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Exploring the Impacts of Universal Design for Learning (UDL) on Reading Comprehension: A Systematic Review of Literature

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Abstract

Universal Design for Learning is a framework which advocates for inclusivity and encourages learning for all learners through the minimization of instructional barriers and the ensuring of flexibility (Rose & Gravel, 2010). The integration of Universal Design for Learning principles and guidelines in reading comprehension instruction has gained considerable attention in recent years for its potential to improve diverse students´ learning achievements. Employing the UDL principles´, teachers can design and adapt an effective learning curriculum that supports literacy for all learners. The aim of this systematic literature review is to synthesizes the current research on the effectiveness of UDL in enhancing reading comprehension outcomes for diverse learners. This study utilized six comprehensive scientific databases to identify pertinent studies. Following the Preferred Reporting Items for Systematic Reviews and Meta-Analysis (PRISMA) guidelines, which will aid in the reporting and summarizing of the prevailing studies in a manner that is accurate and straightforward. 7 empirical studies were retrieved based on predefined criteria of inclusion, then the process of data extraction was managed using NVivo to extract relevant data from the studies. The findings revealed that UDL significantly improves the reading comprehension outcomes of diverse learners by providing multiple means of representation, engagement, and expression especially when supplemented with assistive technology and multimodal platforms. It has the potential to foster inclusive reading instruction; however, its successful integration is dependent on the presence of adequate teacher training, institutional support, and the demand for more resources to reinforce UDL´s implementation.

1. INTRODUCTION

Reading is considered as one of the most essential forms of communication and a complex area of language use (Snow, 2021). The aim of reading is to comprehend what is written and gain a broader spectrum of information from distinct situations and contexts. Mental representations of the events and situations depicted in the text are being built by the learners as they initiate their readings, and this enables them to associate and connect the information gathered with their background knowledge; it is constructed from the development of this substantial mental model which progressively accumulates and improves as individuals perform the act of reading (Castles et al., 2018). Hood et al. (2005) states that the ability to adequately read texts, can be a predictor of accomplishment in all other learning skills. A number of researches however

indicate that learners encounter difficulty in comprehending texts that are seen as complex (Biancarosa & Snow, 2004). Learners, who have a comprehension level that is deemed to be insufficient, endure difficulties when decoding and grasping particular aspects of reading (Irwin, 1991, 2007).

Reading comprehension is seen as a multifaceted process that necessitates pinpointing sources of difficulty, planning and developing educational strategies to ameliorate or mitigate these challenges (Kendeou, McMaster, & Christ, 2016; Klapwijk, 2015). To comprehend a text, a reader needs to perceptibly process words, recognize their representation, and apply syntactic rules to link them so as to grasp the sentences meaning, and this cognitive process is alluded to be a complex one (Perfetti & Stafura, 2014). According to Williams (1998), learners regard reading comprehension as a challenging task, and not as an activity for enjoyment or as an opportunity for knowledge development. It is primordial to introduce reading as a pleasant activity that is not solely utile in learners' academic journey but also as an occasion to be exposed to the development of society and culture. Hence, teachers' role is essential in encouraging and motivating students to read for pleasure (Merga & Ledger, 2019), they ought to apprehend the diversity of learners' characteristics and diverse learning styles when planning for and designing reading comprehension strategies that resort to an educational environment that is inclusive in nature.

One framework that tackles learners' diversity and forges an educational environment that promotes participation, access, and progress for students is universal design for learning (Meyer & Rose, 2000; Rose & Meyer, 2002). Universal design for learning is an instructional theoretical framework grounded in neuroscience and cognitive psychology and is perceived from an educational perspective; it accentuates flexibility and inclusivity, ensuring that instructional aims, materials and methods are obtainable by all, including learners with LDs (Hall, Meyer, & Rose, 2012; Meyer, Rose, & Gordon, 2014). UDL draws from the learning styles theory and tackles the learning needs of a wide range of learners and not only one particular group (Brokop, 2008; CAST, 2018). Although UDL was first intended to target learners with disabilities, research has confirmed that when implemented, it enhances learners' academic performance and achievement in any learning classroom (CAST, 2016).

UDL is formed around three fundamental principles which guide and aid the design and development of a curriculum that is inclusive for all learners by offering multiple means of representation, multiple means of action and expression, and multiple means of engagement. By designating areas where students are more likely to differ, these principles assist teachers in designing instruction that targets a range of learning needs (Meyer & Rose, 1998; Meyer & Rose, 2005; Rose & Meyer, 2000, 2002). Introducing UDL into educational practices can present some difficulties if the classroom in question leans towards conventional and traditional methods of instruction; the framework approaches the curriculum as a whole (goals, methods, and assessment) to render it attainable physically, intellectually, and emotionally (Hitchcock, Meyer, Rose, & Jackson, 2002; Jackson & Harper, 2005).

UDL is an effective framework for enhancing the reading performances of learners and increasing their engagement (Lowrey, Hollingshead, Howery, & Bishop, 2017). Acquiring access to information that is written is a basis for the social inclusion of distinct groups either

be those with cognitive disabilities or struggling readers. When it comes to learners, it is undeniable that a great number of them, including those not classified as special, face challenges with reading, handling distinct kinds of materials, and are unequipped for the intricacies of the materials they will confront (Snow, 2002). The students' level of reading comprehension can be impacted by different factors, including challenges with decoding, limited vocabulary, low motivation, and reduced self-esteem (Català et al., 2007; Kendeou et al., 2016; Klapwijk, 2015). To change and enhance learners reading outcomes, teachers need to change the manner learners read by implementing a novel set of comprehension strategies and skills that target students distinct learning styles (Taylor, Pearson, Perterson, & Rodriguez 2001; Wilson & Rupley, 1997).

The Implementation of UDL supports the holistic development of learners by instigating a motivated and goal-oriented student body. Its principles aid students become adept at identifying resources that align with their individual preferences (Alba Pastor, 2016; CAST, 2011). However, much of the literature on Universal Design for Learning (UDL) and reading comprehension concentrates on learners with disabilities. This emphasis highlights UDL's roots in special education and its objective to offer learning opportunities that are equitable for all learners, especially those with distinct learning needs. While UDL was first designed to address and support learners with disabilities, its principles are tailored to include students´ diverse distinct needs. This systematic review intends to propose a comprehensive understanding and examine the potential pertinence and effectiveness of UDL in general and special education classrooms to assist all learners, in spite of their special abilities. By delivering evidence-based insights, this review has the potential to aid educators tailor and adapt their approaches to benefit all learners, especially those with reading comprehension struggles.

This study attempts to address the research gap in the effectiveness of integrating UDL in a reading comprehension class by conducting an SLR to answer the hereby questions:

1) What is the present state of research on the effectiveness of integrating universal design for learning (UDL) in improving reading comprehension outcomes for diverse learners?
2) How does the integration of UDLs principles influence reading comprehension across different age groups and educational settings?
3) What are the perceived challenges and merits of its implementation?

2. METHOD

The present study employed a Systematic Literature Review (SLR), which is a methodology that reviews published works that are connected to a research question or a domain of interest (Petticrew & Roberts, 2005). This research method, which involves summarizing, evaluating, and synthesizing evidence to bring about comprehensive reviews on key issues, is relevant for the aims of this study (Borrego et al., 2014; Petticrew & Roberts, 2006). Moher et al. (2015) stated that an SLR employs precise and systematic methods to reduce bias up from the identification till the summarization of studies.

2.1.Study design

This systematic literature review (SLR) investigates the efficacity of implementing a universal design for learning (UDL) in a reading comprehension class by showcasing a description,

review, and analysis of its impact. The review follows PRISMA (Preferred Reporting Items for Systematic Reviews and Meta-Analysis), which provides guidelines that can craft comprehensive literature reviews. Its instructions encompass a 27-item checklist and a four-step flow diagram made to improve the quality of reporting in systematic reviews and meta-analyses (Moher et al., 2009).

Inclusion and Exclusion Criteria:

The inclusion and exclusion criteria outlined below were applied to maintain a clear focus on the area of interest and ensure the eligibility of the articles to be included.

Inclusion criteria

- Articles that are indexed in the Scopus database
- Scholarly or peer reviewed articles
- Empirical studies
- Published in English
- Implemented UDL in reading comprehension instruction

Exclusion Criteria

- Duplicates
- Published in a language other than English
- Studies that are not empirical
- Studies that did not account for the implementation of UDL and its outcomes

2.2.Search Procedure

This study utilized six comprehensive scientific databases, Scopus, Web of Science, ScienceDirect (Elsevier), ERIC (ProQuest), JSTOR, Taylor and Francis to identify pertinent studies. These databases were selected due to their reliability, their broad disciplinary coverage, and significance to the topic. The search was conducted on August 24th 2024, and was designed to encompass a wide array of studies across multiple databases within the time frame of 2000 to 2024, by using a blend of controlled vocabulary, keywords, and Boolean operators as shown in Table 1.

Table 1

Search String Employed During the Search

Databases	Search String	Limiter	Results
Scopus	TITLE-ABS-KEY (("Universal Design for Learning" OR "UDL") AND ("reading comprehension" OR "literacy"))	None	94
Web of Science	("Universal Design for Learning" OR "UDL") AND ("reading comprehension" OR "literacy")	Language	88 ➡ 82
ScienceDirect (Elsevier)	("Universal Design for Learning" OR "UDL") AND ("reading comprehension" OR "literacy")	None	3
ERIC (ProQuest)	("Universal Design for Learning" OR "UDL") AND ("reading comprehension" OR "literacy")	Peer Reviewed	90 ➡ 57

JSTOR	("Universal Design for Learning" OR "UDL") AND ("reading comprehension" OR "literacy")	Language	494 ➡ 426
Taylor and Francis	[[All: "universal design for learning"] OR [All: "UDL"]] AND [[All: "reading comprehension"] OR [All: "literacy"]	None	448

2.3.Study Selection Process

After the completion of the databases search, the study selection procedure commenced and was conducted following the PRISMA guidelines, which will aid in the reporting and summarizing of the prevailing studies in a manner that is accurate and straightforward, and managed utilizing Zotero a reference management software.

Identification:

All the results obtained from distinct databases were exported in RIS format and imported into a reference manager tool named Zotero, then the following steps were followed to organize the data; a library titled “UDL implementation in reading comprehension SLR” was created, then subfolders were devised amidst this library for each database. Search strategies were also documented for each subfolder, including the terms and filters employed.

Screening:

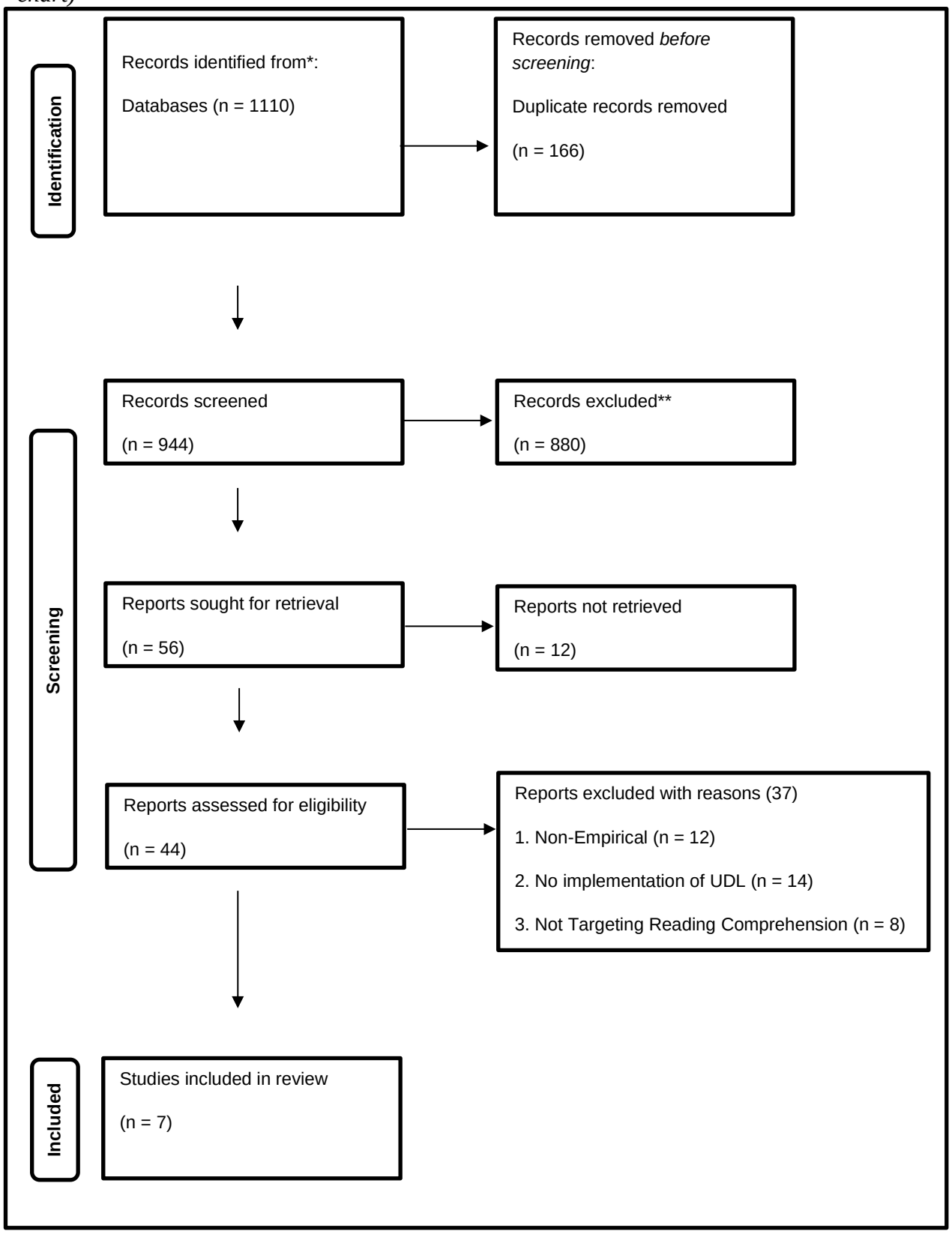
During the article screening and selection procedure, the search results imported into Zotero were screened to detect and eliminate duplicate records using the application´s duplicate detection feature. This action resulted in the reduction of the initial count of records from 1110 to 944 individual references. The next step involved the reviewing of titles and abstracts to assess which ones fit the predetermined criteria. The criteria for inclusion focalized on scholarly indexed articles as the main source for empirical data; published in English amid the time frame of 2000 to 2024. The remaining 944 articles were screened utilizing the tagging system of Zotero, as included or excluded, then each record was sorted with added notes explaining their inclusion or exclusion to avoid confusion and inaccuracy. After complying with the beforementioned criteria of inclusion/exclusion (Table 1), a substantial account of articles was excluded from the review and the remaining number declines to 56 with 8 records removed when found duplicated.

Eligibility:

In this stage, the missing full texts of the records were first retrieved and attached to their corresponding documents in Zotero, then the titles, abstracts, and full texts of the 56 remaining records were examined meticulously to ascertain that they met the criteria for inclusion. Studies with no full text available were eliminated. Following the in-depth inspection, a total of 7 articles met the inclusion criteria and were selected for further examination.

Figure 1

Prisma Flow Chart (Systematic review process (adapted from Moher et al. 2009 PRISMA flow chart)



2.4.Quality Assessment

The quality of the designated studies was appraised utilizing the guide of Connolly et al. (2012). The process of the quality assessment was done by two reviewers, and the articles were then evaluated and assessed according to the five-dimension criteria of comprisal; the research

design adequacy to address the research questions, the methods and analysis´s appropriateness, findings generalizability, relevance of the study´s focus in addressing the research questions, and credibility of the study´s findings. Based on these five dimensions it was found that all the included records met the criteria of comprisal.

2.5.Data Extraction and Analysis

The process of data extraction was done using NVivo to extract relevant data from the designated studies. The full texts were imported into NVivo, then a coding framework was incorporated based on the research questions at hand. It comprised nodes like `participants´, `country´, aim of the study´, `research methodology´, `results´, `age groups´, `study design´, educational level`, `implementation challenges´, `implementation merits´ and so on. Each study was coded and categorized following these criteria, enabling a thorough systematic analysis of the data. Then, a framework matrix was generated and two tables summarizing all the forementioned information were extracted.

The analysis of the data was first conducted using NVivo. This allowed for the identification of patterns associated with the effectiveness of UDL, its influence across distinct age groups, and its implementation´s merits and challenges through thematic coding.

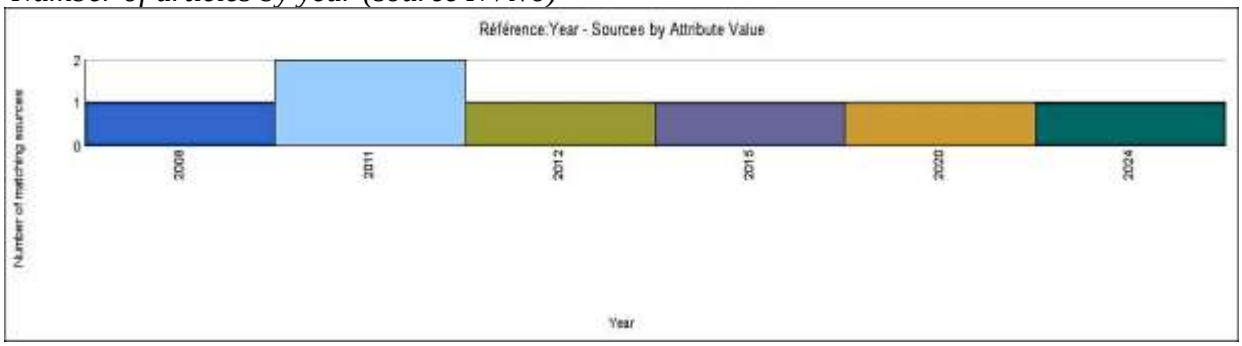
3. RESULTS

Following a comprehensive process of screening and eligibility process, a total of 7 reviewed studies were incorporated in the final analysis. The results section comprises two main parts. The first one is a descriptive account of the data gathered from the reviewed records and an answer to the first research question, while the second part addresses the remaining research questions and key findings identified.

3.1.Descriptive overview of the reviewed studies

Figure 2

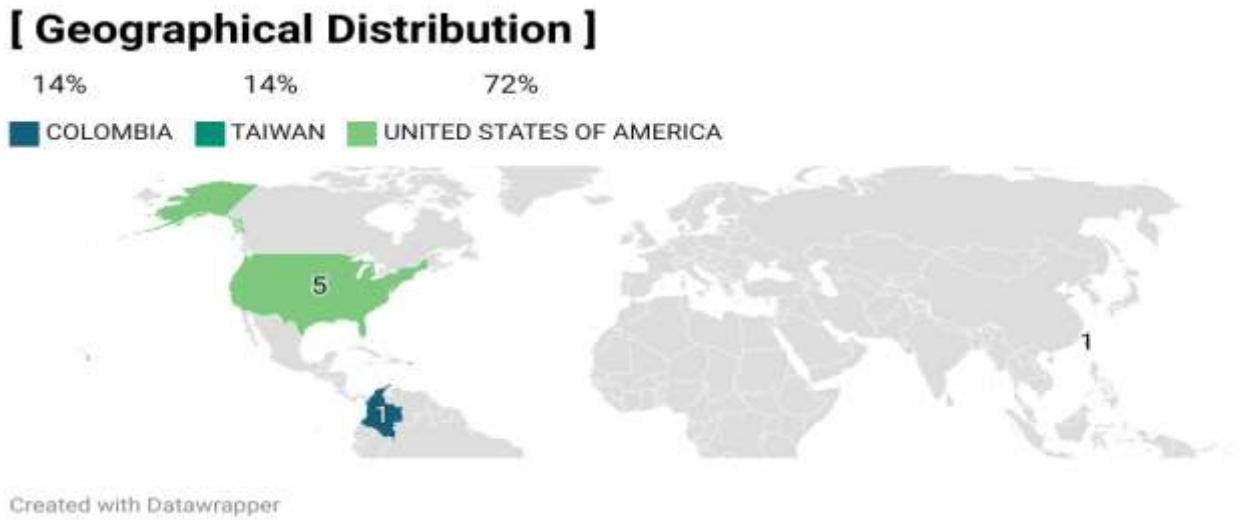
Number of articles by year (source NVivo)



Based on figure 2, the reviewed records are distributed across several years. Bowder et al. (2008) conducted one study, while Chien-Chuan Ko et al. (2011) and Dalton et al. (2011) each provided one source. Coyne et al. (2012) contributed with one source, followed by Hall et al. (2015) with one source. Daley et al. (2020) also released one paper, and Nieves et al. (2024) published one source, reflecting the distribution of research related to UDL and reading comprehension over time.

Figure 3

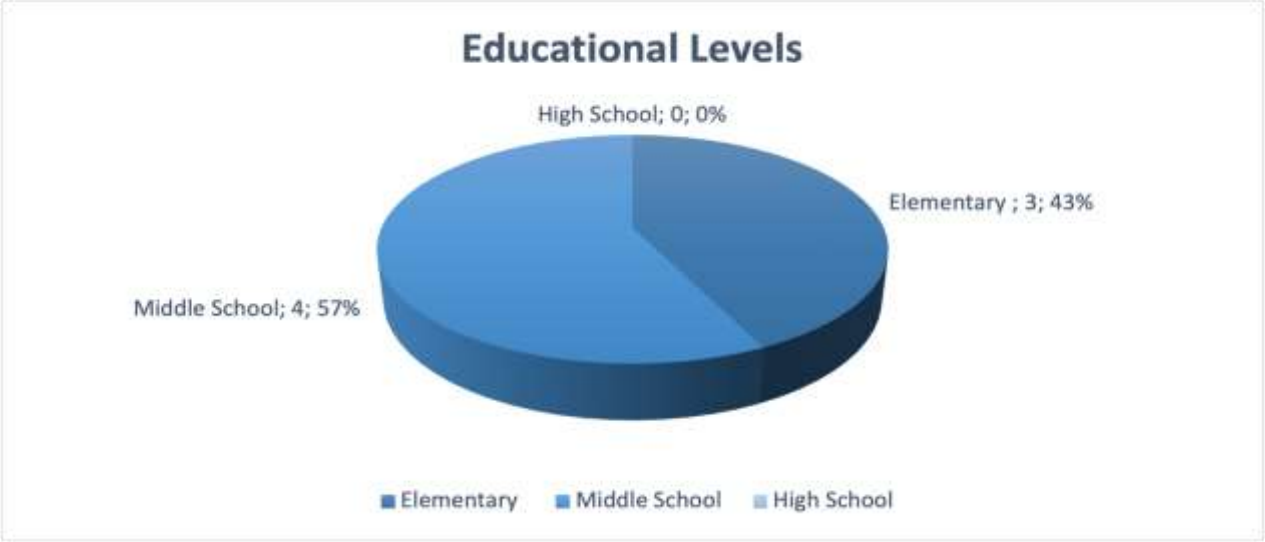
Geographical distribution of the studies.



This systematic review included a total of 7 studies, published between 2008 and 2024. In terms of their geographical distribution, a good number of studies (72%) were conducted in the United States, with others deriving from countries like Colombia (14%), Taiwan (14%).

Figure 4

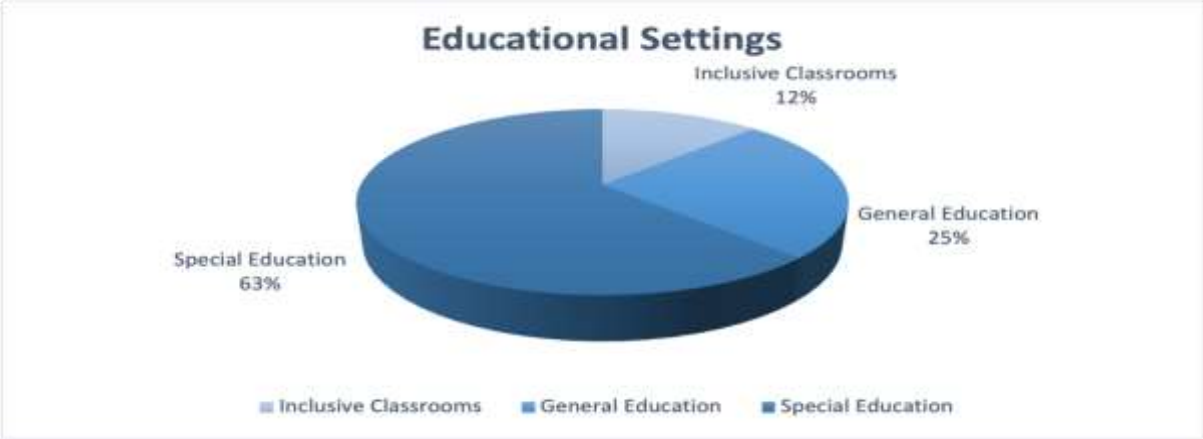
The Educational Level of the Reviewed Studies.



The educational level varied across the studies as can be seen in figure 4, with the majority conducted in middle schools (57%). 43% of the studies took place in elementary education while none were found in high schools.

Figure 5

The Educational Settings of the Reviewed Studies.



The hereby figure illustrates the distribution of the reviewed studies across three educational settings. The majority (Chien-Chuan Ko et al. (2011), Browder et al. (2008), Hall et al. (2015), Daley et al. (2020), Dalton et al. (2011)) accounting for 63%, focus on special education environment. General education (Hall et al. (2015), Nieves et al. (2024)) follows, constituting 25% of the total, while similar inclusive education represents the smallest section (Daley et al. (2020)) with a percentage of 12%. This dispersion demonstrates that there is a predominate emphasis on special education in the research, with significantly less attention given to general and inclusive education.

3.2.Main Findings of the reviewed studies

Figure 6

Word Cloud of the most used keywords in the database (Based on Abstract Analysis)

The figure represents a word cloud generated from NVivo, it shows the frequently occurring words or themes from the dataset addressing reading comprehension, Universal Design for Learning (UDL), and Literacy research. It illustrates a preliminary analysis that would aid in the identification of the most frequent topics and themes to enable deeper analysis and interpretation. Based on the thematic mapping from the word cloud and detailed reviewed studies in table 3 (see Appendix B), the analysis approaches and tackles each research question respectively.

3.3. Effectiveness of UDL in Improving Diverse Learners Reading comprehension

the present state of research on UDL´s effectiveness emphasizes a persistent focus across multiple studies that applying UDL principles significantly improves and strengthens reading comprehension for learners with diverse learning needs. These distinct learners encompass those with disabilities, English language learners, and learners facing academic challenges. The adoption of UDL principles has exhibited immense improvements when it comes to students´ reading comprehension by means of bestowing diverse manners of presenting the learning materials, multiple means of engagement, and differentiated approaches to express understanding. Through multimodal instructional approaches, learners are given flexibility when engaging with reading materials.

Concrete examples of the ways UDL interventions have favourably influenced learners who present intellectual/physical disabilities and those who have language barriers have been identified in the studies of Chien-Chuan et al. (2011), Coyne et al. (2012) and Bowder et al. (2008). Bowder et al. (2008) that proclaim that by drawing from UDL principles, the read aloud lessons are planned in a manner that is inclusive for learners with severe disabilities. Also, students who employed UDL aligned strategies, enhanced their independent responses and comprehensive engagement with the reading activities. Daley et al. (2020) also revealed that middle school learners who faced reading challenges showcased notable development when employing UDL supported platforms that integrated text to speech tools and supported reading behaviour. Likewise, Coyne et al. (2012) discovered that the implementation of UDL principles in the LBD instructional approach exhibits positive improvement in the reading comprehension of learners with significant intellectual detriments. UDL based e-books that incorporate text to speech (TTS) and interactive comprehension prompts were identified as effective in the improvement of students with disabilities´ reading outcomes.

A significant aspect of UDL´s efficacity is the use of assistive technologies. The integration of technology in a UDL based environment was a prevalent theme across the studies. Hall et al. (2015) indicate how digital tools embedded in UDL frameworks, as the Strategic Reader, that promoted to a highly responsive comprehensible learning environment. The design of the web based Strategic Reader tool was intended to find whether incorporating curriculum-based formative assessment into an interactive digital reading, universally designed environment, would enhance and better learners' outcomes. The results of this research establish the efficacity of the use of technology to integrate both UDL and CBMs for learners with LDs and also its importance in strengthening reading comprehension for all learners. Daley et al. (2020) likewise built their study on the principles of a universally designed for learning digital literacy platform; Udio is a supplemental intervention that was designed to promote engagement and

autonomy in an online reading environment. The technology application permitted for a real time development monitoring and granted flexible scaffolding, which prompted an improvement in learners´ comprehension regardless of their ability. Chien-Chuan et al. (2011) highlights that incorporating tools as text-to-speech (TTS) software and digital scaffolding in reading let to an enhancement of their comprehension, especially when it comes to decoding and word recognition. This strengthens the position that technology-based UDL environments are efficient in furthering access and comprehension.

3.4. Influence of UDL Across Distinct Age Groups and Educational Settings

The research demonstrates that the integration of UDL principles in reading comprehension differs in its impact and extends across a wide range of educational settings and age groups. The influence of UDL was observed to more pronounced among young learners (elementary to middle school) in special inclusive settings.

A number of studies highlighted UDL´s implementation in elementary classrooms (Browder et al., 2008; Chien-Chuan Ko et al., 2011; Coyne et al., 2012). The studies found that young learners in an elementary setting demonstrated an increase in motivation and engagement, which in turn lead to an enhancement of comprehension. Chien-Chuan et al. (2011) established that the TriAccess e-reading system implements UDL´s principle of multi-representation to provide learners with learning difficulties an access to reading materials. The integration of auditory and visual aids tailored to fifth and sixth grade learners was a cornerstone in the positive results obtained.

Research studies like Hall et al. (2015), Nieves et al. (2024), Daley et al. (2020), and Daley et al. (2020) depict the adaptability of UDL for somehow older students, where the importance shifts to granting cognitive and motivational aid. Hall et al. (2015) ascertained that the Strategic Reader had an impact in inclusive middle school classrooms. The study showed that learners in grades 6 to 8, counting those with learning disabilities, profited from UDL´s flexible framework. This designated framework permitted for the tailoring of multiple modes of expression (e.g., oral recordings, multiple choice questions and so on). Nieves et al. (2024) further indicate the effectiveness of UDL for middle school learners through the adaptation of texts to Easy-to-Read formats and supplying different forms of interaction like visual glossaries and audio supports; these are beneficial in that they promote deeper engagement and comprehension.

UDL´s influence is notable in general education classrooms, recurrently in co-taught or inclusive settings. This can be seen in the study of Dalton et al. (2011) in which the use of UDL in bilingual classrooms is stressed, where bilingual and monolingual learners with distinct literacy abilities were subjected to UDL based reading strategies as questioning, summarizing, and predicting. The study discovered that UDL developed reading comprehension for all learners through its integration of linguistic diverseness through bilingual texts and pedagogical means. The UDL framework aims to render learning accessible for all learners by offering a multitude of ways to access and engage with the learning materials. Several studies, as Bowder et al. (2008) and Coyne et al. (2012), highlighted UDL´s ability to build a reading environment that is inclusive for learners with cognitive, physical, and learning disabilities. UDL enables learners with disabilities to access the same reading content as their peers,

through the incorporation of assistive technologies as adaptive learning, screen readers, and interactive text platforms, thus decreasing the gap in reading comprehension results.

3.5. Perceived Merits and Challenges of UDL Implementation

There were numerous challenges observed in the reviewed studies that were related with the implementation of Universal Design for Learning (UDL). Bowder et al. (2008) put emphasis on the challenge of logistics, especially the difficulties faced when attempting to procure assistive devices as AAC (Augmentative and Alternative Communication) tools within a certain timeframe. This resulted in the limitation of the one-on-one instruction efficacy. The study of Chien-Chuan Ko et al. (2011) highlighted the necessity for a deeper comprehension that will best address particular disabilities, accentuating UDL´s need for tailored approaches to attain a successful implementation. Coyne et al. (2012) addressed problems in documenting the fidelity of software usage because of sporadic teacher reporting. This impeded learners´ interactions with UDL-based e-books, and in turn this lack of documentation restricted important analysis that could have improved e-book design and instructional practices. Daley et al. (2020) further observed a limitation in the measurement of UDL´s influence, ascribed to learners´ autonomy in choosing activities which confounded the interpretation of engagement and its relation with the intended outcomes. The last study that reported challenges was the one of Hall et al. (2015). It was revealed that there was variability in the instructional environments across classrooms, where inconsistent use of novels from the Strategic Reader were observed, which posed a challenge when analysing and evaluating the influence of UDL on reading outcomes. These challenges showcase a range of pedagogical, logistical, and measurement related barriers to UDL´s implementation and reading comprehension attainment in general.

Regardless of these impediments, the positive impacts of UDL on learners reading comprehension, engagement and motivation are numerous. a key asset that was consistently mentioned and endorsed across the studies was UDL´s potential in providing multiple means of engagement. For instance, Nieves et al. (2024) established that when learners were exposed to UDL principles adapted Easy-to-read texts, they exhibited improved comprehension; visual, auditory and interactive aids and supports strengthened learners' interaction with the designated texts as well as furthered their lexicon. With the use of these UDL-supported strategies, students were offered numerous access points to engage actively with the reading texts and encouraged to participate in the learning process. Daley et al. (2020) highlighted the importance of utilizing interactive and game-based materials within a UDL framework so as to increase learners' motivation.

Dalton et al. (2011) also stressed the significance of integrating bilingual supports within a UDL based framework to permit both bilingual and monolingual learners to enrich and enhance their comprehension of reading texts. One of UDL key merits resides in its inherent flexibility to easily adjust to the linguistic background and cognitive abilities of the students distinctly in diverse classrooms. Hall et al. (2015) demonstrated the potential of UDL to be implemented into wider curricula. This can only happen if educational institutions invested in teacher training and technology integration. Tailored universal-e-learning platforms as well are instrumental in scaling the influence of UDL on the reading outcomes of diverse students.

The aforementioned findings validate the effectiveness of UDL principles implementation in improving diverse learners reading comprehension outcomes; its impact is particularly witnessed when correlated with technological tools. While there are a number of challenges, this does not undermine the efficacity of its implementation; improved engagement, flexibility, autonomy, and inclusion are amongst many other merits that render UDL a promising approach.

4. DISCUSSION

This paper´s purpose is to conduct a systematic literature review of a number of empirical studies (n= 7) that have investigated Universal Design for Learning´s (UDL) integration in reading comprehension and its effectiveness on diverse learners across distinct educational settings. One of the findings encountered relates to the distribution of the published articles overtime; this reveals that not many articles pertaining to the topic of this systematic review have been undertaken. In recent years, UDL´s principles enabled the creation of ways to render reading lessons more practical and accessible (Centre for Applied Special Technology, 1998). This accessibility and diversity prospects did not influence the educational domain until the early twenties when Kentucky, Ohio, New York, and California embraced UDL´s principles and guidelines to attend to learners' diverse needs, principally those with physical disabilities (Muller and Tschantz, 2003). Now, UDL has started being perceived as a useful framework to further the reading achievement and engagement of learners (Lowrey, Hollingshead, Howery & Bishop, 2017). Another prominent finding observed, is in terms of the geographical distribution of the distinct studies; a good number of the studies were conduct in the United-states while others in Asian and European countries. This affirms how certain of these countries particularly the United-states are more inclined towards a socio-educational model that adheres to the adoption of an inclusive environment with the aid of Universal Design for Learning (Boothe et al., 2018; Rogers-Shaw et al., 2017). This diverseness is not abundantly witnessed in the Arab countries, it is still somehow novel (Mohaidat et al., 2020).

A further result relates to the educational settings in which the studies were carried; it was found that the majority were conducted in middle schools followed by elementary ones while none were found in high schools. UDL has been in fact scarcely implemented in secondary education, either be it addressing reading comprehension or other areas of education. Studies that examined the application of UDL in secondary education emphasized the lack thereof, to reasons pertaining to teachers´ confidence, professional training, resources´ scantness, curriculum rigidity, and administrative assistance (Adams, S et al., 2021; Capp, M. 2020; Meyer et al., 2014; Flood, M. et al., 2021).

The positive impacts of UDL on learners´ reading comprehension were confirmed by the reviews´ findings. This aligns with existing literature that marks UDL as a framework designed to strengthen the teaching and learning process as well as accommodate a wide array of distinct learners with its foundational principles of engagement, representation, action and expression (Meyer, Rose, & Gordon, 2014). Bowder et al. (2008) and Coyn et al. (2012) show that by following UDL guidelines, learners with disabilities and other challenges were able to meaningfully engage and interact with the provided reading materials. This occurred because students were provided with the necessary and needed supports to easily access the curriculum; the use of the three key principles of UDL ensures that learners are not excluded from the

learning process regardless of their abilities. This affirms UDL´s potential in reducing barriers, increasing learning opportunity and promoting a learning environment that is equitable for all learners (Meyer et al., 2014).

The results of the analysed studies reveals both overarching consistencies and divergences in the effectiveness of implementing UDL in reading comprehension instruction. While the studies highlight and support the benefits of UDL´s integration in fostering engagement and providing a learning that is flexible and multimodal in its experience, certain inconsistencies are witnessed in terms of UDL´s degree of effectiveness and factors that influence its implementation. These disparities are mainly linked to technology use, scaffolding and teacher mediation. Coyne et al. (2012) and Chien-Chuan Ko et al. (2011) both argue for the valuable use of technology to support UDL´s implementation through web-based platforms and adaptative e-books. Coyne et al. (2012) however emphasises discrepancies in the manner these software-based UDL supports were employed by the learners, indicating that sporadic usage patterns posed a difficulty when it came to tracking fidelity. Likewise, Browder et al. (2008) noted how delays in the acquisition of assistive technology devices predominantly limited learners´ ability to fully become engaged with UDL strategies; studies in which a digital learning environment was already established, this challenge was not witnessed. Regarding the role of teacher mediation, Hall et al. (2015) indicated that UDL´s efficacity is dependent on teachers´ guidance and the use of strategic scaffolding to improve comprehension achievements. Contrastingly, Daley et al. (2020) contended that the extent of the autonomy given to learners during UDL-driven activities can impact learning outcomes, and in turn hinder the effectiveness of structured instruction. Herein, Nieves et al. (2024) proposed that motivation strategies and direct feedback are consistent predicators in sustaining engagement and comprehension, indicating that continuous teacher scaffolding and mediation results in a UDL based reading lesson that is most productive, rather than a purely student-driven one.

UDL fosters meaningful retention of the reading materials by offering adjustable support structures that accommodate individual learning needs. Learners with disabilities who were presented with adaptative technologies, as digital readers (LBD e-books, Strategic Reader and so on), text-to-speech (TTS) tools, and different modes of assessment, had a chance to improve their reading comprehension. This corroborates well with the way technology can support multiple means of representation and permits learners to have a choice in whether or not to interact and engage with the learning content for assistance and guidance (Daley et al., 2016; Marino, 2009; Marino et al., 2010; Robinson, 2017). In terms of multiple means of action/expression, technology use enables learners to have more opportunities to be expressive of their learning (Daley et al., 2016, 2020; Hitchcock et al., 2016; Marino et al., 2014; Robinson, 2017; Smith et al., 2020). This resonates with Hall, Meyer, and Rose (2012) research which stressed the significant role that technology plays in reinforcing UDL´s strategies. Herein, it can be observed that UDL not only supports academic achievements but as well accommodates significant educational objectives of inclusion and equity through the accordance of technological tools that can reinforce learners´ confidence and engagement with the designated learning materials (Hitchcock et al., 2016).

A notable finding of this systematic review is UDL´s applicability across a broad range of distinct age groups and educational settings. This maintains its standing as an adaptable, all-

encompassing learning framework. The included studies extended across elementary to middle school settings in both general and special inclusive environments. This proves that UDL is adjustable to various contexts, for instance, Chien-Chuan Ko et al. (2011) and Nieves et al. (2024) demonstrate how UDL can improve and support younger students in elementary classrooms, whilst Hall et al. (2015) studied its pertinence in middle school education. The developmental and cognitive requirement of learners at various phases of their education, is in line with UDL´s comprehensive applicability. Taking younger leaners as an example, they were shown to profit from multisensory approaches like the TriAccess e-reading system, which grants diverse modes of representation for students who face challenges in traditional classrooms (Chien-Chuan Ko et al., 2011). While students proceed to middle school settings, UDL´s emphasis moves towards strategic engagement and self-regulation as highlighted in Hall et al. (2015). These students were provided with a learning environment that is responsive and that reduces barriers. This indicates that even if UDL´s principles and guidelines are unvarying, its application is adaptable to the developmental wants and needs of different learners.

4.1. Limitations

While this systematic literature review synthesizes and presents a comprehensive body of research, certain limitations need to be acknowledged within the literature. A first limitation was observed in terms of the scarce number of studies found that address the implementation of UDL´s principles in a reading comprehension classroom. There is a lack of empirical research in this area; further research is needed to better analyse and understand the impacts this intervention has on learners´ reading achievements. The sampling strategy also was limited in that only six comprehensive scientific databases were employed and the records retrieved related only to empirical ones discarding conference papers, book chapters, dissertations and any other non-empirical publications. Lack of longitudinal data and measurement difficulties also presented limitations, particularly when distinct assessment methods were employed across the intended studies and therefore challenged the comparison of the findings directly. Also, a number of studies failed to track learners progress subsequent to the intervention period, which left the long-term effects of UDL-based instruction a mystery. Future research should focus on standardizing assessment tools so as to provide more rigorous comparisons of UDL´s benefits; performing longitudinal research can allow the assessment of reading comprehension retention over years and impart perceptions into the lasting effects of UDL instructions. Moreover, most of the reviewed studies were conducted in North American, European, and Asian educational studies while none were observed in middle eastern ones. This denotes that findings may be influenced by factors that are not truly indicative of global classrooms. This geographical distribution limits the generalizability of the findings to distinct educational settings. Additional research is necessary to appraise UDL´s impacts in resource-limited settings and diverse cultural and linguistic settings; moving beyond resource-available, English predominant environments will aid in rendering UDL-based reading intervention a universal approach.

4.2. Implications and Directions for Future Research

The findings of this systematic literature review possess significant implications for both research and educational practice, it also has revealed significant gaps in the literature that ought to be addressed by future research. Longitudinal studies first are needed to assess the long-term effects of UDL on reading comprehension achievements of diverse learners. Future research is needed to highlight how UDL can be adapted in distinct diverse geographical and cultural contexts; also, assistive technologies that make use of UDL guidelines provide an opportunity for learners to study in an environment that is flexible; the included studies have analysed the integration of UDL features within instructional technologies and how they can enhance students´ retention of the reading materials. More research is then required to examine how these UDL-based features are employed by learners in a digital reading environment to increase motivation and comprehension. This instructional design framework can be adapted and redesigned by instructors so as to find ways to reduce learning barriers and improve effective practices. The current study affirms the feasibility of utilizing and incorporating UDL principles in a reading comprehension lesson; however, additional research is necessary to confirm its accuracy and impactful implementation in various educational settings, particularly in non-Western contexts where the challenges of inclusive education linger and are more pronounced.

5. CONCLUSION

This systematic literature review has explored the effectiveness of implementing UDL principles in a reading comprehension class so as to improve diverse students´ achievements. The analysis of 7 studies reveals the promising impacts of UDL as an approach to enhance reading comprehension, specifically for learners with disabilities, cognitive impairments, and English language learners. The framework´s success lies in its flexibility and inclusivity, enabling learners to interact with the reading materials through several means of representation, action, and engagement. It also supports their diverse needs by adapting to their individual strengths and preferences. While UDL has the potential to establish a more inclusive and accessible environment for learners, its efficacity depends on the systematic integration of its principles into curricula, teacher training, and institutional endorsement. Further research is required to assess the long-term impact of the framework and its applicability in diverse contexts.

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Appendices.

Appendix A

Table 2. Review of the Included Studies (Source: NVivo)

	G : Setting	*H : Year*	*B : Participants' Information*	*C : Purpose*	*D : Research Instruments*	*E : Research Methodology*	*F : Research Problem*	*A : Findings*
1 : Browder et al., (2008)	In a special education classroom In the southeastern United States	2008	The class encompassed nine students, all of whom suffered from complex, multiple disabilities such as medical concerns.	The purpose of this study was to show a method for planning and implementing shared stories for students with multiple disabilities that incorporated both task analytic instruction and team planning using principles of UDL.	No explicit research instruments	A multiple probe single subject design across participants. Quantitative	"Read alouds may be a critical means for students with severe disabilities who do not become independent readers to access literature throughout their lives. However, incorporation of assistive technology, selection of age-appropriate books, and physical and cognitive adaptations of books may be needed to make them fully accessible. The use of these instructional methods may be some of the ways the shared story may vary for this population. that used shared stories with students with severe disabilities" (Bowder et al., 2008)	Outcomes indicate that all three students improved literacy skills and added to the literature base that shared stories can promote early literacy.

	G : Setting	H : Year	B : Participants' Information	C : Purpose	D : Research Instruments	E : Research Methodology	F : Research Problem	A : Findings
2 : Chien-Chuan Ko et al. (2011)	southern Taiwan	2011	Thirty learners (20 boys and 10 girls) in fifth and sixth grades	this study was set to develop an individualized e-reading environment that can provide not only essential support for Mandarin readers but also a convenient interface that allows material developers to create adjustable material. (Chien-Chuan Ko et al., 2011)	interviews tests	A within-subjects, repeated-measures design was employed two-way repeated-measures ANOVA Quantitative Methodology	The strategies were proven effective by past studies, existing assistive reading software could only offer separate strategies (Chu, Li, & Chen, 2002; LoPresti et al., 2004)..There has been no integrated system that can simultaneously provide physical, sensory, and cognitive access and none has especially focused on Mandarin learners with cognitive disabilities.(Chien-Chuan Ko et al., 2011)	The results indicated better comprehension performance when the participants read with cognitive support.
3 : Coyne et al. (2012)	New England states	2012	16 students with intellectual disabilities in Grades K-2.	No explicit Purpose stated	pre- and posttest	quantitative Analysis	Dalton and Coyne (2002) developed an e-book prototype that permitted students to be highly engaged by the e-books and be able to navigate the interface and use the various supports; however, this study did not assess the effect on reading achievement. To address this gap in theory and research on UDL, the current study investigated the effect of LBD, a universally designed approach to literacy instruction.	The results of the LBD project add to a small but growing body of research demonstrating the potential value of comprehensive literacy programs for children with significant intellectual disabilities that address five core aspects of literacy-phonemic awareness, phonics, fluency, vocabulary, and

	G : Setting	*H : Year*	*B : Participants' Information*	*C : Purpose*	*D : Research Instruments*	*E : Research Methodology*	*F : Research Problem*	*A : Findings*
								comprehension (Erickson et al., 2009).
4 : Daley et al. (2020)	United States	2020	Participants included 315 students in grades 6, 7, and 8	The purpose is to report on how middle-school readers identified as having reading difficulties, engaged with literacy activities in a yearlong implementation of a supplemental UDL-based digital literacy platform.	The RAPID reading comprehension subtest post-test pretest	No explicit research methodology	Despite increased focus on the needs of adolescents with reading difficulties in recent years, improving reading comprehension has been exceptionally difficult for this population (Biancarosa & Snow, 2006; Kamil et al., 2008; Roberts, Fletcher, Stuebing, Barth, & Vaughn, 2013). Recent calls for action have broadened conceptualizations of what it takes to address lagging literacy skills in middle school by increasing attention to engagement and motivation. (Daley et al., 2020)	An interaction effect indicated that students who started the year with lower reading comprehension skills were likely to benefit more from higher reading-related behaviors and more use of text-to-speech than those starting with relatively higher comprehension skills. Indeed, UDL has its roots in arguing that when we design for those in the margins of traditional distributions, instruction better reaches all students. (Daley et al., 2020)

	G : Setting	H : Year	B : Participants' Information	C : Purpose	D : Research Instruments	E : Research Methodology	F : Research Problem	A : Findings
5 : Dalton et al. (2011)	The Payton school district and the Winter school district USA	2011	Six fifth-grade teachers and their classes participated in the study, a sample of 106 students.	No explicit Purpose stated	Pre- and postintervention standardized reading achievement tests. ANCOVA Gates-MacGinitie Reading Test ICON strategic digital reading environment, Versions 1, 2, and 3.	No explicit research methodology	"Research on scaffolded digital text comprehension has tended to focus on one component or the other, leaving much to be learned about the relative contribution of reading strategy and vocabulary scaffolds in digital texts that are designed to improve comprehension. Furthermore, even less is known about the potentially differential effects of these kinds of digital scaffolds for bilingual and monolingual students with varying language and literacy abilities. To address this gap in the research on technology-mediated reading and comprehension, we designed three versions of ICON". (Dalton et al., 2011)	"Results indicated that after controlling for initial reading achievement, there was a main effect for condition on the researcher measure of vocabulary, with the combination and vocabulary groups both significantly outperforming the strategy group. There was no effect of condition on comprehension, nor was there an effect of language status on narrative comprehension. However, there was a main effect of language status on expository text comprehension and standardized vocabulary achievement, with monolingual students performing more strongly than bilingual Spanish-speaking students" (Dalton et al., 2011)
6 : Hall et al. (2015)	United States	2015	14 classrooms with a total of 307 students.	Researchers designed this study to analyze the synergy between two proven approaches: UDL and CBM	Strategic Reader with online CBM) Pre and post-tests using the Gates-MacGinitie	A mixed-method study design, of quantitative and qualitative methodology was used.	"Teachers are in need of innovative supports, strategies, and tools that will make it possible to meet the educational needs of all students. In researching and developing universally designed learning environments since the 1980s, CAST has sought to fundamentally alter the relationship between children and literacy by using technology to embed reading strategy instruction directly into high quality educational	"Research results from this experimental study demonstrate (a) the effectiveness of the general approach of using technology to combine UDL and CBMs for students with LDs and (b) the significant potential of UDL and CBMs for improving reading comprehension for all students". (Hall et al., 2015)

	G : Setting	*H : Year*	*B : Participants' Information*	*C : Purpose*	*D : Research Instruments*	*E : Research Methodology*	*F : Research Problem*	*A : Findings*
							content for all students". (Hall et al., 2015)	
7 : Nieves et al. (2024)	Northern Colombia.	2024	A population of seven sixth grade students and six seventh grade students, a total of 13	This research´s purpose was to strengthen students' reading comprehension by taking advantage of the benefits of Easy-to-Read, in the context of a methodology applied in Universal Design for Learning.	Participant observation, a questionnaire and a standardized language test.	A mixed approach was used, representing a set of systematic, empirical and critical research processes involving the collection and analysis of quantitative and qualitative data.	The main difficulties encountered by students are inferential and critical comprehension, which shows that a lack of language proficiency results in discrimination and sociocultural marginalisation (Flotts et al., 2016). Therefore, confronting students with different strategies where the focus is directed to the essential ideas, and providing them with the possibility of selecting the strategies best suited to their needs, can improve reading comprehension. (Nieves et al., 2024)	"Easy-to-Read generates a positive impact not only on text comprehension, vocabulary increase, motivation and interest in reading, but also reflects a significant increase in performance levels". (Nieves et al., 2024)

Appendix B

Table 3. Analysis of the Included Studies (Source: NVivo)

		B : Educational Settings			F : Implementation of UDL in Reading			K : Influence Across Age Groups			
	A : Challenges of UDL implementation	D : Inclusive Classrooms	C : General Education	E : Special Education	G : Multiple means of action and expression	H : Multiple means of engagement	I : Multiple means of Representation	L : Elementary	M : High school	N : Middle school	O : Merits of UDL Implementation
1 : Browder et al. (2008)	Instruction was provided in a one-to-one format. The planning team process identified some AAC devices that might have been beneficial but could not be procured in the timing of the study			All three students were classified in their psychological evaluations as having "profound" intellectual disabilities with lQs below 20 and developmental levels below 1 year.	Changed switch from Big Mac switch (Able Net) to Jelly Bean Switch (Able Net) Hold objects vertically so student can eye gaze up or down versus left to right	Praised exact student response. Used low lighting in the room to relax and increase engagement Before beginning lesson, "warm up" arm and head movement using music	Displayed objects on bulletin board behind interventionist and required student to look toward board for a response/ Use a light box behind the objects Presented two book options by sweeping in each book across student's full field of vision. Use a light box behind the objects	Elementary			
2 : Chien-Chuan Ko Et al. (2011)	Which supports will benefit the particular reader with specific disabilities needs to be explored.			All of the students had reading difficulties and received special education service in their schools. None of them reported difficulty in vision, hearing, or motor control.		Not Mentioned	This study aimed to develop an integrated, web-based e-reading system called the "TriAccess system," which would not only provide individualized physical, sensory, and cognitive access for special needs learners but also attend to the needs of instructors and material developers.	Thirty students (20 boys and 10 girls) in the fifth and sixth grade			

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3 : Coyne et al. (2012)	Teachers' sporadic reporting of software use, affecting docu- mentation of fidelity of treatment data. The use of software tracking would have provided valuable information about students' use of the software. This type of information is needed to refine UDL e-book design principles and instruction for this population.				Prompts to apply reading strategies (e.g., predict, question, retell, connect) and personal response Pedagogical agents that provide prompts, think aloud, and models Varied response options (e.g., visual multiple choice, sentence starters, open responses typed or audio-recorded) Prompts to echo read, partner read, and read independently.	Use of popular children's stories with quality illustrations Students are encouraged to decide when to click on a support option and are given control of the mouse so that they are in charge of navigation. Students listen to their oral reading recordings Prompts to reflect on progress and identify what they like or don't like	Sentence-by-sentence human digitized voice with synchronized highlighting Word and phrase synthetic text to speech with synchronized highlighting Animation and oral pronunciation of onset-rhyme for phonetically regular words Hyperlinked glossary items with graphic and multimedia illustrations Story illustration enhancements (e.g., click on a character to hear what the character is thinking and feeling) Videos and photo essays to build background information	K-2 students			Further investigation of the potential of UDL and technology in expanding opportunities for access, participation, and progress in the general education curriculum for young students with significant intellectual disabilities.
4 : Daley et al. (2020)	The autonomy-oriented use of literacy-related activities provides insight into students' choice-driven engagement, but it means that self-selection is inherent to the measurement. thus, limiting the interpreting causality of the effects of behavioural engagement or use of features	Students with significant intellectual disabilities, in both inclusive and sub-stantially separate classrooms.		Special education						Grades 6, 7, and 8	

	A : Challenges of UDL implementation	B : Educational Settings			F : Implementation of UDL in Reading			K : Influence Across Age Groups			O : Merits of UDL Implementation
		D : Inclusive Classrooms	C : General Education	E : Special Education	G : Multiple means of action and expression	H : Multiple means of engagement	I : Multiple means of Representation	L : Elementary	M : High school	N : Middle school	
5 : Dalton et al. (2011)	Not Mentioned			Bilingual and monolingual students with varying language and literacy abilities.	After reading a screen of text, student prompted to apply reading comprehension strategy (predict, question, clarify, summarize, visualize) or personal response (feeling). Corrective feedback on closed responses. Closed, constructed, and open-response options.	Age-appropriate and appealing folktales and informational texts with quality illustrations. Quality interface design and functionality. Easy to navigate. Student can access Spanish translations of text and directions; Student can write or record in first language. Multiple opportunities for student choice and customization. Student controls use of learning supports.	Shared features: a) All texts and instructional supports can be read aloud at word or passage level via text-to-speech (TTS) tool with synchronized highlighting, in English and Spanish. b) Spanish text translations provided c) Bilingual pedagogical agent speaks Spanish and English. d) Vocabulary hyperlinked to multimedia glossary. e) Anaphoric reference highlighting.			Middle-grade students	Designing for diversity and differentiating instruction for students with different language and literacy strengths and needs is a challenge for teachers and thus an opportunity for developers of digital learning environments. We find it encouraging that both bilingual and monolingual students benefited from, and were able to manage, reading within a strategic digital reading environment that offered an array of sup- ports.
6 : Hall et al. (2015)	Instructional conditions varied slightly across all classrooms for how the novels were addressed within the classroom's curriculum.		General Education	Special education teacher teams in inclusive co-taught classes						Mixed grade levels of students from sixth to eighth grades	The built-in flexibility of the Strategic Reader leads teachers to create tailored interventions for individuals in their classrooms. The variety of observed effective approaches suggests that there was indeed synergy between the relatively prescriptive principles of CBM and flexible principles of

		B : Educational Settings			F : Implementation of UDL in Reading			K : Influence Across Age Groups			
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											UDL.
7 : Nieves et al. (2024)	Not Mentioned		General Education		Through images, multiple-choice questions with a single answer and with several answers, audio, relationships, and oral expression, among others.	It is important to mention that the third principle was incorporated by offering multiple forms of motivation and involvement by giving constant feedback, strategies to face challenges, and self-assessment activities.				A population of seven sixth grade students and six seventh grade students,	Its effectiveness was evidenced, making the texts more understandable and allowing better responses from the students. The UDL principles based on the objectives, methodology, resources and evaluation made it possible to create a virtual course that encouraged the motivation of the students.