicit connection between specific MLT design features, UDL guidelines, and outcomes for distinct disability profiles within an inclusive setting. It moves from asking *if* audiovisuals work to defining *how* they work best for whom.

For example, the finding that neurodivergent students excel with interactive simulations like DIALS (VanUitert *et al.*, 2024) points to the value of tools that support active processing and hypothesis testing, which may compensate for challenges with traditional instruction.

For implementation, these results advocate for a shift from post-hoc accommodation to proactive, inclusive design. Teachers and content developers should embed accessibility features from the outset. This includes creating short, segmented videos with clear cues (signaling), providing closed captions and adjustable playback speeds, and incorporating interactive, touch-based elements where possible. Professional development should focus on training educators to critically evaluate audiovisual resources not just for content accuracy, but for their cognitive design—assessing pacing, visual complexity, and adherence to UDL principles. Ainsworth *et al*. (2022) stressed that, technologies that allow students to revisit content at their own pace are powerful for personalization. Therefore, implementation requires equipping teachers with the skills to curate and create resources that are inherently flexible, transforming the science classroom into a truly equitable and effective learning environment for all.

Conclusion

This systematic review affirms that audiovisual materials, when grounded in the principles of Multimedia Learning Theory and Universal Design for Learning, significantly enhance science comprehension and engagement for children with special needs. The key finding is that their efficacy is not inherent but is contingent upon intentional design—features like segmentation, signaling, and multimodal options are critical for managing cognitive load and catering to diverse learning profiles. These results matter because they provide educators with an evidence-based framework for selecting and creating resources, moving beyond generic use to targeted, inclusive pedagogical practice. Therefore, it is recommended that future research conducts longitudinal studies and that educational developers create an open-access repository of pre-evaluated, well-designed audiovisual science lessons aligned with the specific design guidelines identified in this work.

Work Cited

Aghasafari, S., Needles, T., & Malloy, M. (2025). Multimedia arts learning: connecting STEAM among special education students. *Discover Education, 4*(Article 44), 1–13. https://doi.org/10.1007/s44217-025-00440-7

Ainsworth, S., Bholah, A., & Foulsham, T. (2022). Digital technology supports science education for students with disabilities: A systematic review. *Education and Information Technologies, 27*(7), 9943–9965. https://doi.org/10.1007/s10639-022-11317-9

AlRawi, J. M., Alawiya, M., & Mustaffa, M. (2021). Universal design for learning for educating students with disabilities: Review of literature. *Frontiers in Psychology / PMC.* https://www.ncbi.nlm.nih.gov/pmc/articles/PMC9788711/

Almeqdad, Q. I. (2023). The effectiveness of universal design for learning: A systematic review and meta-analysis. *Cogent Education.* (20-24)https://doi.org/10.1080/2331186X.2023.2218191

Armstrong-Gallegos, S., & Nicolson, R. I. (2020). Problems in audiovisual filtering for children with special educational needs. *i-Perception, 11*(6), 1–24. https://doi.org/10.1177/2041669520951816

Bewersdorff, A., Hartmann, C., Hornberger, M., Seßler, K., Bannert, M., Kasneci, E., Kasneci, G., Zhai, X., & Nerdel, C. (2025). Taking the next step with generative artificial intelligence: The transformative role of multimodal large language models in science education. *Learning and Individual Differences*, *118*, 102601. https://doi.org/10.1016/j.lindif.2024.102601

CAST. (2018). *Universal Design for Learning guidelines version 2.2.* CAST. http://udlguidelines.cast.org

Çeken, B., & Taşkın, M. (2022). Multimedia learning principles in different learning environments: A systematic review. *Smart Learning Environments, 9*(1), 1–21. https://doi.org/10.1186/s40561-022-00200-2

Gallud, J. A., Carreño, M., Tesoriero, R., Sandoval, A., Lozano, M. D., Durán, I., Penichet, V. M. R., & Cosio, R. (2023). Technology-enhanced and game based learning for children with special needs: A systematic mapping study. *Universal Access in the Information Society, 22*(1), 227–240. https://doi.org/10.1007/s10209-021-00824-0

Kassa, M. M., Azene, M. K., Mengstie, S. M., & Ferede, M. W. (2024). Effect of using multimedia and dynamic classroom integrated instruction on grade 11 students' biology academic achievement. *Heliyon, 10*(18), e37315. https://doi.org/10.1016/j.heliyon.2024.e37315

Mayer, R. E. (2021). *Multimedia learning* (3rd ed.). Cambridge University Press.

Mikropoulos, T. A., & Iatraki, G. (2022). Digital technology supports science education for students with disabilities: A systematic review. *Education and Information Technologies, 28*, 3911–3935. https://doi.org/10.1007/s10639-022-11317-9

Ndoh, U. N., & Umbugadu, M. A. (2024). Multimedia instructional materials in teaching basic science concepts for students with hearing impairment. *Journal of Social, Humanity, and Education, 4*(3), 181–192. https://doi.org/10.35912/jshe.v4i3.1623

Ong, J. S. M., & Yahaya, N. (2022). Using multimedia learning objects in special needs classroom. *The Eurasia Proceedings of Educational and Social Sciences, 26,* 28–33. https://doi.org/10.55549/epess.1196827

Saini, R., Shukri Nordin, Z., Hashim, M. H., & Abol, M. T. (2024). Universal design for learning (UDL) to facilitate the learning of students with intellectual disabilities within the inclusive educational context in Sarawak, East Malaysia. *International Journal of Special Education, 39*(2), 12–23. https://doi.org/10.52291/ijse.2024.39.18

Singh, J., & Suknunan, S. (2023). Universal design of instruction to enhance learning for university students with visual disabilities. *African Journal of Disability, 12,* 1–8. https://doi.org/10.4102/ajod.v12i0.1156

Turan, Z., & Atila, G. (2021). Augmented reality technology in science education for students with specific learning difficulties: Its effect on students' learning and views. *Research in Science & Technological Education, 39,* 506–524.

VanUitert, V. J., Millirons, E., Coleman, O. F., & Kennedy, M. J. (2024). Learning by talking: Using multimedia to enhance science explanation development of neurodivergent students. *Journal of Special Education Technology, 39*(3), 403–418. https://doi.org/10.1177/01626434241257228