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Review

A Scoping Review of Research on the Use of Digital Technologies for Teaching Reading Fluency

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Abstract: Background: Reading fluency is a crucial component of reading. Research indicates that the use of digital technologies can help students with reading difficulties and disabilities improve their reading fluency. **Objectives:** The objective of this scoping review was to identify and describe research focusing on the use of digital technologies for teaching reading fluency to primary or elementary students in English-speaking settings. **Design:** Online databases were used to identify papers published between 2013 and 2023. Eighty-six papers that met the inclusion criteria were selected for analysis. **Results:** The review indicates that research has primarily focused on the use of digital technologies as interventions to support students at risk of reading difficulties and students with disabilities, with relatively little research emphasis on general classroom teaching of reading fluency. Moreover, uses of digital technologies for the teaching of reading fluency could mostly be categorised as "enhancements" of common non-digital strategies for teaching reading fluency, such as explicit teaching, drill and practice, and repeated readings. Much of the research has focused on the use of programs as opposed to the innovative use of open-ended digital tools. **Conclusions:** This paper raises questions about the relatively narrow uses of digital technologies in the teaching and research of reading fluency and calls for an expanded research agenda to include a broader range of pedagogical goals and approaches.

Keywords: reading fluency; digital technologies; reading fluency pedagogy; automaticity; primary school; elementary school

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Citation: Oakley, G. A Scoping Review of Research on the Use of Digital Technologies for Teaching Reading Fluency. *Educ. Sci.* **2024**, *14*, 633. https://doi.org/10.3390/educsci14060633

Academic Editor: Daniel Muijs

Received: 26 March 2024
Revised: 10 May 2024
Accepted: 4 June 2024
Published: 12 June 2024

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1. Introduction

It has been argued that reading fluency has not been sufficiently emphasised in research [1], even though it is an important aspect of reading, being necessary but not sufficient for reading comprehension [2]. This article presents an overview and discussion of research conducted over the last two decades on the use of digital technologies for teaching reading fluency, informed by a systematic scoping review. The objective of the paper is to highlight the characteristics of research that has been conducted in this area and identify gaps in the research. Although other scoping and systematic reviews have been conducted, the present review adds to knowledge in that it focuses on the use of digital technologies for teaching reading fluency in elementary school children and does not focus exclusively on children with reading difficulties and disabilities. It is not the intention of this review to provide an analysis of the results of the research. Outside the scope of the review was research conducted in non-English-speaking settings and the teaching of phonics. The emphasis was on word-level fluency (automaticity) and text-level reading fluency, including reading expression. The article suggests possibilities for transforming the teaching of reading fluency through the use of digital technologies, including artificial intelligence (AI), and a broadening of the research agenda.

What is reading fluency, and why is it important? Reading fluency is crucial to successful reading and was named in the USA National Reading Panel (NRP) [3] as one of the "Big 5" components of reading that must be taught, alongside phonemic awareness, phonics,

vocabulary, and reading comprehension. Reading fluency development is intertwined with overall reading development, which, according to the Simple View of Reading [4], involves the development over time of word identification (decoding) ability and language comprehension. As children develop their skills in these two areas through explicit teaching and ample opportunities to practise, they become more proficient at reading fluency and comprehension, as they have a larger store of words they can read quickly and easily on sight (automaticity), as well as better language comprehension ability and strategic knowledge for reading [5]. There are various "stage" theories of reading development, with Chall's [6] stage theory stating that people go through six stages in their reading development. Relevant to the primary school years are Stage 0, which is pre-reading (birth to age 6); Stage 1, which is initial reading and decoding (ages 6 to 7); Stage 2, which is confirmation and fluency (ages 7 to 7.5); and Stage 3, which is reading for learning the new (ages 7.5–13). In Stage 1, there is a focus on decoding words accurately in simple texts, sometimes decodable texts, which children will have been prepared to read through explicit teaching of the grapheme-phoneme correspondences and high-frequency words appearing in them. Most relevant to this paper, in Stage 2, there is more of a focus on reading rate [2] and expression. It is noted that these stages do not necessarily align with curricular requirements in various countries. For example, in Australia, where the author of this paper is located, 6-year-old children will not normally be in the pre-reading stage and will be able to read and write simple texts.

Reading fluency needs to be established at both the word level and text level, with word-level fluency involving the ability to read words accurately and effortlessly on sight (automaticity) and text-level fluency involving the ability to read connected text at an appropriate speed or rate with a high degree of accuracy (automaticity), as well as appropriate expression and phrasing (prosody) [3,7,8]. For children who are reading words and texts in the English language, which has an opaque orthography or many variations in the ways that sounds can be represented by letters, reading fluency can develop more slowly than for children who are working with intermediate or transparent orthographies, because decoding and word identification skills take longer to develop [9].

Fluent reading involves the orchestration of complex reading skills and can be conceptualised as a bridging process that intersects with word recognition and language comprehension processes [10]. Conceptualisations and definitions of reading fluency are not necessarily consistent in the literature [2], and fluency is often narrowly defined as automaticity [11]. Thus, many fluency studies focus on automaticity, measured by words correct per minute (WCPM) [1,12], with little emphasis on expression or prosody or on silent reading fluency [13,14]. Prosody can be defined as "appropriate expression or intonation coupled with phrasing that allows for maintenance of meaning" (p. 233) [15].

The emphasis on automaticity can be attributed in part to the theory of automatic processing [16], which purports that when word recognition becomes automatic, attention and cognitive resources for higher-level skills, including comprehension, are freed up. This proposition is supported by cognitive load theory [17] and work by Ehri [18] on orthographic mapping. Ehri proposes that being able to read a word from memory automatically means that "sight of the word activates its pronunciation and meaning immediately in memory and allows readers to focus their attention on comprehension rather than word recognition" (p. 5). It has been found that 90% of comprehension difficulties can be attributed to poor oral reading fluency [19], yet it is important to note that although automaticity is necessary for comprehension, it is not sufficient [2,20]. Text-level reading fluency is particularly important and is intertwined with reading comprehension, which is a prime aim of most reading activities [15,21–23]. In addition, it has been found that fluent readers tend to have more positive attitudes towards reading and engage in more reading [20,24]. It is thus crucial that text-level reading fluency be effectively taught.

Key strategies for teaching reading fluency. There are several well-known and research-backed strategies for teaching reading fluency. Activities to build automaticity at the word level are essential. Although decoding is not a focus of this paper, children must have a

strong command of grapheme-phoneme correspondences so that they can decode words effectively, and practising decoding through a range of activities is important in being able to read words quickly and efficiently. This is particularly important in the early stages of reading. Hoover and Tunmer [25] point out that as readers become more proficient and practised, they move from laborious decoding to recognition of words on sight, which involves a shift of attention to the orthographic features of words. It has been suggested that this involves a gradual shift, through practice, towards a "word form" area of the brain being activated when reading as opposed to "word analysis" areas being activated [25].

To improve children's automatic and autonomous word recognition, several key strategies are effective. Drill and practice activities such as the use of flashcards are a traditional means of enhancing the automaticity of word recognition, which can improve children's ability to read words on sight [26]. However, these researchers found that having the ability to read isolated words on sight does not necessarily transfer to text-level fluency. Furthermore, it is cautioned that attempting to teach words by visual methods alone (such as flashcards) may be ill-advised as children need to understand multiple levels of word knowledge, such as their sounds, orthographies, and meanings. As summarised by Moats (p. 30): "Current theories of word learning processes, however, do not support the idea that so-called visual learning of orthography is independent of phonology or sound-symbol mapping" [27]. Notwithstanding the limitations of flashcards, their use can be made more motivational and multimodal by being gamified [28].

One of the most heavily researched practice strategies for teaching reading fluency is repeated reading, which has been shown to improve students' reading fluency of connected texts through the early years to high school [8,29–31]. The strategy has been found to be beneficial no matter what the demographics of the student are [31]. It is noted, however, that the What Works Clearinghouse [32], which is a clearinghouse that aims to be a trusted source of scientific evidence regarding "what works" in education, through rigorously appraising educational research, found repeated reading to have potentially positive effects on reading comprehension but not on reading fluency, for students with learning disabilities. It is noted that this finding does not align with findings in which repeated readings are conducted within computer-assisted reading programs [33].

Although there are several different articulations of repeated reading, the strategy essentially entails the student reading the same short text (usually 50 to 300 words) up to four or five times to achieve appropriate accuracy, rate, expression, and phrasing [34]. Repeated reading is effective because it gives readers a chance to practise and, often, to reflect on their reading fluency. Repeated reading can also involve the reader being given assistance and feedback (known as assisted or guided repeated reading). For example, the teacher, a peer, or a computer may supply unknown words where necessary. Repeated reading can involve repeatedly reading texts during rehearsals for a performance, for example through readers' theatre [35]. Using digital technologies, repeated readings can involve having the student repeatedly read a digital text or ebook and clicking on unknown words where necessary [36] so that fluency and comprehension are supported.

Reading while listening (RWL) is another strategy that is often mentioned as a strategy for teaching reading fluency. Here, the student reads along while listening to a fluent model reading aloud [37]. This may be in the context of a digital text or audiobook [38]. There has been limited recent research on the benefits of this strategy, however. A similar assisted reading strategy is paired reading [39], where a fluent reader pairs up with a novice reader to read a text. In a version of paired reading called Reading Together or Neurological Impress Method (NIM) strategy, two readers read together, and the novice reader may signal to the experienced reader to fade out when appropriate [40].

A key strategy to improve reading expression or prosody is modelling fluent reading by reading aloud to students with appropriate accuracy, rate, expression, and phrasing. It is theorised that this kind of modelling can help students build "inner models" of what fluent reading sounds like [41,42], which they can then learn to compare to their own oral reading. This modelling can be done in the context of teacher read-alouds, modelled reading, and

shared reading. Digital technologies have also been used to support modelling and self-modelling. For example, students can hear models of fluent reading through listening to audiobooks or ebooks [38]. In video self-modelling, students can view and listen to models of themselves reading at a slightly more advanced level of reading than their usual level (after editing of the video). This is thought to help students envision themselves as more efficient readers. This strategy and video peer modelling have been found to improve oral reading fluency in children with diagnosed disabilities [43]. It can also be useful to have students analyse different versions of their recorded repeated readings to notice and reflect on any improvements in accuracy, rate, expression, and phrasing [44].

Another suggested strategy to teach reading expression is the phrased text lessons [45], whereby texts are marked up to indicate phrase boundaries, which can help readers chunk the texts appropriately for fluent reading and comprehension, whether orally or silently. In other words, symbols such as slashes can be inserted in texts to indicate which group of words should be read together as a chunk of words, as not all readers are adept at breaking sentences into phrases in order to read them [45]. However, few research studies have focused on this strategy. Overall, the teaching of reading expression has been understudied compared to reading automaticity [46].

Assessment of reading fluency. Approaches to assessing or measuring reading fluency vary and are linked to the underlying conceptions or definitions of reading fluency. In many cases, oral reading fluency is measured by checking reading rate and accuracy, which is often expressed as the number of words read correctly per minute (WCPM). WCPM can be conducted using standardised texts such as those in the Dynamic Indicators of Basic Early Literacy Skills-DIBELS tests [47] or authentic classroom texts. There is a strong correlation between WCPM and reading comprehension, and it can be an efficient assessment, although measuring fluency through WCPM in authentic classroom texts can entail limitations as the difficulty level of texts may vary, reducing the reliability of WCPM in these circumstances [48]. It is worth noting that Valencia et al. [12] found that the use of WCPM does not provide fine-grained information about readers' fluency, so assessment including multiple indicators is needed. Although WCPM is an efficient measure of automaticity, it does not measure prosody and, in fact, can detract from prosody if students read at an inappropriate speed (for example, too quickly). The assessment of prosody needs to consider aspects such as vocal emphasis on appropriate words; voice tone rising and falling at appropriate points in the text; inflection that reflects punctuation; appropriate vocal tones to represent dialogue in texts; and appropriate pauses at phrase boundaries [49] (p. 707). There are inherent difficulties in assessing prosody, as teacher judgement in allocating ratings is often required. It is often measured through rating scales or rubrics such as the NAEP Oral Reading Fluency Passage Reading Expression Scoring Rubric [50] and the Multidimensional Fluency Scale [51]. Because these are rubrics that rely on teacher judgement, there may be reliability issues.

Use of digital technologies to enhance reading. There is a wealth of research on the use of digital technologies to improve various aspects of reading, including aspects of reading fluency [52]. According to a review conducted by Yang et al. [53], most of the studies conducted have focused on the use of technology for teaching comprehension and vocabulary. These authors found that digital technologies in reading instruction have been used in three main ways: to improve motivation; to present multimodalities; and to facilitate collaboration. It would be true to say that considerable research has also been conducted in the area of teaching phonics using digital technologies (outside the scope of this review) [53].

Key advantages of using digital technologies for literacy learning are that they can be adaptive to student needs and thus provide teaching that is personalised for individual students with timely and individualised support and feedback. As noted by Yang et al. [53], digital technology can also present content multimodally, which can assist students in learning to read and make meaning through the provision of multiple symbol systems [54]. The highly multimodal and interactive teaching and learning activities afforded by digital

technologies can enhance learning and motivation [55]. Game-based learning of reading can also be afforded by digital technologies, enhancing motivation and engagement [56]. Not least, digital technologies can be a context for children to practise literacy skills independently. It is worth noting that a great deal of the research so far conducted has focused on the use of digital technologies to assist students with reading difficulties or disabilities. A meta-review conducted by Hall et al. in 2023 showed positive outcomes, particularly in terms of foundational skills such as phonics and word reading skills for students in the elementary years of school who have, or are at risk of, reading disabilities [57]. Likewise, a systematic review by Dean et al. in 2020 found that reading programs have positive effects on the reading of students with reading difficulties [58].

A review on the use of technology for teaching reading to children who are English language learners (English as a Second Language) found that the use of digital technology can improve reading motivation, provide scaffolding, expand semiotic resources (as digital texts are often multimodal), enhance collaboration, and improve reading performance [59].

Touchscreen technologies such as tablets, because they facilitate physical interaction and can be easy to use for young children, have been found in some studies to be useful in early literacy learning. Xie et al. [60] conducted a meta-analysis of 36 research articles involving 4206 participants and found an overall effect size (d = 0.46), indicating that the use of touchscreen technologies enhances learning. There are also technologies such as social robots, which are now being used to teach early language and literacy, with some beneficial effects [61]. Technologies such as augmented reality and virtual reality have also been used to teach reading [62], and the increased accessibility of artificial intelligence in recent years has resulted in an interest in the use of AI in literacy education [63].

Despite the relatively large body of research on the use of digital technologies in reading instruction, there is a need for a clear overview of the research that has been conducted on the use of such technologies in the teaching of fluency in primary or elementary children.

Categorising digital technologies in education. Puentedura [64] suggested that digital technologies can be used to either enhance or transform teaching and learning activities or tasks. In his SAMR (substitution, augmentation, modification, redefinition) model, enhancement includes substitution and augmentation, where substitution involves either a direct substitute of a non-digital task or activity with a digital task, where there is no functional change, although the digital task may involve cost-saving, convenience, and efficiency. For example, reading a pdf on a screen without using features such as text-to-speech would be a substitution. Augmentation is where digital technology acts as a substitute, but there is also some functional improvement. Thus, using a text-to-speech feature to read a pdf or ebook would be considered an enhancement. The upper levels of SAMR are modification and redefinition, which allow for transformation of teaching and learning. Modification is where a task or activity can be significantly redesigned when using technology. For example, collaborative writing or reading response tasks using such tools as Google Docs might fall into this category because they allow collaboration over time and space. Finally, redefinition entails the creation of new teaching and learning tasks that were previously inconceivable. An example of this might be the creation or reading of multimodal texts and ebooks that include an integration of audio, video, animation, etc., rather than just the written word and printed images. Although digital technologies have the potential to transform the teaching of reading, many uses of technology tend to replicate traditional reading instruction.

It has been suggested that technologies in education can be categorised as either program-based or tool-based [65], where program-based technologies "are specifically designed for pedagogical purposes with premade learning content delivered through algorithm-enabled instruction, such as learning games and online personalized learning programs that use artificial intelligence to give each student individualized academic exercises. They are often developed by companies and large not-for-profit organizations" [65] (p. 3). Tool-based technologies, on the other hand, are not specifically created for educa-

tional purposes and require teachers to innovatively use them for pedagogical purposes; for example, teachers may create animated flashcards using MS PowerPoint.

This introduction has presented an overview of reading fluency, its definition, and key teaching and assessment strategies. A brief overview of digital technologies and reading has also been presented. Although there has been ample research on digital technologies and reading comprehension, vocabulary, and overall reading skills and performance, a clear picture of research on how digital technologies can be used to teach reading fluency specifically is needed.

2. Materials and Methods

The scoping review of the research on the use of digital technologies to teach reading fluency to students in their elementary years followed the process recommended by Peters et al. [66], and the PRISMA statement and PRISMA-ScR checklist (for scoping reviews) were followed [67].

First, a sweeping review was done in Google Scholar (23 August 2023) using the search string ("teaching reading fluency" OR "reading fluency") AND ("primary students" OR "elementary students" OR "primary children" OR "elementary children") AND (technology OR digital) 2010 to 2023. This returned 7430 articles. Specific technologies like e-books or artificial intelligence were not included in the sweeping search. From an examination of common keywords in the sweeping review, a search string for the scoping review was constructed, which was discussed with a senior university librarian. The search string was deliberately kept broad so that no important articles were missed, with the intention that the exclusion of irrelevant articles would occur later in the process. The final search string (Figure 1) was entered into both Proquest Education and Onesearch. Searches were restricted to peer-reviewed articles between 2003 and 2023 to incorporate quality research over 20 years.

(technol* OR computer* OR gam* OR digit* OR software OR mobile OR tablet OR app OR multimedia OR ebook*) AND (intervention OR train* OR teach* OR practic*) AND ("sight word" OR "read* automaticity" OR "reading fluency" OR "reading expression" OR "reading rate" OR "reading accuracy") AND (primary OR elementary OR "early childhood" OR child*).

Figure 1. Search string.

Onesearch returned 910 articles, and Proquest Education returned 3369 articles. Furthermore, 290 duplicates were removed, and 14 articles were added manually. Moreover, 4053 articles were screened for relevance (by the researcher reading the abstracts), and 3765 articles were excluded at this stage if they did not meet the inclusion criteria (Table 1).

Table 1. Inclusion criteria.

Included	Excluded
Population	
Primary/elementary school children/students	Secondary/high school students
Primary teachers	Hearing impaired children
English-speaking countries or medium of instruction	Visually impaired children
	Adults
Teaching focus	
	Phonics
Uses of digital technologies to teach: Reading fluency	Decoding
	Reading fluency in languages other than English

Table 1. *Cont.*

Included	Excluded
Study characteristics	
Peer reviewed Qualitative Quantitative Mixed methods Published after 2003	Scoping and systematic reviews Published before 2003

The full text of 287 articles was read and assessed against inclusion criteria. At this point, 201 were excluded at this point, leaving 86 articles to be analysed (Figure 2). Covidence software was used at all stages for data extraction, then data were transferred to a table (Supplementary Table S1 and then double checked against the original papers. Only one researcher participated in the process. Data were extracted on article characteristics (such as country, journal type), characteristics of students, research design used, fluency focus, and pedagogical approaches used.

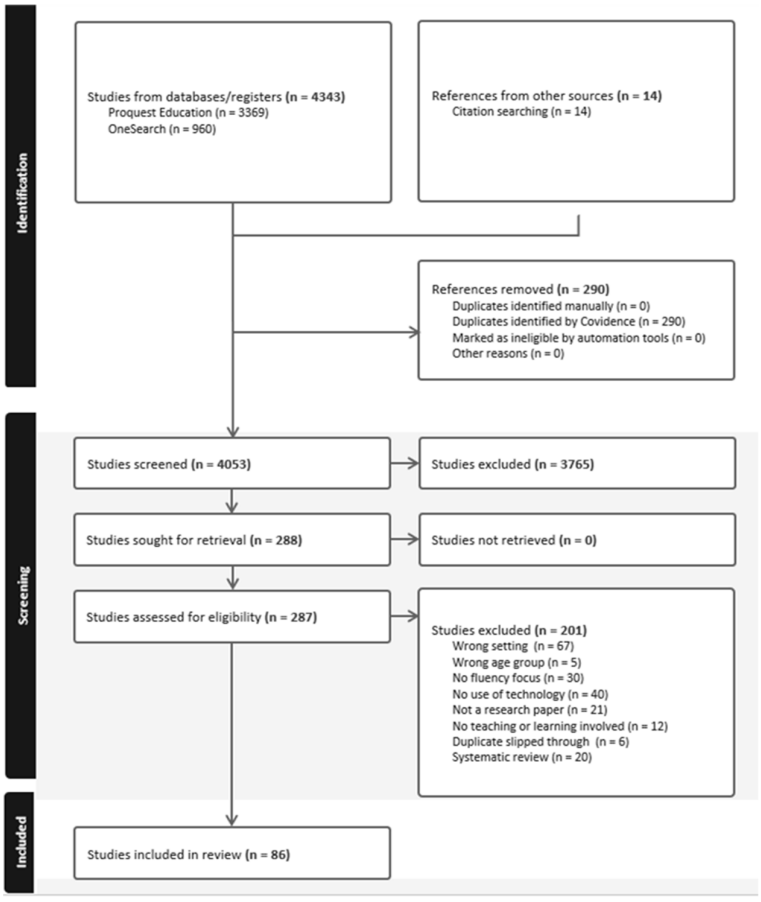


Figure 2. Scoping process.

3. Results

In this section, the characteristics of the studies included in the review are presented. There is no attempt to provide an analysis of "what works" in the use of digital technologies for teaching reading fluency; rather, the purpose of this article is to identify the characteristics and foci of research conducted since 2003, or over the last 20 years at the time of the analysis. Many of the studies focused on reading fluency alone (42, or 49%), while the rest focused on multiple aspects of reading, including fluency. Seventy-one (83%) of the 86 studies were conducted since 2010, indicating an increasing interest in research on the

teaching and learning of reading fluency using digital technologies over the 20 years in question. This is not surprising, given the rise in access to digital technologies both inside and outside the classroom.

There has been a predominance of research coming from the United States, with 72 (84%) of the 86 studies being conducted in the United States. Other countries were Australia, Canada, Ireland, Singapore, South Africa, and the UK (Figure 3). As noted above, research from countries in which English is not the medium of instruction was excluded as beyond the scope of this review.

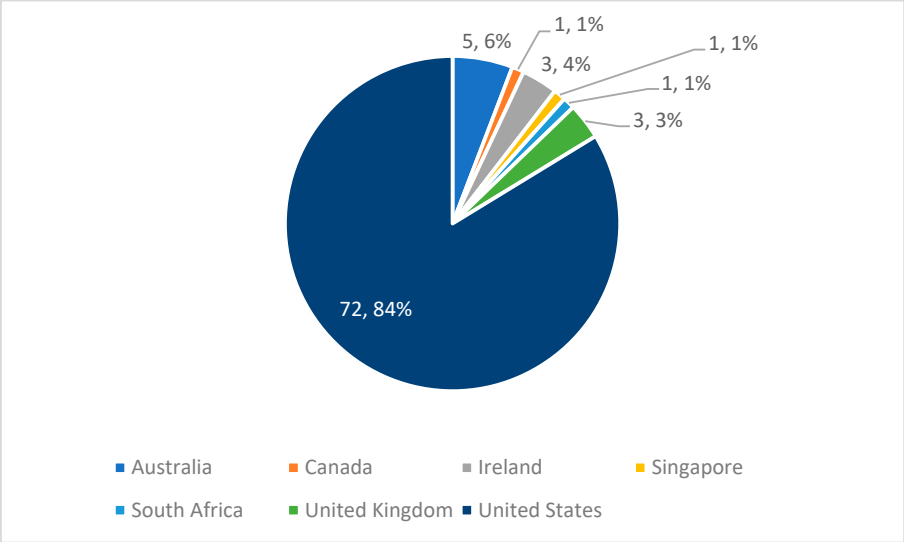


Figure 3. Country of study.

Of the 86 articles, only 13 (15%) were published in journals focusing on reading or literacy, and 16 (19%) in general education or educational technology journals. The majority of the articles (54, 63%) were in psychology-focused journals, including educational psychology and special education. Accordingly, the majority of the studies focused on students with special or additional needs, with 30 (35%) studies including children deemed to be "at risk" of, or demonstrating, reading difficulties. Children with ASD/autism were the focus of 12 (14%) studies, and children with ADHD were the focus of five (6%) studies. English language learners or children for whom English is a second language (6, 7%), children of poverty or low SES (6, 7%), learning disability or intellectual disability (8, 9%) were also target populations. In 15 (17%) of the studies, any diverse learning characteristics of the students were not mentioned (Figure 4). It should be noted that several studies focused on students with more than one diverse characteristic; for example, some students with ADSD as well as ASD participated.

The number of students participating in the reviewed studies was often quite low, reflecting the fact that many were intervention studies targeting individuals or small groups. Five (6%) of the 85 studies with student participants involved a single student, with 32 (38%) involving two to five students and nine (10%) studies involving six to 10 students. Thus, 54% of the studies involved 10 students or less. In one of the studies, participants were teachers, not students (Figure 5).

The above findings show that there is limited research being conducted in general classroom contexts among children who are deemed to require so-called 'Tier 1' reading fluency instruction and practice. Tier 1 refers to evidence-based instruction given to all members of a classroom, with Tier 2 instruction given to students who need additional support, usually in small groups, and Tier 3 being intensive and specialised, individualised instruction for students who do not respond to Tier 2 intervention [68]. The majority of the research located for this review has focused on reading fluency supplementary support and interventions for children at risk or experiencing reading or other learning

disabilities. In addition, there has been a focus on children in the lower grades of school, with 38 (44%) of the studies focusing on lower primary or elementary school (Grades 1 and 2), 11 (13%) focusing on children in their middle elementary years (Grades 3 and 4), and 26 (30%) involving children across their elementary (primary) years. Only seven studies (8%) focused on the upper elementary (Grades 5 and 6). Four (5%) of the studies involved students from both elementary and secondary school (Figure 6). Although children from one country to another may not be exactly the same age in each grade or year level, in this review the grade level is recorded, rather than age, because children are not generally taught according to their age, but their grade level or reading stage. Most studies used grade rather than age in their reporting.

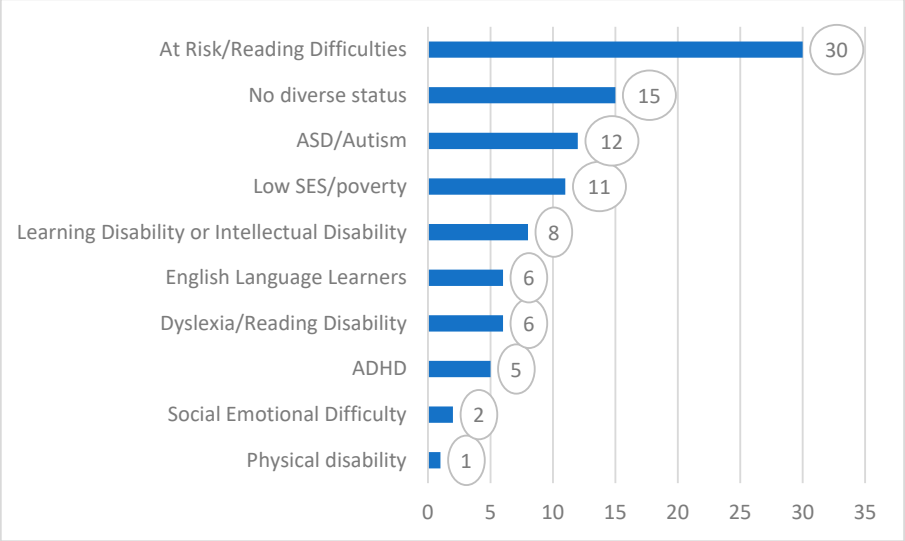


Figure 4. Characteristics of student participants.

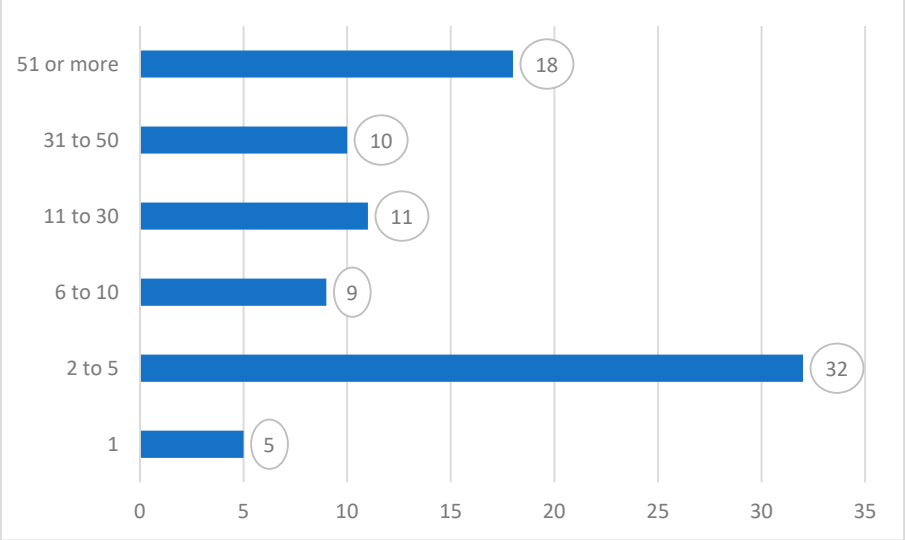


Figure 5. Number of participants in study.

As might be expected when many of the studies were intervention studies, single-case designs were the most prominent research designs (34, 40%), with quasi-experimental and experimental designs also being common (18, 21% for each). The quasi-experimental design studies did not have random assignment of participants. It is noted that the design of some of the studies was not clearly articulated. Eleven (13%) of the studies utilised

mixed methods, and there were a few action research, case studies, design experiments, and formative experiments (Figure 7).

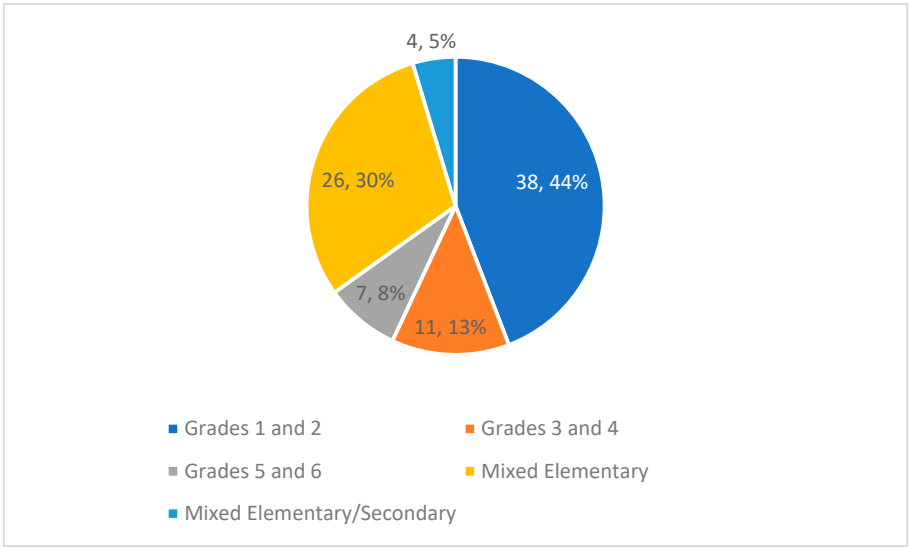


Figure 6. Age groups of participating students.

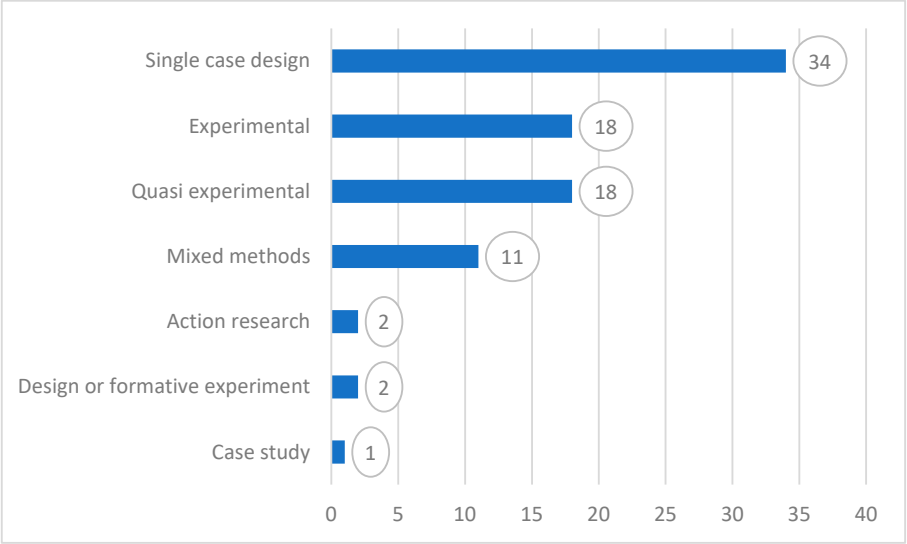


Figure 7. Research design.

Among the 86 studies, six main types of hardware were mentioned, with some of the studies using more than one type of hardware. Sixty of the 86 studies (69%) used computers (either desktop or laptop), whereas 19 (22%) utilised touchscreen tablets such as iPads. The next most common hardware type was audio-playing or recording devices, with seven studies (8%) using them. Other hardware devices used were smart phones, game consoles, and, in one study, a robot (Figure 8).

Several categories of software were used in the research being reviewed (Figure 9). The most-used category was the computer-assisted instruction program (37, 44%), many of which were commercial programs. Programs represented included ABRACADABRA, Headsprout, Kurzweil, Data Mountain, Read Naturally, QuickRead, and others. These programs usually offer explicit, systematic, and personalised instruction and practice opportunities for individual children. Many of them are comprehensive programs that address a range of reading skills, including word identification, comprehension, and fluency. Bespoke researcher-created programs were also used (8, 9%). Presentation software such as

MS PowerPoint was used in nine (10%) of the studies, often for presenting digital flashcards, and audio recording/editing software was used in three of the studies. Mobile apps of various kinds were used in 13 (15%) of the studies. Fifty four (63%) of the uses were categorised as program-based, and 32 (37%) as tool based.

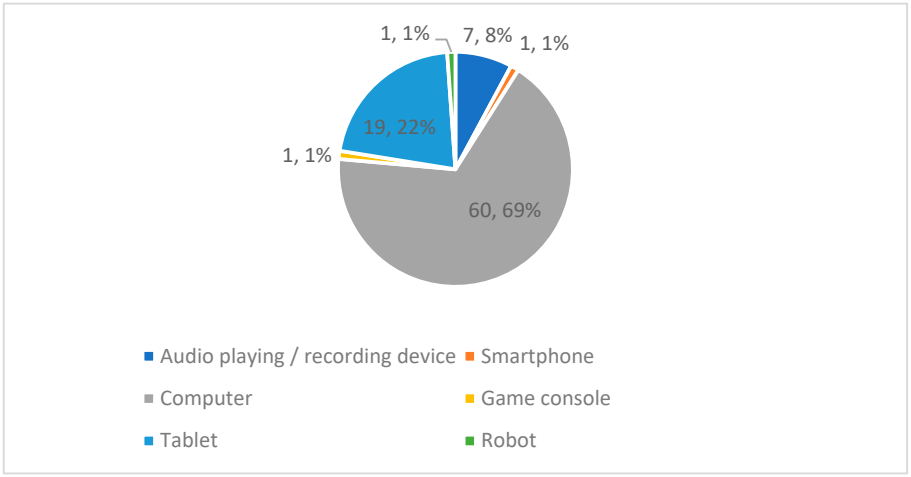


Figure 8. Hardware used.

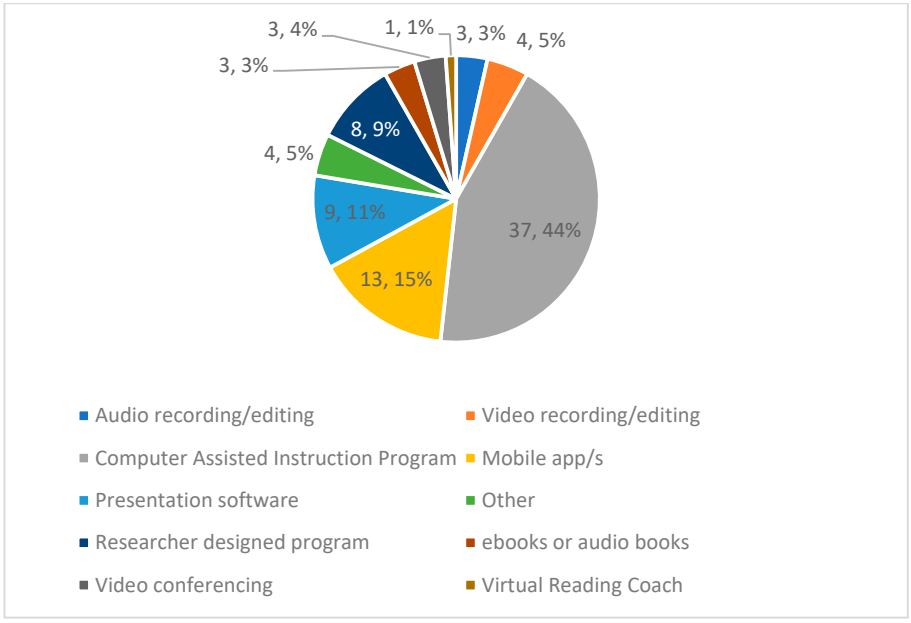


Figure 9. Software used.

3.1. Fluency Focus

Of the studies examined, 21 (24%) of them focused on teaching fluency at the word level only with the aim of improving single word reading automaticity or sight words. The majority of studies focused on passage reading fluency, and the WCPM was used as a measure in 49 (57%) of the studies. Only eight (9%) of the studies mentioned that expression or prosody was a target skill. The rest of the studies used a range of measures, such as standardised reading tests or untimed word-correct assessments.

3.2. Fluency Strategies Used

Many of the digital practices and interventions under investigation utilised more than one reading fluency teaching strategy. Some of the strategies were instructional, and others were focused on providing the students with opportunities to practise. It is noted

that many of the studies did not explicitly state the fluency strategies used or did not give clear details. Computer-presented explicit instruction or direct instruction appeared to be used in 24 (28%) of the studies, and in terms of practice, repeated readings were identified as a popular strategy to be delivered using digital technologies, being mentioned in 29 (34%) of the studies. Many of the studies involved some drill and practice, with 14 (16%) utilising digital flashcards. In 24 (28%) of the studies, reading while listening was one of the strategies used, while listening to models of fluent reading featured in 19 (22%) studies. Students were given opportunities to reflect on their oral reading fluency through some sort of self-analysis of recorded readings in 11 (13%), although this may also have been a feature of repeated reading activities in other studies and not explicitly reported. In quite a number of the studies, software was used to provide unknown words and feedback to support readers. It is noted that only eight (9%) of the studies included the teaching and assessment of expression or prosody.

3.3. Pedagogical Uses of Technology

In terms of Puentedura's [64] categories, 76 (88%) were deemed by the researcher to be enhancements, 8 (9%) as transformative, and 1 was not categorised due to insufficient detail. Enhancements were where there was no real functional change to the activity other than it being more efficient and possibly more motivational—a skilled human tutor or teacher could conceivably perform the same function without the technology, although it might be time-intensive and involve a great deal of formative assessment to inform feedback and teaching. The studies that were judged to be transformative or innovative are briefly described below.

Four of the studies that harnessed technology to create tasks deemed to be transformative used variations of video self-modelling [43,69–71]. Here, students viewed edited videos of themselves reading aloud as a basis for reflection on their oral reading fluency. Clearly, without video, this kind of activity could not be implemented.

Holyfield et al. [72] studied an intervention that used Augmentative and Alternative Communication (AAC) technology that featured visual scene displays (VSDs), in this case students' favourite characters from popular culture. Hotspots were embedded in these scenes to help students with complex communication recognise single words. It would not be possible to implement such a task without technology. The three participating children were being taught to recognise single words and did not apply them to connected texts.

Oakley [44] had a small group of students create ebooks. This involved the students repeatedly listening to their repeatedly recorded (and, thus, repeatedly read) narrations and analysing them for prosodic features. Students also visually analysed waveforms of their recordings, which supplied additional cues for self-analysis. There could be no alternative to this task without the use of technology.

Patel et al. [73] studied the use of bespoke-designed software (ReadN'Karaoke 2.0) that augmented text with visual prosodic cues as a means of improving children's reading expression. The visual cues included cues relating to pitch, duration, and intensity (volume), and the typically developing 7- and 8-year-old students' reading attempts using these visual cues were recorded in the software. The students could also listen to an auditory model of a fluent reading of the text and listen to their own recording.

Stover et al. [74] used presentation software called VoiceThread as an instructional tool to teach literacy in elementary, middle school, and high school classrooms. Some of the participating students uploaded narrations to the texts they created in VoiceThread. This qualitative study, which gathered the perspectives of three teachers on using VoiceThread, found that one of the perceived benefits was an improvement in reading fluency, due to children being motivated to practise the narrations and having opportunities to hear recordings of themselves reading and self-evaluate their fluency. This activity involved digital multimodal text creation and could not have been achieved without technology.

Vasinda and McLeod [75] studied readers' theatre with podcasting in six Grade 2 and Grade 3 classrooms. Over 10 weeks, small groups of students were allocated readers'

theatre scripts and practised them through the week with some modelling and feedback from the teacher, as needed. At the end of the week, students recorded their readers theatre performances using Audacity recording software. They were able to re-record or edit their recording if desired. Students improved their comprehension, but fluency itself was not measured. However, qualitative data indicated that the students felt that the activity was authentic and helped them read expressively. Teachers shared this sentiment and felt that the activity fitted into the rhythm of the classroom.

The above results outline the characteristics of the research conducted on teaching reading fluency using digital technologies and have highlighted what has been emphasised and underemphasised.

4. Discussion

It has been argued that "technologies have not fundamentally changed the activities of teaching and learning; neither have they brought much innovation into classrooms" (Gao et al., 2020, p. 2) [65]. The findings of this scoping review appear to support this assertion with reference to fluency instruction as, referring to the SAMR framework [64], most of the uses of technology could be considered enhancements of existing approaches rather than transformative approaches.

It is clear from the findings that research on the use of technology for teaching fluency has largely focused on assistive technology through the use of comprehensive computer assisted instruction (CAI) programs to help students experiencing reading difficulties or disabilities, or students with difficulties or developmental disabilities. These programs can be highly advantageous as they can meet the needs of students with additional needs and provide assistance to teachers who may not have adequate time, resources, and training to design individualised learning experiences. Indeed, according to Pindiprolu and Forbrush [76] (p. 257), such programs "can provide highly specialised instruction in the area of reading for relatively low costs and with high fidelity" and "can provide immediate feedback and motivate students through features like graphics, game-like activities, and multimodal presentations". Although educational outcomes are not the focus of this review, the vast majority of studies involving programs reported gains in student reading. Of the 86 studies, only seven did not report an improvement, with five of these being programs. With AI, these programs are likely to become more and more powerful with regards to their ability to personalise instruction and provide individualised coaching. However, such programs have not necessarily been made available or researched in the context of Tier 1 teaching in mainstream classrooms. It is worth noting that the focus on teaching students with difficulties as opposed to general classroom teaching across the ability range appears to be a feature of reading fluency research more generally, i.e., research that does not focus on the use of digital technologies.

The majority of the studies reviewed focused on word identification or passage reading automaticity, and this was thus one of the most prevalent measures (WCPM) used in the studies reviewed. While automaticity is crucial [2], expression must also be taught. Few of the studies analysed for this review dealt with reading expression or prosody. With the increased accessibility of AI, there is scope for a broader range of teaching experiences and thus more research relating to prosody. AI may be able to analyse students' reading for prosodic features in a more consistent and detailed fashion than busy teachers can and provide more timely feedback [77].

What the findings clearly indicate is that teachers designing fluency instruction and practice activities using tool-based technologies [65] for Tier 1 classroom instruction have been under-researched, although this is not to say that teachers do not innovate in this space. Although research is scarce, classroom teachers implement strategies for assisting children with their reading fluency, for example, through the use of accessible tools such as MS Immersive Reader (to read aloud unknown words), mobile apps available to support automaticity, and generative AI tools such as ChatGPT to generate texts for readers' theatre or personalised text reading [78]. Other recently emerging tools include the AI reading

coach Ello (https://www.ello.com/, accessed on 15 March 2024), which provides AI-driven individualised coaching. There is clearly a need for research on how AI-enhanced tools can enhance and transform the teaching of reading fluency, especially in classroom contexts.

A limitation of this paper is that the scoping review excluded research from countries and settings where English was not the main medium of instruction. The decision to exclude these studies was to scope the review to a manageable size and because the English language was the area of interest due to its opaque orthography and large vocabulary. It was decided that studies that focused on English as a Foreign Language would also be excluded so that the scope of the review could be contained, although it is acknowledged that this body of research has some potentially useful research around the use of technology for teaching oral reading fluency.

Another potential limitation is that data extraction and coding of the papers were conducted by the author without a second researcher to seek consensus. Finally, the search string, although comprehensive and checked by a senior university librarian, may have excluded some useful studies. To counteract this possibility, the author added research articles to the pool using ancestral searches, and 14 studies were added manually. "Prosody" was not in the initial search string, although "reading expression" was. To check whether this was an important omission, a separate search with the following search string was undertaken, but no additional relevant studies were identified: (technol* OR computer* OR gam* OR digit* OR software OR mobile OR tablet OR app OR multimedia OR ebook*) AND (intervention OR train* OR teach* OR practic*) AND ("prosody") AND (primary OR elementary OR "early childhood" OR child*).

5. Conclusions

This article has presented a review of research published from 2003 to 2023 on the use of digital technologies for teaching reading fluency in elementary schools in English-speaking settings. The review has highlighted that most of the research has focused on interventions for students with reading difficulties, disabilities, or special needs and has primarily focused on single word recognition and automaticity at the passage level, whilst there has been limited research on the use of digital technologies to teach prosody. Much of the research has focused on the effectiveness of programs and less so on how teachers design fluency lessons using more open-ended digital tools. While the research that has been conducted has been highly valuable, particularly with regards to children with reading difficulties and disabilities, this review has highlighted research gaps that require further research emphasis.

Supplementary Materials: The following supporting information can be downloaded at: https://www.mdpi.com/article/10.3390/educsci14060633/s1, Table S1: Summary of articles reviewed.

Funding: This research received no external funding.

Institutional Review Board Statement: Not applicable for desk-based studies not involving humans or animals.

Informed Consent Statement: Not applicable for studies not involving humans.

Data Availability Statement: The original contributions presented in the study are included in the article/Supplementary Materials, further inquiries can be directed to the corresponding author(s).

Conflicts of Interest: The author declare no conflicts of interest.

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