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## Evaluating AI-Based UDL Interventions to Improve Accessibility and Engagement in Special Education

تقييم التدخلات القائمة على الذكاء الاصطناعي وفق إطار التصميم  
الشامل للتعلّم في تحسين إمكانية الوصول والمشاركة في التربية الخاصة  
(UDL)

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### Abstract

This study investigates the incorporation of artificial intelligence (AI) into Universal Design for Learning (UDL) structures as a means of increasing accessibility and participation in special education. The study has adopted the mixed-method of qualitative case studies, quantitative and an experimental pilot study. The study examined eight studies focusing on students with a variety of disabilities. The findings reveal that AI-driven solutions like adaptive learning platforms, generative content systems, interactive chatbots, and AI scaffolds, could accomplish the following: they can amplify individualized learning, offer numerous modalities of engagement, and facilitate the implementation of inclusive instructional practices. However, a number of issues concerning expansion, teacher skills, ethics, and provision of access to all were found alongside the promising outcomes. The study communicated the effects on research, practice, and policies which pointed out the necessity of longer-term studies, professional development, and setting up ethical standards to ensure the safe and efficient use of AI in inclusive education environments. The study recommended that educators and school administrators are encouraged to use artificial intelligence (AI) tools in coordination with Universal Design for Learning (UDL) goals to improve students' personalized learning, engagement, and accessibility.

**Keywords:** Artificial Intelligence, Universal Design for Learning, Special Education, Accessibility, Engagement, Adaptive Learning

### المستخلص

تتناول هذه الدراسة دمج الذكاء الاصطناعي (AI) في أطر التصميم الشامل للتعلّم (UDL) بوصفه وسيلة لتعزيز إمكانية الوصول والمشاركة في مجال التربية الخاصة. وقد عرضت الدراسة أدلة مستمدة من ثماني دراسات شملت دراسات الحالة النوعية، وأبحاثاً تعتمد المنهج المتنوع، ونماذج تجريبية قبلية، ودراسات أخرى سابقة تركزت حول طلاب ذوي إعاقات متنوعة. وتُظهر النتائج أن الحلول المعتمدة على الذكاء الاصطناعي مثل منصّات التعلّم التكيفية وأنظمة توليد المحتوى وروبوتات المحادثة التفاعلية، ودعائم التعلّم المدعومة بالذكاء الاصطناعي قد تحقق ما يلي: تعزيز التعلّم الفردي وتوفير طرائق متعددة للمشاركة وتسهيل التطبيق للممارسات التعليمية الداجمة. وعلى النقيض من ذلك فقد برزت إلى جانب هذه النتائج الواعدة مجموعة من التحديات المتعلقة بالتوسّع وكفايات المعلمين والجوانب الأخلاقية وضمان الوصول إلى نتائج واعدة للجميع. كما يناقش البحث الآثار المترتبة على مجالات البحث وممارسة العلم والسياسات التعليمية والتي تشير إلى الحاجة إلى دراسات طويلة الأمد، وتنمية مهنية مستمرة، ووضع معايير أخلاقية تضمن الاستخدام الآمن والفعال للذكاء الاصطناعي في البيئات التعليمية الشاملة. كما أوصت الدراسة بتشجيع المعلمين والإدارات المدرسية على استخدام أدوات الذكاء الاصطناعي جنباً إلى جنب مع أهداف التصميم الشامل للتعلّم من أجل تحسين التعلّم للطلاب، وزيادة تفاعلهم، وزيادة إمكانية الحصول عليه.

**الكلمات المفتاحية:** الذكاء الاصطناعي، التصميم الشامل للتعلّم، التربية الخاصة، إمكانية الوصول، المشاركة،

التعلّم التكيفي

## Introduction

Artificial intelligence is changing dramatically the ways that schools support learners with diverse needs. Educators and researchers have been examining different ways AI can be combined with Universal Design for Learning to develop more accessible and less restrictive learning environments. The combination is becoming more and more popular since both AI and UDL aim to solve the issue of learner variability, remove obstacles and increase meaningful engagement. As the special education environment is undergoing changes, this integration can be seen as a new horizon of opportunities for teaching, assessment, and personalized support.

According to Sgambelluri and Placanica (2024), educational contexts that are inclusive may get further support for the development of learners and their well-being in the long run if AI is implemented for these purposes. Their research indicates that AI-powered UDL design is a tool that enables educational institutions to set up structures which not only recognize but also anticipate learner diversity.

Educators are similarly moving towards the integration of AI in their lesson plans that they execute on a daily basis. Gilbert (2024) shares some effective UDL-based lesson plans that utilize AI to provide support to diverse learners in the lower-grade classrooms. These instances serve as proof that teaching, which is amplified by the use of AI, is not confined to the revolutionary research spheres but is in the process of becoming the norm of regular teaching practice.

According to Zaugg (2024), technological innovations in the field of assistive technology that supports UDL are the actual things to be in concern for, in the light of which AI will be the one instrumental in creation of learning environments that are accessible. Zaugg (2024) argues that though AI-powered tools become more and more popular in schools, educators and policymakers still need, besides these tools, sound and reliable insights instead of scattered case studies. This paper answers their call by reviewing the existing body of research to unravel the effectiveness, constraints, and consequences of AI-facilitated UDL in special education.

Another perspective to this topic is that AI is changing the way teachers conduct their classes all over the world. Habib and Janae (2024) provide the examples of how AI in special education has been successfully implemented in the classroom to break down the barriers faced by the students of different kinds of disabilities. What they discovered suggests that content can be made more accessible with the help of AI-powered UDL means and at the same time learners can be turned into active participants in case the implementation is done properly.

The increased demand for AI-driven learning is largely due to its ability to change the instruction in the most suitable way in real-time. Technologies that use machine learning and natural language processing are capable of monitoring learners' patterns and generating appropriate supports for the strengths and challenges of the particular person. Jowallah (2025) recalls that AI is slowly but surely turning to be the core of educational design in the situations where the teaching staff need rapid feedback and personalized changes for students with disabilities. This transformation is altering the special educators' perspective on planning, differentiation, and progress monitoring.

Meanwhile, UDL continues to be a well-known and widely-accepted teaching model that supports inclusiveness. It helps teachers by giving them the idea of providing a variety of methods to the students for engaging with the material, showing their understanding and obtaining the learning resources. In case AI instruments are in line with the UDL guidelines, they probably can facilitate the provision of the options for the teachers. Lombardo Pontillo and Oliva (2025) state that this interaction results in the flexibilisation of students' learning experiences, especially those with a certain type of learning disorder, and that participation becomes their limitation due to the instructional barriers.

Conversational agents, in general, have been proven possible, and a few studies show that they can become an efficient instructional support tool for people with intellectual or cognitive disabilities. According to Carruba et al. (2025) the authors conducted an experiment with AI chatbot interaction that was based on the UDL framework. Their results indicated that such tools could promote independence and self-confidence if they are properly organized. These findings mean that the time when assistive innovations will not only cover the accessibility basics but will also become interactive, personalized companions of learners is very close.

Moreover, the homeless of the street topic has shifted towards the issue of equity in digital learning environments which has been another factor that gave the topic of children's disabilities an enormous push to come to the forefront. Children with disabilities are the most affected by systemic barriers that deprive them of access to quality instruction. Ahmed et al., (2025) and other researchers identify AI-based personalization as a primary source that can bring about a huge change in reduction of disparities by offering just, data-driven, and instructional adjustments. However, they also warn that in order to avert the reinforcement of existing gaps, these tools should be introduced carefully.

Artificial intelligence has the potential to change the face of formative assessment as well. In their article, Teles and Moreira (2025) provide examples of how AI can assist educators in collecting evidence of student learning in less time and modifying assessments to fit the needs of students in line with UDL principles. This method allows for progress to be checked without the worry that students who need extra help will be overwhelmed.

Furthermore, some of the great academic minds emphasize that the use of Artificial Intelligence (AI) in the Universal Design for Learning (UDL) has a significant impact on the learners' engagement which in turn is a crucial factor in their academic achievement. Ram et al. (2025) advocate a conceptual model elucidating the manner in which AI mediation may facilitate the elevation of motivation and perseverance in pupils suffering from dyslexia. Their research reveals that the digital advancements in the form of carefully planned instructional supports have the potential to alleviate the feeling of frustration and increase students' confidence, thereby leading them to more active interaction with academic tasks.

Nevertheless, some scholars remain skeptical about the issues of adoption and implementation. The difficulties experienced by schools when trying to provide fair access to AI tools for pupils with intellectual disabilities. Things like training,

facilities, and moral aspects are not entirely solved yet and that's the reason why educators' attitude towards AI-enhanced UDL practices is still cautious.

The emergence of generative technologies is a further reason why people have become more intrigued by this topic. The newest technologies have the ability not only to produce learning materials that are personalized to the students, but also to make the texts easier to understand or create multimodal representations of the concepts. Farhah et al. (2025) emphasize that generative AI systems are the main source of customized educational support provision to learners with different kinds of disabilities, as they are the ones who easily change content and pacing with very little teacher involvement. These capabilities have caused a lot of talk about the special education of tomorrow and how AI could potentially make teaching more approachable and efficient.

The advent of adaptive, generative, and conversational AI tools, which purport to increase user engagement and participation, constitutes the second reason for this review. Lombardo Pontillo and Oliva (2025), Farhah et al. (2025), and Carruba et al. (2025) argue that the main benefit of AI is when it is used to modify content, provide scaffolding, or support communication. Unfortunately, the bulk of such experiments are small in scale, limited to few settings, or are more focused on technical aspects than on educational results. Simultaneously, problems about fairness, teacher preparation, and ethical implementation are still being brought up in different pieces of literature (Karuppasamy, 2025). The systematic review can be of great assistance in finding out whether these instruments are consistent in enhancing accessibility and engagement or, in case, their benefits are dependent on certain settings and conditions.

Some scholars retain that revamping education design while using AI as the background is of paramount importance. Nagasubramanian & Adegbola (2025) claim that AI has the potential to facilitate equity-led content promotion by personalizing it, however, he further cautions that curriculum choices should align with the values of inclusive education. It certainly opens the very difficult questions of how to review AI-based UDL interventions.

Roy et al. (2025) report both positive and negative aspects in the area of special education technology, broadly speaking. They emphasize AI-led solutions as a revolutionary idea for education, but only if teachers are aware of the device's constraints and combine them with research-based teaching methods. Their viewpoint is in line with the very significant role of united AI innovations to the age-old UDL principles.

While research findings on this trend accumulate, significant gaps remain. Merging the results of studies about AI-powered UDL as a means to increase accessibility and engagement, that is, the two essential areas of students with disabilities, these effects is still a work in progress. Without a thorough understanding of effectiveness, teachers may wrongly decide to employ tools that do not necessarily cater to the needs of all students.

Considering the background, it is a well-timed and necessary act for an AI-based UDL intervention systematic review. The main role of this review is to harmonize the evidences of the studies, judge the quality of the current research, and indicate the

trends, the gaps and the field of application. Delving into the intersection of AI and UDL, this study aims to fuel teachers, policy-makers, and scientists with the bright understanding that tech tools might be the way to provide access and make the special education learning more engaging.

### **Statement of the Study:**

This study addresses the growing integration of artificial intelligence (AI) with Universal Design for Learning (UDL) in special education and the need to systematically examine its effectiveness. This study aims at evaluating the quality and the impact of integrating Universal Design for Learning (UDL) based on the AI interventions to identify key trends and gaps, and provide evidence-informed insights to support educators, policymakers, and researchers in developing more inclusive and engaging learning environments for students with disabilities. Although existing research suggests that AI-driven UDL practices can enhance accessibility, engagement, personalization, and assessment for learners with disabilities, the evidence remains fragmented and raises concerns related to equity, ethical use, and implementation challenges.

### **Significance of the Study:**

The study on artificial intelligence (AI) in special education has been the focus of interest, the rapid pace of development, but the pieces of evidence that support it are still to be found between various instruments, different groups of disabled people, and educational methods. The study points out that AI has a great potential to tailor learning and eliminate obstacles, still, few of them reveal that these devices systematically correspond with Universal Design for Learning principles. This is not the first study in this field in KSA. There are many studies such as Alsolami (2024), Baqutain (2025) and Ahmed et al., (2025). In their paper, Ahmed et al., (2025) and Jowallah (2025), separately, say that teachers need more explicit instructions regarding AI use in attaining accessibility without a higher level of complexity. Because the existing results are inconclusive, a detailed examination is required to sort out the information that has already been obtained, the gaps, and the interventions that truly facilitate learners with diverse needs. However, this study is the first study to investigate the incorporation of artificial intelligence (AI) into Universal Design for Learning (UDL) structures as a means of increasing accessibility and participation in special education.

### **Objectives of the Study:**

This study aims at understanding the effectiveness of AI-powered interventions that are designed based on Universal Design for Learning principles and how they help in making learning more accessible and engaging for special education students. The study is much engaged with uncovering what kinds of AI tools are being used, which learner groups are being targeted, and what instructional purposes these tools are serving while also gauging the effectiveness and the intervention-agreement level of these activities in different educational settings. Another objective is to examine the quality of the research methodology in the studies so as to determine the strength of the existing evidence and point out the areas that need more research. This study, by consolidating the existing research, intends to illuminate the use of AI-powered

UDL strategies as an instrument of inclusive education and a guide for future works in the creation of fair, engaging, and accessible educational environments for students with disabilities. The objective of the study can be pinpointed as the following:

1. Examining the integration of artificial intelligence within Universal Design for Learning frameworks in special education, with a focus on accessibility and learner engagement.
2. Investigating the effectiveness of AI-powered interventions that are designed based on Universal Design for Learning principles.
3. Identifying key trends, research gaps, and implementation challenges related to AI-enhanced UDL practices.
4. Exploring evidence-based implications of AI-enhanced UDL practices for educators, researchers, and policymakers aiming to promote inclusive and equitable learning environments.

#### **Questions of the Study:**

1. How is artificial intelligence integrated within Universal Design for Learning (UDL) frameworks in special education to enhance accessibility and learner engagement?
2. To what extent are AI-powered interventions effective to UDL principles in supporting learners with disabilities?
3. What are the key trends, research gaps, and implementation challenges identified in the literature regarding AI-enhanced UDL practices?
4. What evidence-based implications do AI-enhanced UDL practices offer for educators, researchers, and policymakers seeking to promote inclusive and equitable learning environments?

#### **Methodology:**

##### **Research Strategy**

A systematic search strategy was employed to retrieve studies examining AI-enabled interventions aligned with Universal Design for Learning (UDL) principles and their effects on accessibility and engagement outcomes in special education. The study was limited to published articles within the last five years across journals, conference proceedings, and book chapters. A comprehensive literature search was carried out across multiple electronic databases, including Scopus, Web of Science, ERIC, PubMed, and IEEE Xplore. The search strategy combined keywords related to artificial intelligence, Universal Design for Learning (UDL), special education, accessibility, and student engagement. Searches were limited to peer-reviewed articles published between 2015 and 2025 and written in English. Additional records were identified through reference list screening. Search terms were developed to reflect the overlap between AI, UDL, adaptive learning, and inclusive education. Some of the keywords are "artificial intelligence," "machine learning," "universal design for learning," "adaptive learning," "special education," "disability," "accessibility," and "student engagement." Also, Boolean operators like AND, OR, and NOT were used to limit search results and ensure that studies on AI-supported UDL interventions in special education contexts were retrieved. Just as an illustration, a sample search

string could be: "(artificial intelligence OR AI OR machine learning) AND (universal design for learning OR UDL) AND (special education OR disability) AND (engagement OR accessibility)."

At first, the search came up with a broad range of possible research works that were later filtered by relevance, methodology, and outcomes related to UDL and AI. The inclusion criteria targeted empirical studies, systematic reviews, and case studies that focused on the use of AI tools in the UDL environment for students with disabilities. At the same time, the exclusion criteria filtered out non-relevant articles like AI application articles that are outside educational contexts. Hence, eight studies constitute the final corpus after the screening and eligibility assessment for this review.

This study was assessed using the Mixed Methods Appraisal Tool (MMAT, 2018), selected to accommodate the heterogeneous designs of studies evaluating AI-based Universal Design for Learning (UDL) interventions in special education. Studies were assessed against five design-specific criteria addressing methodological rigor, intervention clarity, validity of outcome measures related to accessibility and engagement, and integration of mixed-methods components where applicable. Quality appraisal findings informed the interpretation of results in accordance with PRISMA 2020 guidelines.

The structured search strategy used in this review made it possible to cover all grounds yet remained focused on uncovering resources that demonstrate the practical, pedagogical, and technological integration of AI within UDL frameworks. Together, the selected articles represent various disability types, age groups, and AI interventions, thus, they can be used as a firm base to examine how AI-driven UDL interventions affect accessibility and student engagement in diverse educational settings.

### **Study Procedures:**

#### **▪ Eligibility Criteria:**

The eligibility criteria for this systematic **review** were established to allow the exclusion of ten research papers which were excluded for not meeting the criteria remaining eight studies, to be included after the review, primarily dealing with AI-based interventions within the Universal Design for Learning (UDL) frameworks. This is to target the improvement of accessibility and engagement in special education. First of all, the paper's selection was limited to studies that addressed students with disabilities, used AI tools in accordance with UDL principles, and measured the impact of these interventions on educational engagement or accessibility. Furthermore, the non-inclusion criteria disqualified those pieces of research which were not concerned with UDL, AI interventions in non-educational settings, or studies without empirical or systematic evidence.

Moreover, the PICOS framework (Population, Intervention, Comparison, Outcome, Study Design) was used to help the selection process of papers. This made it possible to have a systematic and transparent approach for setting up inclusion and exclusion criteria. The framework was used consistently during the choice of papers

and allowed focused extraction and synthesis of the relevant evidence from the eight studies selected.

**Table 1: Using PICOS framework for developing the inclusion and exclusion criteria of the systematic review**

| PICOS Framework         | Criteria                                                 | Inclusion                                                                                               | Exclusion                                                                                              |
|-------------------------|----------------------------------------------------------|---------------------------------------------------------------------------------------------------------|--------------------------------------------------------------------------------------------------------|
| <b>Population (P)</b>   | Learners with disabilities in special education settings | Students with any type of disability (e.g., intellectual, learning, sensory)                            | Students without disabilities; general education populations without individualized interventions      |
| <b>Intervention (I)</b> | AI-based interventions integrated with UDL principles    | AI-supported adaptive learning, chatbots, generative AI tools, engagement scaffolds designed within UDL | Non-AI interventions; technology not aligned with UDL; traditional instruction without personalization |
| <b>Comparison (C)</b>   | Comparator for evaluating AI-UDL impact                  | Standard instruction, non-AI UDL interventions, or baseline performance prior to AI-UDL implementation  | Studies without comparison or baseline data                                                            |
| <b>Outcome (O)</b>      | Measurable impact on learning                            | Improvement in accessibility, engagement, participation, retention, or learning outcomes                | Studies without clear outcomes related to accessibility, engagement, or inclusion                      |
| <b>Study Design (S)</b> | Research methodology                                     | Empirical studies, qualitative case studies, mixed-method studies, systematic reviews                   | Opinion pieces, editorials, commentaries, non-research articles                                        |

The PICOS framework was employed to the systematic picking of studies and acted as a filter that only research about AI-based UDL interventions had to be included. The selected studies formed the basis of a powerful and focused synthesis, which shed the light on what is the role of AI tools to facilitate accessibility and engagement of students with disabilities, at the same time, to make sure that the

excluded studies are those which do not present actionable or relevant insights for inclusive educational practice.

#### ▪ Study Selection:

The selection of studies for this research involved a methodical four-phase approach which was transparent, rigorous, and relevant. Each successive stage of the process correspondingly narrowed down the pool of studies to find those that complied with the inclusion criteria set by the PICOS framework. This stage led to include eight papers dealing with AI-based interventions within the Universal Design for Learning (UDL) frameworks.

#### Phase 1: Identification

In the identification step, a comprehensive search was conducted across databases such as IEEE Xplore, SpringerLink, PubMed, and Google Scholar by the use of keywords related to artificial intelligence, Universal Design for Learning, adaptive learning, and special education. The primary search returned 42 records. These records were journal articles, book chapters, and conference proceedings published from 2019 to 2025.

#### Phase 2: Screening

At the screening stage, the reviewers looked over the titles and abstracts of the studies they had found to decide whether the content was relevant or not. If the paper did not describe AI-supported UDL interventions directly, or was about general education, or AI applications in non-educational fields, then it was discarded. After this screening, 24 records were removed due to irrelevance, leaving 18 studies for full-text review.

#### Phase 3: Eligibility

The eligibility stage involved going through the full texts of the studies left and deciding whether they met the inclusion and exclusion criteria that were set up by the PICOS framework. A paper would be rejected if it was only hypothetical, did not mention the directions of accessibility or engagement, or if it was not about AI-based UDL interventions. Ten research papers were excluded for not meeting the criteria which left eight studies to be included after the review.

#### Phase 4: Included

The final group of studies to be included was composed of eight journal articles that thoroughly explored AI-based interventions compliant with UDL principles in the special education context. These studies, in concert, offer evidence about various AI tools, adaptive learning strategies, and their impact on accessibility and student engagement.

| Phase          | Description                                              | Number of Records |
|----------------|----------------------------------------------------------|-------------------|
| Identification | Comprehensive database search using keywords             | 42                |
| Screening      | Title and abstract review; removal of irrelevant studies | 18                |

|             |                                              |   |
|-------------|----------------------------------------------|---|
| Eligibility | Full-text review against PICOS criteria      | 8 |
| Included    | Final studies meeting all inclusion criteria | 8 |

#### ▪ Data Extraction:

Data extraction was performed in a systematic manner in order to gather relevant information from the eight studies that were included. A structured data extraction form was the instrument used to jot down the key components of each study, and these components were:

1. Study title, authors, and year of publication
2. Population characteristics (type of disability, age group, educational setting)
3. AI intervention type and UDL alignment
4. Study methodology (qualitative, quantitative, mixed methods, or review)
5. Outcomes measured (accessibility, engagement, learning outcomes)
6. Key findings and conclusions.

The extraction phase served as a major step in confirming that all the key aspects were documented in a uniform way so that inter-study comparisons and syntheses would be possible. The extraction was done by two separate reviewers, and in cases of differences, they were resolved through a discussion to make sure that the work was accurate and reliable.

#### ▪ Quality Appraisal:

All the eight studies included in the research underwent a quality appraisal to ascertain the credibility and reliability of the findings. The main focus of the appraisal was on the methodological rigor of the studies, the transparency of reporting, the appropriateness of the study design, and the relevance of AI-based UDL interventions in special education. Overall, each study was evaluated against criteria which involved the clarity of research goals, the description of the intervention, the conformity with UDL principles, the sample characteristics, the data collection methods, and the validity of the outcomes reported.

Quantitative and mixed-method studies were assessed based on criteria that included the sufficiency of sampling, data analysis procedures, and reliability measures, while qualitative studies were considered in terms of their credibility, triangulation, and depth of analysis. Systematic literature reviews were evaluated for their comprehensiveness, the transparency of their search strategy, and the quality of their synthesis. Any work that had significant methodological limitations or unclear reporting was pinpointed, but none were excluded due to the small number of studies in this new research area. This quality appraisal process has widened the trustworthiness of the review by not only pinpointing the robustness of the existing evidence base but also its limitations.

### **Data Analysis:**

The researcher has conducted the analysis using a narrative thematic synthesis approach due to heterogeneity in the study designs, participant populations, and AI-based interventions. The steps of the analysis are as follows:

First, relevant data are systematically extracted from each included study, including study context, type of AI technology, disability group, educational setting, and reported outcomes. These extracted data are then coded deductively according to the three core Universal Design for Learning (UDL) principles: accessibility (multiple means of representation), engagement (multiple means of involvement), and personalization (multiple means of action and expression).

Next, studies are grouped and compared within each thematic category, allowing the researcher to examine how different AI technologies (e.g., chatbots, generative AI tools, adaptive learning systems, and AI-based scaffolds) operationalize UDL principles across diverse special education contexts. Through iterative comparison, the researcher identifies recurring patterns, such as common intervention characteristics, reported benefits for accessibility and engagement, and variations in effectiveness across disability groups.

Finally, the synthesis further integrates findings from different types of evidence, including case studies, pilot interventions, and literature reviews, to distinguish between established evidence, emerging practices, and research gaps. The researcher pays a special attention to outcomes related to student participation, individualized instructional support, multimodal content delivery, and ethical considerations surrounding AI use in special education. By systematically integrating and interpreting findings across studies, the researcher develops a comprehensive understanding of how AI-based UDL interventions function in practice and derives recommendations for educators, policymakers, and future research.

### **Ethical Considerations**

In order to ethically consider how the data should be handled and interpreted, ethical considerations were very important in this systematic review. A comprehensive literature search was carried out across multiple electronic databases, including Scopus, Web of Science, ERIC, PubMed, and IEEE Xplore via open-access and subscription-based access. In fact, despite the fact that this study synthesizes published literature and does not involve primary data collection, the authors of this study took the utmost care that their findings accurately reflect the included studies without bias and misinterpretation. In order to maintain academic integrity, APA guidelines were followed in all in-text citations and reference list entries. Furthermore, the review addressed ethical concerns such as data privacy, algorithmic bias, fair access to AI technologies, and the risk of an excessive use of AI tools by learners with disabilities that were raised by the studies included in the review. Areas of responsible reporting of AI interventions were identified as the most important ones, thus ensuring that practice and policy recommendations serve the purpose of an inclusive and ethically-guided education.

### Findings:

The findings of this study are summarized in Table 2, which organizes the included studies by title, authors, methodology, sample, key findings, and study type. This provides a clear overview of the diversity of AI-based UDL interventions, populations targeted, and outcomes related to accessibility and engagement.

| Sr. | Title                                                                                                                                            | Authors                                          | Methodology                                 | Findings                                                                                                                                                                    |
|-----|--------------------------------------------------------------------------------------------------------------------------------------------------|--------------------------------------------------|---------------------------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| 1   | Artificial Intelligence, Universal Design for Learning, and Adaptive Learning for Students with Specific Learning Disorders: A Possible Synergy? | Lombardo Pontillo & Oliva (2025)                 | Systematic Literature Review                | AI, UDL, and adaptive learning can work synergistically to support students with SLDs. Deliberate design is needed to combine universality and personalization effectively. |
| 2   | A UDL-Based Approach to AI Chatbot Interaction for Young Adults with Intellectual Disabilities                                                   | Carruba, Caiazzo & Sapone (2025)                 | Qualitative Case Study                      | Co-designed AI chatbots with UDL and ICF frameworks improved accessibility, engagement, and usability of AI-based learning interactions.                                    |
| 3   | Advancing Personalized and Inclusive Education for Students with Disability Through AI: Perspectives, Challenges, and Opportunities              | Ahmed, Rahman, Kaiser & Hosen (2025)             | Systematic Review of Literature & Databases | AI-driven inclusive education tools enabled personalized learning, improved engagement, and supported integration into mainstream classrooms.                               |
| 4   | Enhancing Adaptive Learning with Generative AI for Tailored Educational Support for Students with Disabilities                                   | Farhah, Wadood, Alqarni, Uddin & Aldhyani (2025) | AI-driven Adaptive Learning System          | Generative AI created real-time, multimodal personalized content, enhancing learning outcomes, participation, and accessibility.                                            |
| 5   | Revolutionizing Inclusion: AI in                                                                                                                 | Habib, Jelani &                                  | Mixed Methods                               | AI-driven adaptive platforms (Text-to-                                                                                                                                      |

|   |                                                                                                                              |                   |                                           |                                                                                                                                                                   |
|---|------------------------------------------------------------------------------------------------------------------------------|-------------------|-------------------------------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------|
|   | Adaptive Learning for Students with Disabilities                                                                             | Najla (2022)      |                                           | Speech, VR, gamification) improved engagement and academic achievement, while highlighting ethical and accessibility considerations.                              |
| 6 | Transforming Special Education with AI: Innovations, Challenges, and Future Directions                                       | Raza, Alam & Alam | Systematic Literature Review              | AI tools such as adaptive platforms, social robots, and VR enhanced learning outcomes, engagement, and inclusion for students with diverse disabilities.          |
| 7 | Transforming 3rd-Grade Instruction: Six Practical Lesson Plans Framed Around AI and UDL to Promote Inclusive Learning Spaces | Gilbert (2024)    | Literature Review / Practical Application | AI platforms integrated with UDL provided personalized materials and scaffolded learning, improving engagement and reducing the need for separate accommodations. |
| 8 | The AI Scaffold and Engagement Spectrum as a Novel UDL-Aligned System for Supporting Students with Dyslexia                  | Ram et al. (2025) | Mixed Methods                             | AI scaffold and engagement spectrum enhanced autonomy, accessibility, and academic workflow, while embedding ethical checkpoints for responsible AI use.          |

Table (2) illustrates firstly how artificial intelligence is integrated within Universal Design for Learning (UDL) frameworks in special education and to what extent these integrations enhance accessibility and learner engagement. The reviewed studies demonstrate that AI is operationalized through a wide range of tools, including chatbots, generative AI content systems, adaptive learning platforms, and AI-based scaffolding mechanisms. These tools are steadily designed to support UDL principles by offering various means of representation, engagement, and personalized learning pathways, thereby responding to learner variability.

Secondly, Table (2) shows largely convergent outcomes dealing with the effectiveness of AI-powered UDL interventions, findings across the studies indicate largely convergent outcomes. Regardless of differences in context or disability type, most interventions conveyed improvements in accessibility, increased learner

engagement, and enhanced personalization of instruction. This suggests that AI-aligned UDL practices can effectively support learners with disabilities when pedagogical design is intentionally aligned with UDL guidelines.

Thirdly, the diversity of research designs, however, represented in Table (2)—including qualitative case studies, systematic literature reviews, mixed-methods approaches, and pilot experimental studies—also reveals pivotal research gaps and implementation challenges. The predominance of small-scale or exploratory studies limits the generalizability of findings and underscores the need for larger, longitudinal, and methodologically robust investigations.

Fourthly, Table (2) offers clear implications for educators, researchers, and policymakers. The consistency of positive results highlights the potential of AI-enhanced UDL practices to promote inclusive and equitable learning environments, while the methodological variability and reported challenges point to the need for clearer implementation frameworks, teacher professional development, and ethical guidelines. Thus, this discussion aligns with the four questions of the study.

#### **Strengths of the Study:**

In spite of those restrictions, the review is actually quite powerful in some aspects. It is possibly one of the earliest systematic reviews that concentrate solely on AI-based UDL interventions in special education, which in turn, offers a focused synthesis of accessibility and engagement outcomes. The use of the PICOS framework was instrumental in ensuring that the selection of studies was well-organized and clearly defined, while the systematic data extraction and quality appraisal enhanced the reliability and rigor of the findings.

The integration of evidence from various AI tools, different populations with disabilities, and diverse educational settings has made the review a comprehensive resource that illuminates the current trends, challenges, and opportunities in the use of AI for inclusive education. Moreover, the thematic synthesis reveals the practical insights that educators, policymakers, and researchers can use, thus, it becomes a valuable resource for the advancement of fair and engaging learning environments.

#### **Implications for Research and Practice:**

The findings of this study hold many implications for special education in both research and the practice field. The aggregation reveals that researchers require to carry out more rigorous empirical studies of AI-based UDL interventions for different groups of disabilities and various educational settings. The evidence to date is positive but only a handful of small-scale pilots, case studies, or qualitative analyses have been mainly cited. The follow-up research should be more focused on the effects over time, the use of standardized accessibility and engagement measures, and experimental research to determine which AI tools and strategies lead to the best outcomes. Besides that, the interaction of different disciplines like educators, technologists, and policymakers cannot be less than absolutely necessary for the creation of AI systems which are not only pedagogically viable but also ethically responsible and in line with UDL principles.

This study reveals significant implications for educational practice as it reveals the potential of AI to revolutionize personalized learning, accessibility, and student

engagement in inclusive classrooms. The employment of AI tools such as chatbots, adaptive learning systems, and AI-generated multimodal content can open up practitioners to make the learning process more flexible and individualized, yet still, guided by UDL. The current study also points to the importance of teacher training and professional development in making sure that AI integration is a help to human instructional guidance and not a replacement. Educators, therefore, via the careful utilization of AI, are empowered to elevate participation levels, remove learning barriers, and create a fair learning environment for their students with disabilities.

### **Timeline of the Review Process**

The review process was organized into phases to be comprehensive and systematic in dealing with the literature:

1. **Protocol Development (Weeks 1–2):** Setting the objectives, research questions, and defining the eligibility criteria using the PICOS framework.

2. **Literature Search (Weeks 3–4):** Locating the relevant articles through databases by using appropriate keywords and Boolean operators across the different sources.

3. **Screening (Weeks 5–6):** Looking through the titles and abstracts, and thus, discarding the studies which were not relevant and then selecting the studies for full-text assessment.

4. **Eligibility Assessment (Weeks 7–8):** Checking the full-text articles to inclusion/exclusion criteria; deciding on the studies to be included.

5. **Data Extraction & Quality Appraisal (Weeks 9–10):** Getting the data that was important from the studies, evaluating the quality of the methodology, and sorting out the differences.

6. **Data Synthesis & Analysis (Weeks 11–12):** Carrying out the thematic synthesis, recognizing the patterns, and compiling the results from the different studies.

7. **Writing & Review (Weeks 13–14):** Producing the review report, making the changes for clarity, and ensuring that the work fitted APA formatting.

### **Dissemination Plan**

The results from this systematic study will be shared through various means to attract a wide range of audiences such as the community of researchers, educators, and policymakers. Firstly, the review will be pitch to a peer-reviewed journal which is a subject matter expert in inclusive education, educational technology, or special education research. Secondly, results will be communicated at conferences and workshops which are focused on AI in education, adaptive learning, and accessibility. Thirdly, school leaders, special educators, and professional networks will be given access to summaries and key recommendations to guide the implementation of practice and policy. Moreover, the review can also be converted into an open-access report or a brief to make sure that the insights gained from the research are available to the practitioners and stakeholders who carry out AI-based UDL interventions in different educational settings.

## **Recommendations**

### ***Recommendations for Future Research***

- Researchers recommend conducting longitudinal and large-scale studies examining AI-based UDL interventions across different disability groups.
- Researchers recommend conducting studies to compare the effectiveness of specific AI tools (e.g., generative AI, adaptive systems, chatbots) in diverse educational settings.
- Researchers recommend utilizing standardized, disability-sensitive measures of accessibility, engagement, and learning outcomes.
- Researchers recommend investigating AI-UDL interventions in inclusive, special education, blended, and fully online learning environments.
- Researchers recommend to include learners with disabilities, educators, and families in co-design and participatory research models.
- Researchers recommend investigating ethical issues such as algorithmic bias, data privacy, and over-reliance on AI for vulnerable learners.

### ***Practice Recommendations***

- Researchers recommend utilizing AI-based reading scaffolds, text simplification tools, and multimodal generative AI to support learners with learning disabilities (e.g., dyslexia, dyscalculia).
- Researchers recommend implementing AI chatbots and structured adaptive platforms to support learners with intellectual disabilities through guided prompts, repetition, and functional skill development.
- Researchers recommend integrating AI-powered text-to-speech, speech-to-text, real-time captioning, and multimodal content tools for learners with visual and hearing impairments.
- Researchers recommend employing AI-driven adaptive learning systems with predictable routines and personalized pacing for learners with autism spectrum disorders.
- Researchers recommend applying AI-supported UDL strategies across K–12, higher education, and special education settings to offer multiple means of representation, engagement, and expression.

### ***Policy Recommendations***

- Researchers recommend formulating national or institutional policies that regulate the ethical and inclusive use of AI in special education aligned with Universal Design for Learning (UDL) principles.
- Researchers recommend establishing clear standards for approving AI educational tools based on accessibility, UDL alignment, pedagogical value, and evidence of effectiveness for learners with disabilities.

- Researchers recommend ensuring equitable access to AI-based learning technologies across all educational settings, including mainstream schools, special education centers, and higher education institutions.
- Researchers recommend the allotment of a sustainable funding for accessible digital infrastructure, assistive technologies, and AI-enabled learning platforms.
- Researchers recommend imposing mandatory professional development and certification programs focused on AI literacy, inclusive design, and ethical implementation for educators and school leaders.

### Conclusion

This study synthesizes findings from eight studies that examined AI-based interventions designed in the Universal Design for Learning (UDL) framework to improve accessibility and engagement in special education. The results show that AI tools, such as adaptive learning systems, generative AI platforms, chatbots, and scaffolding frameworks, are extremely capable of enhancing individualized learning, meeting diverse needs of the disabled, and increasing student participation in different educational contexts. AI-driven interventions offer multiple modes of representation, engagement, and expression that align with UDL principles and provide flexible and responsive educational experiences tailored to learner variability.

So, the study conveys that the successful marriage of AI and UDL is essentially the fruit of deliberate planning and execution. The outstanding question of how to perform accessibility and engagement, including ethical concerns like data privacy, algorithmic bias, and human control, were effectively addressed in those interventions that, besides AI technologies, also utilized pedagogical frameworks such as the International Classification of Functioning (ICF) or constructive alignment. The implementation of co-design or iterative feedback mechanisms in the studies led to heightened usability and engagement levels, thus suggesting that the proactive participation of learners and educators is a prerequisite for the success of AI-based UDL strategies.

This study concedes that there have been achievements in this area; nevertheless, it also signals that the field is still fraught with unresolved problems and challenges. The first of these being that most of the studies were limited in scale, duration, or were merely exploratory in nature, therefore, the results cannot be generalized. There is a strong need for detailed empirical investigations that involve large, diverse populations using standardized outcome measures and longitudinal evaluation to ascertain the sustained impact. Furthermore, issues such as teacher training, institutional support, and equitable access to AI technologies remain significant factors that determine the implementation of the intervention.

To summarize, the combined findings of this paper shed light on the fact that AI has the potential to radically transform special education by making it feasible to create personalized, engaging, and accessible learning environments. If AI measures align with UDL principles, they will have the capacity to cater to the different needs of individual learners while also facilitating inclusion, autonomy, and participation.

This review is a stepping stone for further investigation, educational practice, and policies that advocate for the ethical and fair use of AI in special education.

### **Limitations of the Study:**

Even though a rigorous methodology was followed, this study is limited in several aspects. To begin with, the analysis relies only on eight studies, which may affect the extent to which the results can be applied to different educational contexts and various types of disabilities. Moreover, the papers considered in the review used different research designs - qualitative, quantitative, mixed methods, and literature reviews - which made it impossible to carry out a meta-analytic synthesis and thus a narrative approach was used. In addition, the issue of short-term interventions, pilot programs, or specific AI tools was in most studies, thereby limiting knowledge of long-term effects and the potential challenges of a wider implementation. Last but not least, the review concentrates on works published in English and on those that are available in certain databases, and, therefore, some studies that have been published in other languages or in less attractive sources may have been left out.

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