Implementation of Universal Design for Learning (UDL) in Digital Learning Media: A Systematic Review and Its Implication for Non-Formal Education

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Abstract: This study explores the implementation of Universal Design for Learning (UDL) in digital learning media within the context of non-formal education to enhance accessibility, student engagement, and expression. Using a systematic literature review method, this research analyzes 17 articles from reputable journals to examine how various digital media formats such as text, audio, video, interactive graphics, and augmented reality (AR) can be effectively integrated to support UDL-based learning. The findings indicate that UDL-based digital learning media can address the diverse needs of learners through flexible content representation, active engagement strategies, and personalized learning pathways. However, challenges such as limited educator training, technological constraints, and infrastructure barriers remain significant obstacles to effective implementation. This study contributes to the field by synthesizing prior research to develop a comprehensive framework for optimizing UDL application in digital learning environments, particularly in non-formal education. The findings highlight the crucial role of collaboration among educators, technology developers, and policymakers in ensuring the scalability and sustainability of UDL-based digital learning initiatives. Furthermore, recommendations are provided to enhance educator training programs, infrastructure development, and data-driven approaches to support inclusive and adaptive digital education.
Keywords: universal design for learning, digital learning media, non-formal education, accessibility, adaptive learning

INTRODUCTION

Technology has become an integral part of education in the growing digital age. This transformation provides a great opportunity to create more inclusive learning, especially for students with diverse learning needs (Rao, 2015). One relevant approach in supporting inclusivity is Universal Design for Learning (UDL), a framework designed to create flexible learning environments to accommodate individual differences in learning. UDL is rooted in the concept of "universal design" which was initially applied in architecture in the mid-1980s and later adapted to education to create more inclusive teaching, learning and assessment

(Rao, 2015). The framework aims to create flexible learning experiences by providing multiple ways to represent information, engage students and express their understanding (Rose, 2014). Digital learning media play an important role in supporting the implementation of UDL. Digital learning media includes a variety of software, applications, and digital platforms designed to deliver learning materials flexibly, interactively, and adaptively according to student needs (Menrisal, 2022; Kodrle & Savchenko, 2021). These technologies allow students to learn anytime and anywhere and provide flexibility in the delivery of materials that can be tailored to individual needs . The use of digital media such as video, graphics and text can also increase accessibility and student engagement, supporting UDL principles that aim to create inclusive learning (Yuwono et al., 2024; Prasanti & Indriani, 2017).

Based on previous SLR studies, the implementation of Universal Design for Learning (UDL) in digital learning has been primarily examined in the context of higher education and online learning programs. Research by (Yang et al., 2024) and (Altowairiki, 2023) highlights the role of leadership and communities of practice in adopting UDL in online learning environments. However, these studies have limitations in exploring UDL implementation in non-formal education, which faces unique challenges such as limited technological access and insufficient training for non-formal educators. To address this gap, this study examines how UDL can be effectively applied in non-formal education settings, offering a more inclusive framework to support community-based learning.

The implementation of Universal Design for Learning (UDL) in non-formal education is a crucial approach in creating inclusive and flexible learning experiences for learners from diverse backgrounds. UDL in non-formal education emphasizes the design of accessible learning experiences by considering individual needs and minimizing learning barriers (Ficarra & Chapin, 2016). Technology plays a vital role in supporting UDL principles by providing various alternatives for content representation, learner engagement, and learning expression. However, research highlights gaps in the use of technology to enhance Engagement and Action & Expression, particularly in the context of non-formal education (Bray et al., 2024). Therefore, further exploration of UDL implementation in non-formal education is necessary to ensure its effectiveness in fostering a more inclusive and adaptive learning environment.

Furthermore, previous SLR studies have primarily focused on the Representation principle of UDL, particularly through the use of multimedia such as text, audio, and interactive videos (Bray et al., 2024). However, there is still a gap in research on how technology can support Engagement and Action & Expression, which are crucial for increasing student motivation and active participation. Additionally, while (Dalton, 2017) and (Brown, 2016) emphasize the potential of UDL in digital literacy and media learning, there is limited research on how digital media can be specifically designed to enhance digital literacy within the UDL framework. Moreover, studies such as those by (Saborío-Taylor & Rojas-Ramírez, 2024) discuss the potential of AI in inclusive education, yet the role of AI in optimizing UDL-based digital learning remains underexplored. Therefore, this study contributes by analyzing how AI can enhance personalized learning, provide automated feedback, and adapt learning materials based on individual student needs. By addressing these gaps, this research expands on previous SLR findings by exploring the role of technology in creating a more inclusive, adaptive, and UDL-aligned learning experience.

This research offers a novel contribution by examining the implementation of Universal Design for Learning (UDL) in digital learning media within the context of non-formal education. By integrating insights from previous studies, this study aims to develop a comprehensive framework that can guide the effective application of UDL principles to enhance accessibility and student engagement. The focus of this research is to explore how digital learning media can be optimized to support inclusive learning environments and to

identify the key challenges and potential solutions in its implementation. Based on this, the research questions posed in this study are as follows:

RQ1. How can UDL principles be effectively implemented in digital learning media for non-formal education to enhance accessibility and student engagement?

RQ2. What are the challenges and solutions in integrating various digital media formats to support learning in non-formal education?

This research is organized in five sections. The first section is the introduction which contains the background of the research, the definition of variables, and the urgency of this research. The second section provides a brief overview of UDL and digital learning media. The third section explains the methodology used in the study. The fourth section presents the results and findings of the study. The fifth section is an analysis directed at answering the research questions. Finally, there is a conclusion that also contains the limitations of this study.

LITERATUR REVIEW

Universal Design for Learning (UDL) is a framework designed to create learning environments that are inclusive and responsive to diverse learning needs (Izzo, 2015). The concept rests on three main principles: flexible presentation of information, increased student engagement, and multiple ways to express understanding. In the context of digital learning media, UDL provides a great opportunity to support more adaptive learning through technology that is accessible to all learners (Rao, 2021).

Digital technology plays a central role in supporting the implementation of UDL. Research shows that augmented reality (AR) applications, such as AR-books, can enhance students' learning experience with interactive content that combines visuals and multimedia, especially for students with special needs such as the deaf (Luangrungruang, 2018). In addition, the use of applications such as UDL Book-Builder allows teachers to create digital texts that support the reading process of students with diverse needs (Sánchez-Torrejón, 2024). In higher education, UDL has been applied to improve accessibility and learning success, especially in science, technology, engineering and math (STEM) fields. Strategies such as recorded lectures and deadline flexibility have proven to be very helpful, especially for students with disabilities (Varadhan, 2023). Digital technologies also improve academic performance while promoting student independence through access to multimedia resources and blended learning (Bucheli, 2024).

The growing popularity of online learning also presents its own challenges. The use of digital tools to present information multimodally, provide skill-oriented feedback, and provide organized resources has been shown to reduce learning barriers (Rao, 2022). Other research highlights the importance of social media in increasing accessibility and student engagement, provided it is designed according to UDL principles (Vie, 2018). While UDL offers many opportunities, challenges in its implementation remain. Some students with special needs report suboptimal experiences due to limited accessibility features in some digital learning media (Varadhan, 2023). In addition, professional development for educators is necessary to ensure effective UDL applications (Bucheli, 2024). Further research is also needed to explore the integration of new technologies such as virtual reality and game-based digital learning (Cunningham, 2018; (Romero-Esquinas, 2024).

In UDL implementation, collaboration between various stakeholders, including educators, technology developers, and policy makers, is a key element. Systematic research shows that digital technology can improve inclusivity and student learning outcomes if designed based on UDL principles (Bray, 2024; Choi, 2024) For example, training prospective teachers through UDL-based online modules has been shown to improve their skills in designing inclusive lesson plans (Lee, 2021). Overall, the application of UDL in digital learning media shows a significant positive impact on inclusivity and student learning

success. However, this success requires effective technology integration, educator training, and user-centered learning design. By continuing to develop UDL research and practice, education can become more responsive to diverse learning needs, supporting the achievement of the goal of quality education for all (SDG4) (Salgarayeva, 2024; Zamora-Musa, 2017).

METHOD

This research uses systematic literature review as the main method, as systematic literature review is a reliable, reproducible and scientific method to build a strong knowledge base (Lim et al., 2022; Tranfield et al., 2003). This method was chosen because it can provide a comprehensive and objective overview of the application of Universal Design for Learning (UDL) in digital learning media, as well as to explore various existing research results related to this topic. According to (Cooper, 1982), Systematic Literature Review (SLR) is an approach used to systematically identify, evaluate, and interpret all relevant studies on a particular topic through five main stages: problem formulation, data collection, data evaluation, analysis and interpretation, and presentation of results. The data collection process follows the methodology outlined by (Fauzi, 2023), which comprises four key stages: determining the time frame, selecting the database, choosing relevant articles, and classifying the selected articles.

1. Time Frame

   To ensure the relevance of the literature review, this study focuses on articles published between 2010 and 2024. This time frame is chosen to capture the most recent developments in the application of UDL within digital learning media while also addressing emerging challenges and solutions in this field.

2. Database Selection

   The database selection process is essential to ensure that the articles used in this study come from credible and easily accessible sources. For this reason, relevant publications were identified through the Scopus database using the Publish or Perish software. The Scopus database was chosen because it is one of the largest and most reliable sources in academia, with more than 256 research fields covered and nearly 22,000 journal titles available (Sdrolia & Zarotiadis, 2019). In addition, Scopus is known for its wide reach and provides access to peer-reviewed articles, which ensures the quality and accuracy of the information obtained. In the selection of this database, only highly credible and reliable sources will be used to ensure the validity of the research results.

3. Article Selection

   After database selection, the next step was the selection of articles relevant to the research topic. The articles were selected using keywords with an asterisk (*) at the end of each word to ensure a wide coverage of lexical variation in the articles found. The keyword search process was carefully conducted to cover a wide range of terms related to the application of UDL in digital learning media. The main keywords used focus on the concepts of Universal Design for Learning, digital learning media, educational technology, and accessibility in learning. The selection of keywords was done carefully to cover a wide variety of terms used in the existing literature. Some of the main keywords used were: "Universal Design for Learning" AND 'digital learning media', 'educational technology' AND 'learning accessibility', as well as other variations relevant to the topic. Table 1 shows examples of keywords used in the search for relevant articles.

4. Article Classification

   Once relevant articles were collected, they were imported into the Covidence application to undergo a screening process according to the PRISMA (Preferred Reporting Items for Systematic Reviews and Meta-Analyses) protocol. PRISMA is a reporting guideline for systematic literature reviews and meta-analyses, which includes

the steps of identifying, selecting, scoring and synthesizing existing articles (Yusoff et al., 2023). This protocol was important to ensure that the articles included in this literature review met strict criteria and were relevant to the research objectives. This protocol is important to ensure that the articles included in this literature review meet strict criteria and are relevant to the research objectives. At this stage, duplicate articles were removed and filtered based on predefined eligibility criteria. The eligibility criteria used in this study are as follows:

- Articles must come from peer-reviewed and fully accessible journals; therefore, books, chapters in books, reports, theses, and dissertations are excluded.
- The topic of the article should focus on the application of UDL in the context of digital learning and technology-based learning media.
- Articles should be in English to be understood by international readers and facilitate further analysis.
- The classification of articles is assisted by Convidence, a systematic review tool, to ensure the relevance and reliability of selected studies.

Table 1 Keyword Search results

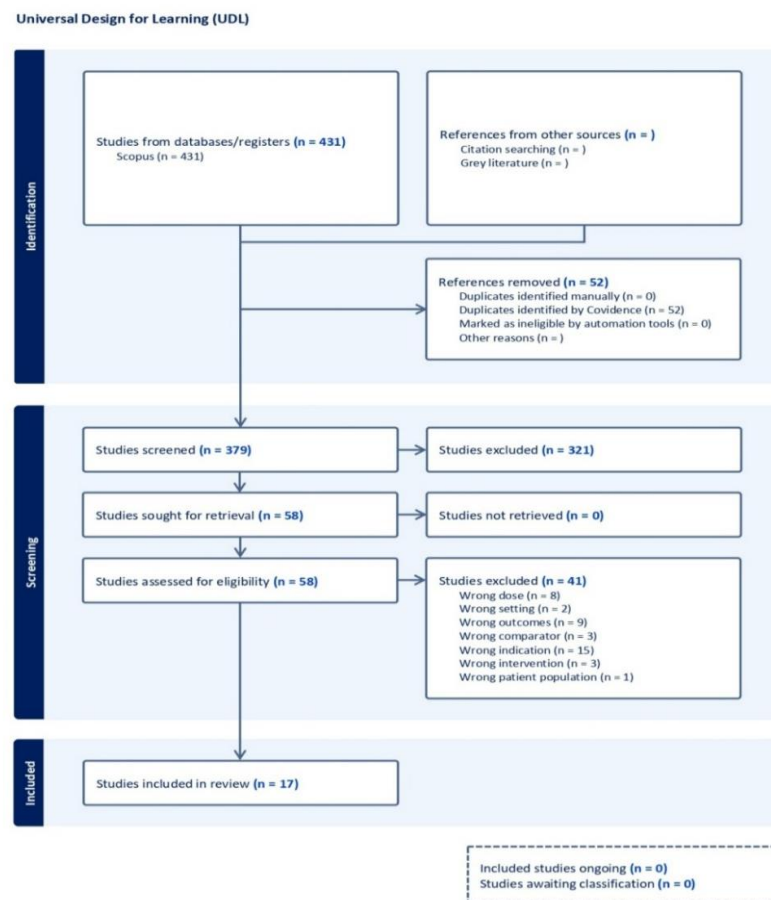| Search Query	Total Articles
Universal Design for Learning AND digital learning media AND educational technology AND learning accessibility	431

Figure 1 Screening Protocol (PRISMA)

The figure above illustrates the article screening process carried out systematically according to the Preferred Reporting Items for Systematic Reviews and Meta-Analyses

(PRISMA) protocol. From the screening results, 17 articles were selected after going through the stages of identification, screening, and selection based on eligibility criteria. This process ensured that only articles relevant to the topic of Universal Design for Learning (UDL) in digital learning media were used in the analysis. The next step in this research is to conduct an in-depth analysis of the selected articles to answer the research questions, namely how UDL principles are applied in digital learning media to improve accessibility and student engagement, and how various digital media formats can be optimally integrated to support students' information representation, engagement and expression. The results of this analysis will be used to develop research findings that provide new insights into the application of UDL in digital learning as well as challenges and recommendations for more effective implementation.

RESULTS AND DISCUSSION

RESULTS
Article Distribution

The literature review analysis collected 17 final articles. The preliminary results illustrate the distribution of articles by publication rank (Scimago), research method, and year of publication, as shown in Table 2.

Table 2 Article Distribution

	Publish Year									
	2010	2015	2017	2018	2019	2021	2023	2024	Total	%
Rating (Scimago)										
Q1	1	0	0	1	1	1	0	2	6	35.29
Q2	0	1	0	1	0	1	0	3	6	35.29
Q3	0	0	0	1	1	0	0	0	2	11.76
Unranked	0	0	1	1	0	0	1	0	3	17.64
Total	1	1	1	4	2	2	1	5	17	100
Research Method										
Qualitative	0	0	1	0	2	1	0	0	4	23.52
Quantitative	0	1	0	2	0	0	1	3	7	41.17
Mix	1	0	0	2	0	1	0	0	3	17.64
SLR	0	0	0	0	0	0	0	2	2	11.76
Total	2	2	2	8	4	4	2	10	17	100
Source : Author's Own Work										

The distribution of articles in this study shows a focus on high-quality sources, with most articles coming from Q1 (35.29%) and Q2 (35.29%) journals. Q3 journals accounted for 11.76%, while articles from unranked journals accounted for 17.64%. No articles came from Q4 journals, reflecting the priority on credibility and publication quality. In terms of research methods, quantitative approaches dominated with 41.17% of articles, indicating a preference for quantifiable data to support research conclusions. Qualitative methods were used in 23.52% of articles, while mixed methods were used in 17.64% of articles.

The distribution of articles by publication year showed fluctuations, with a peak in 2024 (5 articles), reflecting the relevance and focus on recent research. Other years showed an even distribution, with an average of 1-2 articles per year. Articles in this study also came from various multidisciplinary journals, such as Learning Disability Quarterly (Q1), Universal

Access in the Information Society (Q2), and Studies in Health Technology and Informatics (Q3). The dominance of highly ranked journals (Q1 and Q2) emphasizes the credibility of the sources used.

Table 3 shows the distribution of articles by journal source with the dominance of Q1 journals (35.29%), such as Learning Disability Quarterly, British Journal of Educational Technology, and Computers and Composition, which each contributed one article (6.25%).Q2 journals, such as Universal Access in the Information Society and Journal of Special Education Technology, also accounted for 35.29% of articles, with each journal contributing one article (6.25%).Q3 journals, such as Studies in Health Technology and Informatics and Center for Educational Policy Studies Journal, accounted for 11.76% of articles, while the unranked category, such as ICAICTA 2018 - 5th International Conference on Advanced Informatics and Espacios, accounted for 17.64% of articles, with each journal contributing one article (6.25%).

The articles analyzed came from various disciplines, including education, technology, health, and policy, reflecting the multidisciplinary approach in this study.The predominance of highly ranked journals, such as Q1 and Q2, indicates the credibility of the sources used and the validity of the results produced.This indicates that research in this area utilizes reliable sources to support the development of evidence-based theory and practice.

Table 3 Journal Source

Journal	Rating	Total	%
Learning Disability Quarterly	Q1	1	6.25%
Universal Access In The Information Society	Q2	1	6.25%
Center For Educational Policy Studies Journal	Q3	1	6.25%
Journal Of Special Education Technology	Q2	1	6.25%
British Journal Of Educational Technology	Q1	1	6.25%
Australasian Journal Of Educational Technology	Q1	1	6.25%
Journal Of Education For Teaching	Q1	1	6.25%
ICAICTA 2018 - 5th International Conference On Advanced Informatics	Unranked	1	6.25%
Espacios	Unranked	1	6.25%
Discover Sustainability	Q2	1	6.25%
Aula Abierta	Q2	1	6.25%
Studies In Health Technology And Informatics	Q3	1	6.25%
Revista De Investigacion Educativa	Q2	1	6.25%
Computers And Composition	Q1	1	6.25%
ASEE Annual Conference And Exposition, Conference Proceedings	Unranked	1	6.25%
Techtrends	Q1	1	6.25%
International Journal Of Engineering Pedagogy	Q2	1	6.25%

Table 4 Summary of Selected Studies

No	Author	Methodology	Key Findings
1	Basham (2010)	Conceptual	Proposed an ecological RtI framework integrating UDL

		framework, literature review	principles, emphasizing data-driven decision-making and tiered instructional support. Highlights the role of technology in inclusive learning.
2	Izzo (2015)	Case study analysis	UDL improves STEM education accessibility for students with disabilities. Emphasizes flexible teaching strategies and assistive technology to promote independence.
3	McMahon (2019)	Literature review, case studies	Discusses the integration of emerging technologies (iPads, mobile apps) in education, advocating for UDL-based inclusive digital learning environments.
4	Rao (2021)	Systematic literature review	Examines digital tools that support UDL-based online learning. Emphasizes multimodal content representation, collaborative learning, and personalized feedback.
5	Bray (2024)	Systematic literature review, qualitative coding	Identifies challenges and opportunities in technology-assisted UDL at the secondary education level. Highlights underutilization of UDL features in existing digital tools.
6	Nieves (2019)	Experimental study (MOOC implementation)	Demonstrates that gamification (digital badges, rewards) enhances student motivation in MOOCs. Findings suggest that multiple content formats improve accessibility.
7	Lee (2021)	Mixed-methods study (teacher training modules)	Evaluates pre-service teachers' adoption of UDL principles. Discussion forums and peer interaction improve understanding and application of inclusive instructional design.
8	Luangrungruang & Kokaew (2018)	Experimental study (Augmented Reality in special education)	AR-based tools improve learning accessibility for hearing-impaired students. High user satisfaction scores indicate AR's potential in inclusive learning environments.
9	Saborío-Taylor & Rojas-Ramírez (2024)	Conceptual analysis, AI integration in education	Explores the role of AI in personalized UDL-based learning. AI enables automated feedback and adaptive content recommendations, enhancing inclusivity.
10	Bucheli (2024)	Quantitative study (Likert-scale survey)	Highlights student perceptions of UDL in higher education. Findings support the use of digital tools in UDL, but indicate gaps in interactive feedback mechanisms.
11	Sánchez-Serrano (2018)	Descriptive study, student survey	Examines student feedback on digital reading texts using UDL Book-Builder. Most students prefer digital texts over print due to accessibility features.
12	Cunningham & Murphy (2018)	Mixed-methods study (game-based learning)	Analyzes the alignment of Digital Game-Based Learning (DGBL) with UDL. Adaptive models support inclusive learning and personalized feedback.
13	Zamora-Musa (2017)	UDL framework evaluation	Implements open educational resources (OER) using UDL. Supports flexible evaluation and competency-based learning.
14	Varadhan et al. (2023)	Survey-based study (Chi-Square test)	Investigates UDL adoption in STEM courses. Flexible deadlines and recorded lectures improve accessibility, but UDL practices are underutilized.
15	Vie (2018)	Literature review, pedagogical recommendations	Discusses social media integration in online writing classes through UDL. Suggests user-centered design to improve accessibility and engagement.
16	Choi (2024)	Literature review, accessibility analysis	Examines learning experience (LX) and user experience (UX) design in UDL. Highlights the need for better accessibility and usability in digital learning.
17	Salgarayeva (2024)	Experimental study (pre-test & post-test)	Evaluates UDL-based teaching materials for computer science education. Shows significant improvement in programming skills for students with special needs.

RQ1. How can UDL principles be effectively implemented in digital learning media

for non-formal education to enhance accessibility and student engagement?

The application of Universal Design for Learning (UDL) in digital learning media for non-formal education aims to enhance accessibility and student engagement by leveraging innovative technologies. Given the diverse backgrounds and learning needs of students in non-formal education settings, the flexibility of digital learning media becomes a crucial factor.

One of the key aspects of UDL implementation is flexibility in information representation. In non-formal education, where learners often have varying levels of literacy and prior knowledge, digital learning media must provide content in multiple formats, such as text, audio, video, interactive graphics, and augmented reality (AR). This multimodal approach ensures that learners with different learning styles, including those with disabilities, can access information effectively (Basham, 2016; Rao, 2015; Luangrungruang, 2018). For example, an adult literacy program in a community learning center (PKBM) may use narrated digital books or interactive videos to support learners who struggle with reading comprehension.

In addition to representation, active engagement strategies play a vital role in maintaining student motivation in non-formal education. Many learners in non-formal education are working adults or individuals with limited formal schooling, making engagement strategies even more essential. Gamification elements, such as digital badges and progress tracking on learning platforms, have proven effective in keeping learners motivated (Nieves, 2019). Similarly, online discussion forums and collaborative projects encourage peer interaction, fostering a supportive learning environment where students can share knowledge and experiences (Lee, 2021). These strategies not only enhance engagement but also help build a sense of community among learners, which is often lacking in non-formal education settings.

Accessible technology serves as the foundation for UDL implementation in non-formal education. Many learners in this sector face barriers such as limited digital literacy and access to technology. Tools like UDL Book-Builder allow students to access digital texts with interactive features, including voice narration and annotations, which are particularly useful for those with low literacy levels (Sánchez-Torrejón, 2024). Similarly, AR applications like Aurasma enable learners to engage with educational content in an interactive manner, which is particularly beneficial for vocational training programs where hands-on learning is essential (Luangrungruang, 2018).

Furthermore, digital learning media in non-formal education must focus on reducing learning barriers by incorporating scaffolding techniques. Many students in this sector require personalized learning paths due to their varied educational backgrounds. Digital resource banks that provide materials in different difficulty levels and formats allow learners to study at their own pace (Rao, 2015; Bucheli, 2024). Additionally, adaptive learning platforms that offer personalized feedback enable instructors to track student progress and adjust instructional strategies accordingly (Basham, 2016; Zamora-Musa, 2017).

The successful application of UDL principles in digital learning media for non-formal education ultimately fosters inclusive and equitable learning opportunities. By integrating modern technologies such as AR, AI-driven adaptive learning, and mobile-friendly educational tools, non-formal education programs can become more flexible and accessible. This approach ensures that diverse learners, including marginalized communities and individuals with disabilities, can fully participate in lifelong learning and skill development (Romero-Esquinas, 2024; Choi, 2024).

RQ2. What are the challenges and solutions in integrating various digital media formats to support learning in non-formal education?

The integration of various digital media formats within the Universal Design for

Learning (UDL) framework presents both opportunities and challenges in non-formal education. Unlike formal education settings, non-formal education often caters to diverse learner profiles, including working adults, individuals with disabilities, and marginalized communities. Therefore, optimizing digital media formats to support information representation, student engagement, and expression requires strategic solutions to address existing challenges.

1. Challenges and Strategies in Information Representation

    Ensuring effective representation of information in digital learning media for non-formal education requires multimodal content delivery. While formats such as text, audio, video, and interactive graphics enhance accessibility, many learners in non-formal education face limited digital literacy and inadequate technology access. For example, students with low literacy levels may struggle to navigate text-heavy content, while those with hearing impairments require captions or sign language support in video materials (Sánchez-Serrano, 2018). The use of mobile-friendly, low-bandwidth digital resources is essential in addressing these barriers. Community-based learning centers can implement offline digital learning modules that allow students to access multimedia content without requiring a stable internet connection. Additionally, integrating AR-based interactive learning materials, such as Aurasma, can help learners visualize complex concepts in vocational training programs (Luangrungruang, 2018).

2. Enhancing Student Engagement in Non-Formal Education

    Sustaining engagement in non-formal education can be challenging due to irregular learning schedules and low learner motivation. Many students in this sector juggle education with work or family responsibilities, leading to inconsistent participation. While gamification and discussion forums enhance engagement, lack of familiarity with digital platforms often hinders active participation (Nieves, 2019; Vie, 2018). Simplified learning management systems (LMS) with intuitive user interfaces can improve accessibility for non-formal learners. Additionally, utilizing messaging apps and social media platforms as informal learning tools can increase engagement by meeting students where they are already active. For instance, WhatsApp-based discussion groups can facilitate peer interaction and provide an alternative to traditional LMS discussion forums (Lee, 2021).

3. Supporting Student Expression through Digital Media

    Encouraging student expression is crucial in non-formal education, where learners often come from varied educational backgrounds. However, limited access to digital creation tools and low confidence in using technology can hinder self-expression. While platforms such as Canva and PowerPoint allow students to create visual presentations, many non-formal learners may lack the technical skills to fully utilize these tools (Rao, 2021). Non-formal education programs should integrate guided digital storytelling activities, where students can express ideas through simple mobile-friendly tools such as Padlet or voice-recorded reflections. Training workshops on basic digital literacy can also empower learners to confidently use collaborative platforms like Google Jamboard for project-based learning.

4. Reducing Learning Barriers through Adaptive Digital Media

    A key challenge in non-formal education is addressing varied learning paces and accessibility needs. Many learners require personalized learning paths, yet most existing digital media resources are designed for standardized instruction (Bucheli, 2024). Additionally, technical limitations, such as a lack of assistive technology, can exclude learners with disabilities. Implementing adaptive learning platforms with multimodal resource banks including video tutorials, interactive simulations, and written notes allows students to select content that best suits their learning

preferences. Furthermore, providing real-time automated feedback through AI-powered tools can guide learners in self-assessment and skill development (Rao, 2021).

5. Optimizing Digital Media Integration through Data-Driven Approaches

One of the main barriers to effective digital media integration in non-formal education is the lack of data-driven decision-making. Educators often struggle to track student engagement and learning outcomes due to limited access to learning analytics tools (Zamora-Musa, 2017; Choi, 2024). By adopting lightweight data tracking systems such as Google Forms for progress monitoring or simple dashboard tools educators can analyze student interaction patterns and adjust learning materials accordingly. Additionally, AI-driven adaptive learning can help identify the most effective media format for individual learners, ensuring a personalized and efficient learning experience.

Implications

The implementation of Universal Design for Learning (UDL) in digital learning media for non-formal education enhances accessibility, engagement, and inclusivity by integrating multimodal content, adaptive learning strategies, and technology-driven solutions. Despite challenges such as digital literacy gaps and infrastructure limitations, the use of mobile-friendly resources, gamification, and data-driven analytics supports personalized and flexible learning experiences. Strengthening educator capacity and developing user-friendly platforms are crucial for optimizing UDL adoption. Additionally, collaboration between educators, policymakers, and technology developers is essential to ensure the sustainability and scalability of UDL-based digital learning initiatives. Ultimately, integrating UDL in non-formal education contributes to achieving inclusive and equitable learning opportunities, aligning with Sustainable Development Goal 4 (SDG4), while fostering lifelong learning and skill development for diverse learner populations.

CONCLUSION

This systematic literature review analyzed 17 articles on the implementation of Universal Design for Learning (UDL) in digital learning media for non-formal education, with most publications sourced from high-quality journals ranked Q1 and Q2 in the Scimago classification. The findings highlight diverse methodologies and reveal significant gaps in the effective implementation of UDL principles and the integration of various digital media formats to support accessibility, engagement, and expression in non-formal education. The study identifies key factors influencing UDL adoption, including the flexibility of digital media formats (text, audio, video, interactive graphics, and AR), educator training in inclusive digital pedagogy, and technological accessibility to ensure equitable learning opportunities. Additionally, strategies such as gamification, social media integration, and adaptive learning platforms have been found effective in enhancing engagement, but challenges such as limited digital literacy, lack of infrastructure, and economic constraints hinder their optimal application.

Furthermore, this review highlights the need for data-driven approaches to optimize the integration of digital media formats, enabling personalized learning experiences that cater to diverse student needs. Collaborative efforts between educators, technology developers, and policymakers are crucial in ensuring sustainable and scalable UDL-based digital learning solutions in non-formal education. However, the study acknowledges limitations in methodology, particularly its reliance on Scopus-indexed sources, which may have excluded valuable insights from other databases or gray literature. Future research should broaden the database scope, incorporate qualitative case studies, and explore the role

of emerging technologies such as AI and AR in optimizing UDL-based learning in non-formal education settings.

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