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Technology-Assisted Reading Instruction for English Language Learners: A Methodological Review

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Abstract

Purpose: By methodologically reviewing the literature on Technology-Assisted Reading Instruction (TARI) for English Language Learners (ELLs) in K-12 settings, this study aims to advance the knowledge of TARI research and guide future research directions.

Design/Approach/Methods: This study examines 32 peer-reviewed journal articles published between 2000 and 2020. Each article was analyzed for research objectives, reading skills, learner demographics and contexts, theoretical frameworks, research designs, and outcomes.

Findings: A review of the literature reveals a strong focus on evaluating the efficacy of TARI through summative assessments, but limited attention to learners' literacy practices and interactive engagement in digital contexts. Additionally, there is a marked lack of alternative approaches to assessing the effectiveness of technology in promoting ELLs' reading progression and a continued emphasis on developing traditional literacy over multimodal literacy. TARI can enhance reading motivation, foster collaborative learning, provide scaffolding, improve reading performance, and expand semiotic resources.

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Originality/Value: As one of the first comprehensive methodological reviews of TARI, this study elucidates ELL reading education in the era of multiliteracy. Results have implications for technology-mediated education, which expanded rapidly during the COVID-19 pandemic.

Keywords

educational technology, English language learners, multiliteracy, reading, technology-assisted reading instruction

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Recent technological breakthroughs have revolutionized how knowledge is constructed, negotiated, and exchanged (Arnott, 2017). Accordingly, the scope and mode of reading activities have undergone a transformational shift, expanding beyond traditional print-based texts to encompass various modes of communication, including visual, aural, gestural, and spatial (Kress, 2003; New London Group, 1996). Consequently, readers are required to adopt the role of navigators and interpreters of multimodal information (Serafini, 2012), utilizing a diverse range of semiotic practices and resources to decode, encode, and structure meaning (Plester & Wood, 2009). Defined as the ability to derive meaning from multiple modes of communication (New London Group, 1996), multiliteracy has become a vital skill in this digital era. Therefore, it is imperative that reading instruction and learners' repertoires of reading practices evolve to incorporate multiliteracy to enable learners to effectively interpret, evaluate, and produce meaning across various modes of communication, thereby empowering them to become successful communicators and active participants in contemporary society.

In the last decade, the digitalization and technicalization of education have significantly advanced reading instruction for English Language Learners (ELLs). Educators now have access to a plethora of tools to assist in reading instruction, including collaborative notetaking, visual and audio text supplements, and web searching (Shadiev & Yang, 2020). Research on technology-assisted reading instruction (TARI) has revealed its significant potential to promote situated (Gheytasi et al., 2015), sociable (Smythe & Neufeld, 2010), and deep learning. Moreover, multiliteracy pedagogies that incorporate TARI have been shown to benefit ELLs in terms of agency and involvement, language and literacy development, identity affirmation, and critical literacy cultivation (Rajendram, 2015). As such, TARI has the potential to help reduce the academic disparities between ELLs and non-ELLs. However, as digital learning resources become more complex, practitioners may have limited awareness of their affordances and may not fully understand how to effectively utilize TARI (Yi, 2014). Therefore, there is a need for teachers to advance knowledge in this regard.

In this review, TARI is defined as a pedagogical approach that leverages technology to support reading instruction and enables learners to explore diverse modes of meaning-making. It

encompasses a range of newly emerging technologies—including touchscreen tablets, e-readers, and mobile devices—with innovative software and applications that utilize a range of semiotic resources. ELLs refer to primary and secondary-level students whose primary language is not English.

Research on technological interventions for reading instruction of ELLs has primarily focused on large-scale quantitative studies investigating the effectiveness of interventions through summative assessment (Cheung & Slavin, 2011). However, these studies tend to overlook critical aspects of implementation, including the perceptions and experiences of learners, teachers, practitioners, and parents. Investigations of the methodological choices made in these studies are also limited. In addition to providing a comprehensive understanding of the current state of the art in TARI research and guiding future research directions, a methodological review may furnish researchers with the opportunity to critically evaluate the robustness of their studies. This review also provides instructors with an expanded and informed pedagogical repertoire of TARI for ELLs.

This systematic review analyzes the methodological features of research on TARI for ELLs in K-12 contexts with the aim of enhancing the quality of TARI research and facilitating informed discussions about its implementation. This review is guided by the following research questions:

1. What are the key research characteristics of studies on TARI for ELLs in terms of research goals, reading skills, theoretical frameworks, learner demographics, and research design?
2. What patterns emerge in the use of technology in TARI for ELLs across the reviewed studies?

Methodology

Literature search

We conducted an initial search for empirical articles written in English and published in peer-reviewed journals between January 2000 and April 2020, using three databases, namely, the Education Research Information Center (ERIC), Web of Science Core Collection, and PsycINFO, which provide extensive education research literature for educators, researchers, and the general public. The chosen timeframe reflects the significant growth in the field since 2000, largely due to the increased use of information and communication technologies (ICTs) in education. Combinations of the following keywords were used: (*English language learner* OR *bilingual OR multilingual*), (*technology* OR *multimodal* OR *multimedia*), and (*reading* OR *new literacy* OR *digital literacy)* not *(tertiary* OR *university)*. We also retrieved the first 100 returns on Google Scholar that contained these terms in the title or abstract. The search yielded 274 relevant studies.

Articles were screened according to three inclusion criteria: (a) studies that specifically outlined interventions or practices related to improving reading for ELLs, (b) studies reporting both the

implementation and effects of TARI, and (c) studies situated in K-12 contexts. After careful examination of the abstracts and methods sections of each article, 39 studies were selected for further screening. At the full-text level, we excluded studies with special education students or those in after-school settings because our primary focus was on classroom reading instruction for the general ELL population. We also eliminated studies that emphasized content knowledge or skills other than reading, and those in which reading was a tangential topic. Ultimately, a total of 32 articles were included in this review. All of the eligible studies were published between 2004 and April 2020.

Analysis

This review applies thematic analysis (TA), which is a useful tool for helping researchers analyze materials through a particular conceptual lens and summarize key features in a well-structured manner (Braun & Clarke, 2012). Each article was imported into NVivo, a qualitative data analysis software package, as a unit of analysis. We created seven superordinate categories to organize our analysis: (a) TARI description, (b) theoretical framework, (c) participant characteristics and context (e.g., number of participants, age, and language proficiency), (d) research purpose, (e) research method, (f) data sources, and (g) key findings (see Table 1 for a detailed overview). Author 1 was responsible for the initial coding and Author 2 assisted in finalizing the coding scheme. We then followed an iterative analytic strategy by repeatedly reading the codes and sections of the sources to develop subcategories within the superordinate categories. For instance, the category of "TARI description" had the sub-categories of "digital reading platforms," "multimodal storytelling," and "assistive technology," while the category of "data sources" had sub-categories of "classroom observations," "student self-reports," and "standardized reading assessments." Themes were grouped and finalized to ensure that they fully addressed the research questions. Disagreements were resolved by revisiting the original studies to confirm that the results were representative.

Results

Research characteristics

Research purposes. Analysis revealed that the bulk of research on TARI focused on investigating its effectiveness, while neglecting the contextual experiences of learners and instructors with technology. Of the 32 studies, 21 evaluated the effects of technology integration on ELLs' reading using summative assessment. Within this subset, seven studies also explored potential factors that could influence reading performance, such as usage conditions, linguistic background, gender, cognitive styles, and motivation, while five studies examined learners' attitudes toward technology. However, little attention was given to learners' literacy practices and interactive responses to digital tools and

Table 1. Summary of key features and findings of selected studies.

Study	Research Questions/ Statement	Theoretical Perspective	Methodology, Data Collection, and Analysis	Participants/Language/Context	Key Findings	Technology Types
Amelia & Abidin (2018)	To explore the effects of using a tablet-based digital storytelling application in English language learning among young ESL learners.	Mayer's (2001) cognitive theory of multimedia learning.	Qualitative case study. Interviews and observations. Content analysis.	N = 6 Age(s): 11 Language(s): EFL; Malaysian as L1 Language Level: Level 2 with high, intermediate, and low English language proficiency levels Location: A public primary school in Malaysia	Digital storytelling on tablets is an effective, beneficial, and motivating method for vocabulary learning.	Tablet-based digital storytelling application
Brown (2020)	To gain insight into the positive impacts of technology on the literacy development of young children learning English as a new language.	Kress' (2010) multimodality.	Qualitative ethnographic study. Video responses, field notes, weekly memos, sticky notes, videotaping, photographs, and interviews. Thematic and multimodal discourse analysis.	N = 12 second-grade students Age(s): NA Language(s): ESL; Spanish, Vietnamese, Pashto, and Dari as L1 Language Level: NA Location: An English-only classroom in an urban, high poverty school in the southeastern US	Semiotic resources play a significant role in fostering students' agency, providing feedback, establishing identity, and engaging in digital play.	Video production
Brown (2016)	To document the digital literacy experiences of a diverse group of second-graders who used e-readers to read interactive picture books.	Multimodal theory and New Literacies Studies.	Qualitative study. Field notes, videotaping of small groups, survey, monthly memo, monthly journal, and interviews. Comparative and discourse analysis.	N = 21 second-grade students, including 11 ELLs Age(s): NA Language(s): ESL; Spanish (8) French (1), and Korean (2) as L1 Language Level: NA Location: An urban Title I school in the US	Multimodal texts enable students to practice literacy skills, promote student engagement and agency, and increase reading time.	E-readers
Chen et al. (2010)	To determine the effectiveness of an	Collaborative learning (social	Mixed-methods study. Pre-test, post-test, student	N = 56 Age(s): NA	TACO can effectively improve the reading comprehension	TACO

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Table 1. (continued)

Study	Research Questions/ Statement	Theoretical Perspective	Methodology, Data Collection, and Analysis	Participants/Language/Context	Key Findings	Technology Types
	online tag-based, collaborative reading learning system (TACO) for promoting learners' English reading comprehension and assessing instructors.	constructivism, implicit).	tag set, teacher tag set, and survey. Semantic, social network, and statistical analyses.	Language(s): EFL; Chinese as L1 Language Level: NA Location: A high school in Chinese Taiwan	skills of EFL students within a social, collaborative learning environment.	
Chen et al. (2016)	To determine if a digital pen and paper interaction platform (DPPIP) is more effective than traditional paired reading approaches for promoting students' oral reading fluency.	Cognitive theory.	Mixed-methods study. Pre-test, post-test, survey, and interview. Descriptive and inferential statistical analyses.	N = 62 seventh-grade students Age(s): 13–14 Language(s): EFL; Chinese as L1 Language Level: NA Location: A public junior high school in Chinese Taiwan	DPPIP improved students' English-language oral reading fluency, motivation, and learning satisfaction.	DPPIP
Chen et al. (2014)	To examine if a digital reading annotation system (DRAS) can enhance learners' reading comprehension and annotation skills.	Cognitive theory.	Quantitative study with a quasi-experimental design. Annotation ability and reading comprehension assessments. Descriptive and inferential statistical analyses.	N = 64 seventh-grade students Age(s): NA Language(s): EFL; Chinese as L1 Language Level: NA Location: A junior high school in Chinese Taiwan	DRAS helped increase students' reading comprehension and annotation abilities.	DRAS
Delacruz (2014)	To explore the benefits and challenges of using the Nearpod	Technological Pedagogical Content Knowledge	Qualitative study. Student video journal interview, work samples	N = 9 fourth-grade students, including 4 ELLs, and a student teacher	Using mini iPads and the Nearpod app during guided reading instruction engages	Mini iPads and the Nearpod app, which

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Study	Research Questions/ Statement	Theoretical Perspective	Methodology, Data Collection, and Analysis	Participants/Language/Context	Key Findings	Technology Types
	app in guided reading lessons.	(TPCK) and Experiential Learning Theory (ELT).	(quiz results, drawings, poll results), and an interview with the student teacher. Content analysis (implicit).	Age(s): NA Language(s): ESL Language Level: Lowest levels in the class Location: A suburban elementary school in southeastern US, where 60% of the students are eligible for free/reduced lunch	and benefits students, who were able to transfer gained knowledge to independent work. The teacher also reported improved organization in the guided reading group. However, careful planning is necessary to ensure that the technology works properly.	educators can use to create interactive presentations
Gheytasi et al. (2015)	To investigate the relationship between mobile device usage and Iranian EFL students' English reading comprehension.	Situated learning (Social constructivism, implicit).	Mixed-method study. Pre- and post-tests (reading comprehension tests) and interview. Inferential and descriptive statistical analyses; content analysis (implicit).	N = 40 high school students Age(s): NA Language(s): EFL Language Level: NA Location: An English language institute in Iran	Using smartphones to facilitate language learning can have a positive impact on improving the reading comprehension skills of ELLs.	Smart phones
Green et al. (2014)	To examine how vidcasts can be utilized in ESL classes.	Situating constructivism.	Qualitative exploratory case study. Artifacts, semi-structured interview, and observation. Constant comparative analysis.	N = 8 sixth-grade students Age(s): NA Language(s): ESL; Mexican (7) and Chinese (1) as L1 Language Level: NA Location: A sixth-grade ESL reading class at a medium size grade-one campus in the southwestern US	The use of vidcasts fostered students' language growth by facilitating meaning negotiation. Students also benefited from sharing roles and responsibilities.	Vidcasting
Hur & Suh (2012)	To explore the use of interactive whiteboards (IWBs), digital storytelling, and	Sheltered instruction and vocabulary teaching.	Mixed-methods research. Daily video podcasts, vocabulary tests, student survey, photostory project,	N = 11 third- and fourth-grade students Age(s): NA Language(s): ESL; Korean as L1 Language Level: Limited English	IWBs with visual aids, interactive games, and exam recaps helped students acquire new vocabulary,	An IWB, podcast, and digital storytelling

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Study	Research Questions/ Statement	Theoretical Perspective	Methodology, Data Collection, and Analysis	Participants/Language/Context	Key Findings	Technology Types
	podcasting in language acquisition.		teacher interview, classroom observation, final report cards, and informal meetings. Inferential and descriptive statistical analyses; content analysis (implicit).	proficiency Location: An ELL classroom in the southeastern US	promoting their engagement.	
Kim et al. (2018)	To examine kindergarten students' reactions to folktales and traditional cultural values through Korean animated folktales (KAF) and whether it promotes an understanding of cultural values.	Sociocultural theory, new literacy studies, and translanguaging.	Qualitative case study. Audio/video recordings, open-ended interviews with parents and the teacher, and observational field notes. Thematic analysis.	N = 6 fluent bilingual kindergarteners, 1 teacher, and 6 parents Student Age(s): 6 Language(s): English and Korean Language Level: Fluent bilingual Location: A Korean language school in the midwestern US	KAF increased student involvement in stories and facilitated a better understanding of moral themes.	KAF
Kuo et al. (2013)	To evaluate the impact of the multimodal presentation system (MPS) on student learning outcomes.	Cognitive theory of multimedia learning (CTML).	Mixed-method study. Post-test, satisfaction assessment, and interview. Descriptive statistical analysis; content analysis (implicit).	N = 134 fifth-grade students Age(s): 11–12 Language(s): EFL; Chinese as L1 Language Level: NA Location: Six classes in two public elementary schools in Chinese Taiwan	MPS has a positive impact on the English language learning achievement of elementary ESL students.	MPS, which is a multimodal presentation software integrated with IWBs.
Larabee et al. (2014)	To examine the effectiveness of an iPad-based word box intervention in	NA	Quantitative study with a multielement single-case experimental design.	N = 3 first-grade students, including 2 ELLs Age(s): 6 Language(s): ESL; Spanish (1)	No clear evidence of improved decoding performance among first-grade students who used an iPad-	An iPad-supported word box intervention

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Study	Research Questions/ Statement	Theoretical Perspective	Methodology, Data Collection, and Analysis	Participants/Language/Context	Key Findings	Technology Types
	improving decoding performance and task engagement.		Reading assessments (generalization of letter sounds, retention, time on-task). Descriptive statistical analysis.	and Somali (1) student at L1. Language Level: Below grade-level Location: A public elementary school in an urban school district in the midwestern US	supported approach to the word box intervention.	
Liang & Huang (2014)	To investigate the reading patterns and outcomes of sixth-grade students using e-books via a reading-rate-tracking technique.	Cognitive theory of multimedia learning.	Quantitative study with an experimental design. Reading assessments (reading rate and retrieval). Descriptive statistical and explorative analyses.	N = 24 sixth-grade students Age(s): NA Language(s): EFL; Chinese as L1 Language Level: NA Location: A regular class period at an elementary school in Chinese Taiwan	Using e-books can potentially improve retrieval outcomes in sixth-graders compared to printed books. However, more extensive research is needed to understand the reading patterns and outcomes associated with e-books.	E-books
Lin (2014)	To examine the impact of employing PCs and iPad Minis on learners' English reading ability.	Collaborative learning (Social constructivism, implicit).	Quantitative study with an experimental design. Reading skill tests. Inferential and descriptive statistical analyses.	N = 84 tenth-grade students Age(s): NA Language(s): EFL; Chinese as L1 Language Level: Low-intermediate Location: A senior high school in northern Chinese Taiwan	Using mobile tablet PCs in ERP can effectively improve adolescent ELLs' linguistic abilities related to reading, promoting motivation and attitudes toward reading and engagement in online activities.	Online Extensive Reading Program (ERP) using a mobile device and tablet PC (iPad Mini).
Liu et al. (2014a)	To investigate the potential benefits of using mobile technology, namely, the iPod touch, as a teaching and	Situated learning (Social constructivism, implicit).	Mixed-methods case study. Interviews, classroom observations, surveys, and artifacts. Descriptive statistical analysis; content analysis (implicit).	N = NA (2 ELL teachers and their middle school students) Age(s): NA Language(s): ESL Language Level: NA (only school-level statistics)	Mobile technology has unique affordances for ELL students, including multimedia capabilities, portability, connectivity, and flexibility. However, teachers struggled to	iPod touch devices

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Study	Research Questions/ Statement	Theoretical Perspective	Methodology, Data Collection, and Analysis	Participants/Language/Context	Key Findings	Technology Types
	learning tool for ELLs.			Location: A medium-sized school district in south central Texas	integrate the device in their instruction.	
Liu et al. (2014b)	To investigate a mobile learning initiative that provided iPod touch devices to teachers and ELLs.	NA	Mixed-methods study. Interviews, classroom observations, and student surveys. Descriptive statistical analysis; content analysis (implicit).	N = NA (2 ELL middle school teachers and their students in the first cycle and 2 ELL elementary school teachers and their students in the second cycle) Age(s): NA Language(s): ESL Language Level: NA (only district-level statistics) Location: A large school district in the southwestern region of the US	Incorporating the iPod touch in ELL helps increase learners' reading time, provides differentiated learning experiences, and supports language and content learning.	iPod touch devices
Martin-Beltrán et al. (2017)	To explore the potential of digital text for promoting linguistically diverse student engagement in reading.	Sociocultural theory.	Mixed-methods study. Observation, video-taping of buddy sessions and teacher-led lessons, survey (123 kindergartners and 65 fourth-grade students), and interviews (16 students). Sociocultural discourse analysis.	N = NA (kindergarten and fourth-grade students) Age(s): NA Language(s): ESL Language Level: NA Location: Four culturally and linguistically diverse elementary schools in the mid-Atlantic US	The quality of linguistically diverse students' engagement with digital and paper books differs. Students were more engaged in meaningful talk, used text features, and paid more attention to text when using paper books compared to digital books.	Digital text on tablets
Park & Kim (2016)	To investigate the reading strategies used by elementary ELLs when reading	Dialogism.	Qualitative study. Observations and ELLs' verbal protocol reports, interviews, documents,	N = 4 (2 fourth-grade and 2 fifth-grade students) Age(s): 10–11 Language(s): ESL	Students engaged in real and virtual conversations, which helped the development of their reading techniques.	Computer-based texts

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Study	Research Questions/ Statement	Theoretical Perspective	Methodology, Data Collection, and Analysis	Participants/Language/Context	Key Findings	Technology Types
	computer-based texts at school and home.		field notes, and reflective journals.	Language Level: Advanced low (2) and intermediate mid (2) Location: A public elementary school in the southeastern US		
Park & Warschauer (2016)	To determine the effects of visual-syntactic text formatting (VSTF) on students' reading and writing development.	Cognitive theory.	Quantitative study with an experimental design. ELA performance in the CSTs, interviews, and observation. Inferential statistical analysis.	N = 282 sixth-grade students Age(s): 10–11 Language(s): ESL Language Level: 113 English Learners (EL), 59 Initially Fluent English Proficient (IFEP) learners, and 110 Reclassified Fluent English Proficient learners Location: Two suburban school districts in Southern California	VSTF reading helped L2 learners improve their syntactic awareness, which is crucial for their English reading and writing.	VSTF technology
Parvin & Salam (2015)	To examine the advantages and challenges of incorporating audio-visual content in elementary learners' education.	NA	Mixed-method study. Annual school exam results for students in ICT and non-ICT schools, focus group discussion, and school monitoring tools (class observation, video of class teaching, review of teachers' reflection diary). Descriptive statistical analysis.	N = NA (Grades 1–4) Age(s): NA Language(s): EFL Language Level: NA Location: 15 ICT schools and 15 non-ICT schools in a district in Bangladesh	Audio-visual content enhanced interactive language classes depending on the technology design and instructor usage.	Flash based interactive lessons
Poulsen et al. (2007)	To compare the impact of silent reading with the Project LISTEN Reading Tutor.	Cognitive theory (implicit).	Quantitative study with an experimental design. The school district's Curriculum-Based Measures (CBMs).	N = 34 students in the second- to fourth-grade Age(s): NA Language(s): Spanish and English Language Level: NA (only	The Reading Tutor program resulted in considerable fluency improvement but there was no significant overall difference in comprehension scores.	Project LISTEN Reading Tutor uses automated speech recognition to "listen" to

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Study	Research Questions/ Statement	Theoretical Perspective	Methodology, Data Collection, and Analysis	Participants/Language/Context	Key Findings	Technology Types
			Inferential statistical analysis.	district-level statistics) Location: A Spanish–English bilingual program in a school in a suburban area of Chicago		children reading aloud and provides both spoken and graphical feedback.
Proctor et al. (2011)	To examine the effectiveness of an Internet-based vocabulary intervention.	Theories of vocabulary knowledge and acquisition.	Quantitative study with a quasi-experimental design. Standardized English reading assessment, a researcher-designed vocabulary breadth test, and a researcher-designed vocabulary depth test. Descriptive and inferential statistical analyses.	N = 240 fifth-grade students, including 49% Spanish-English bilinguals Age(s): NA Language(s): Spanish and English Language Level: Third percentile in the Gates–MacGinitie total English reading measure Location: Four schools and 12 classrooms in three districts in a northeastern metropolitan area with a medium to large Spanish-speaking population	The Internet-based vocabulary intervention resulted in substantial improvements in students' vocabulary knowledge and depth but not comprehension.	Multimedia texts with embedded instruction on 40 words and reading strategy support.
Rahimi & Yadollahi (2017)	To compare the impact of online digital stories and offline programs on learners' literacy development.	Social constructivism; cognitive theory (implicit).	Quantitative study with a quasi-experimental design. English tests and IT literacy tests. Descriptive and inferential statistical analyses and explorative analysis.	N = 42 first-grade junior high school students (all female) Age(s): 13 –14 Language(s): EFL Language Level: Basic Location: A "smart school" with many different technologies in Iran	Digital storytelling significantly improved learners' literacy skills.	Digital storytelling

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Table 1. (continued)

Study	Research Questions/ Statement	Theoretical Perspective	Methodology, Data Collection, and Analysis	Participants/Language/Context	Key Findings	Technology Types
Reeder et al. (2015)	To investigate the effectiveness of Reading Tutor software for improving ELLs' oral reading fluency and the grade level of mastered materials.	NA	Quantitative study with a quasi-experimental design. Embedded reading fluency measure. Descriptive statistical analysis.	N = 36 students in grades 2–7 Age(s): 6–12 Language(s): ESL; Cantonese, Hindi, Chinese, Spanish, Tagalog, and Vietnamese as L1 Language Level: Beginner to low intermediate Location: A medium sized public elementary school serving a low income, multilingual neighborhood in Vancouver, Canada	Students improved their oral reading fluency and mastered grade level materials.	Reading Tutor (RT) software, which uses speech recognition to listen to oral reading and provides context-sensitive feedback
Smythe & Neufeld (2010)	To explore the potential of multimodal, multilingual, and digital literacy pedagogies.	Van Leeuwen's (2005) social semiotic theories.	Qualitative ethnographic classroom study. Observations and interviews. NA	N = NA (sixth- and seventh-grade students and a teacher) Age(s): NA Language(s): ESL Language Level: NA Location: A middle school in Canada	ELLs have a wealth of semiotic resources and relational networks that are often overlooked in pedagogic discourses, which prioritize print literacy.	Podcast (producing podcasts and accompanying books)
Van Laere & van Braak (2017)	To examine the factors influencing students' use of bilingual text-to-speech (TTS) technology in science education.	Cognitive theory (implicit).	Quantitative study with an experimental design. Log files, reading comprehension test, science achievement test, and a questionnaire. Explorative analysis.	N = 360 fifth-grade students Age(s): NA Language(s): EFL; French, Italian, Polish, Spanish, Turkish as L1 Language Level: NA Location: 31 classrooms in 23 schools in Belgium	Bilingual TTS technology can be an important support tool in computer-based learning environments, especially for students whose home language differs from the language of instruction (LOI) at school.	TTS in computer-based learning environments (CBLEs)

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Table 1. (continued)

Study	Research Questions/ Statement	Theoretical Perspective	Methodology, Data Collection, and Analysis	Participants/Language/Context	Key Findings	Technology Types
Warschauer et al. (2004)	Case studies of two K-12 schools with high-technology learning environments.	Social constructivism (implicit).	Qualitative case study. NA NA	N = NA (Latino fourth-grade students and diverse immigrant and refugee middle school students) Age(s): NA Language(s): ESL (Only district-level statistics) Language Level: NA Location: Two K-12 schools; one located in a low-income Latino community in California, the other in one of the most economically, academically, and linguistically diverse neighborhoods in Maine	Technology-inspired independent reading and scaffolded language development.	Laptops and other new technologies and the Expeditionary Learning Outward Bound (ELOB) model, which focuses on the relationship between learning and representation
Wijekumar et al. (2018)	To examine the effect of SWELL on enhancing reading comprehension across content areas for Spanish-speaking ELLs.	Van Dijk & Kintsch's (1983) Construction-Integration and Van den Broek's (2005) Landscape.	Quantitative study. A distal standardized test (i.e., GSRT) and researcher-designed measures regarding signaling word knowledge and construction of good main ideas and recalls with the structure strategy. Explorative analysis.	N = NA (14 fourth-grade teachers and 17 fifth-grade teachers and their classrooms) Age(s): NA Language(s): ESL (Only district-level statistics) Language Level: NA Location: Twelve schools in Southwestern US	SWELL had positive effects on the reading comprehension skills of Spanish-speaking ELLs.	Strategy instruction on the web for Spanish-speaking English learners (SWELL)

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Study	Research Questions/ Statement	Theoretical Perspective	Methodology, Data Collection, and Analysis	Participants/Language/Context	Key Findings	Technology Types
Yang & Chen (2007)	To explore students' perceptions of the use of internet tools in language learning.	Whole language and constructive theory.	Mixed-methods study. Questionnaires, interviews, e-mails, and document analysis (e.g., web projects, online discussion, and students' work). Descriptive statistical analysis and content analysis (implicit).	N = 44 male tenth-grade students and their teacher Age(s): NA Language(s): EFL; Chinese as L1 Language Level: NA Location: A single boy's senior high school in Chinese Taiwan	Advanced Joint English Teaching (AJET) allowed students to try out new technology, which enhanced their motivation. The students appreciated learning English via the Internet.	AJET, which comprises six Internet-based teaching activities (group e-mailing, a Web-based course, an email writing program, English homepage design, video-conferencing, and chat room discussion)
Silverman & Hines (2009)	To compare the impact of standard and multimedia-enhanced read-aloud vocabulary instruction on ELLs and non-ELLs.	Paivio's (1986) dual-coding (cognitive analysis, implicit).	Quantitative study. Assessments (knowledge of words, general vocabulary knowledge, and knowledge of science concepts). Descriptive and inferential statistical analyses.	N = 85 learners (15 in pre-kindergarten, 28 in kindergarten, 25 in the first grade, and 17 in the second grade; 68% non-ELLs and 32% ELLs) Age(s): Average 6.5 Language(s): ESL; with Haitian Creole, Portuguese, Chinese, and Spanish as L1 Language Level: NA Location: A small, semiurban public school in the northeast of the US	The multimedia-enhanced approach had a positive effect on ELLs' general vocabulary knowledge.	Multimedia-enhanced read-aloud vocabulary intervention

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Study	Research Questions/ Statement	Theoretical Perspective	Methodology, Data Collection, and Analysis	Participants/Language/Context	Key Findings	Technology Types
Yoon (2013)	To examine how digital storytelling in after-school English class affects Korean ELLs' attitudes and perceptions toward learning English.	Situated learning (Social constructivism, implicit).	Mixed-methods study. Students' self-evaluation report and lecture review report gathered for data analysis, as well as quantitative data (pre-/post-survey on the change of students' learning attitude and reading comprehension). Descriptive statistical analysis; content analysis (implicit).	N = 32 fifth-grade students Age(s): 12 Language(s): EFL; Korean as L1 Language Level: NA Location: A public elementary school in Korea	Digital storytelling positively influenced ELLs' attitudes toward learning English.	Digital storytelling

texts, with only nine studies capturing such information and one study exclusively reporting learners' attitudes and perceptions. Teachers' practices and/or perceptions regarding the integration of technology into the curriculum were briefly discussed in only three studies.

Focus on reading skills. The predominant use of technology was to mediate access to traditional literature. Most studies (N = 18) focused solely on developing print-based reading skills, with reading comprehension taking precedence, followed by reading fluency and vocabulary. Although eight studies implied their intention to enhance learners' multiliteracies by emphasizing situated and transformed practices, only six explicitly stated that their objective was to improve learners' skills in terms of digital literacy, new literacies, multiliteracy, and "multimodal literacy." The focus on leveraging the affordances of digital resources primarily to strengthen basic literacy skills is consistent with Lankshear and Knobel's (2003) argument that technology is frequently harnessed to foster "abilities to handle conventional alphabetic print texts rather than to generate multimodal text and to understand principles of making multimodal meanings" (p. 77).

Theoretical frameworks. The reviewed articles demonstrated a strong reliance on learning theories and theories of language and meaning to guide TARI research. However, not all of the articles explicitly state their theoretical frameworks. Of the reviewed articles, ten employed the cognitive theory of multimedia learning or duo-coding to investigate how multimedia texts featuring both visual and auditory components could help promote reading (Mayer, 2014). Five studies applied the situated learning approach, which embraces sociocultural and constructivist views of learning, to explore how learners interact with digital resources, and how technology creates authentic learning environments that contextualize multimodal texts. Two studies utilized the collaborative learning approach, which emphasizes joint intellectual efforts with peer learning supervised by instructors, to examine factors affecting learners' technical and non-technical reading development. Two studies used multimodal theory to explore the impact of digital storytelling and multimodal picture books on learners' new literacy, engagement, self-reflexivity, and forms of meaning making. Several studies also applied sociocultural theory, sociosemiotic theory, dialogism, the semantic approach, and the whole-language approach to reading.

Learner demographic characteristics and research contexts. In terms of language proficiency, four studies included participants with varying proficiency levels, while three studies focused on learners at the beginner level, two at the intermediate level, and two at the fluent level. Although most studies (N = 21) did not report the participants' linguistic proficiency, they typically provided relevant information regarding learners' prior learning experiences. The research predominantly focused on ELLs in elementary school settings (N = 19), with ELLs in kindergarten, middle,

and high schools found to be relatively overlooked. Regarding participants' first language (L1) backgrounds, of the 17 US-based studies, four focused on students with various L1 backgrounds and speakers of Spanish, Korean, and Chinese were studied more frequently than the other language groups. In EFL settings, learners in countries/regions like Iran, Canada, and Chinese Taiwan were examined more frequently.

Research design. Twelve studies employed quantitative designs to investigate whether TARI could enhance learners' reading performance. Some also tracked reading rates and decoding patterns to examine their relationship with test results. Eight of the selected studies used experimental designs. Excluding a study which did not report specific numbers, sample sizes ranged from 3 to 282, with a median sample size of 34.

Nine studies employed qualitative designs with a focus on ELLs' technology-mediated literacy practices and attitudes; of these, some examined the perspectives of teachers and/or parents. Observations, interviews, and artifacts were the most commonly used data sources. Thematic or content analysis was frequently applied to explore how students interacted with technology, how TARI built on students' existing knowledge and skills, and how teachers supported their learning. Comparative and discourse analyses were used to investigate the affordances and constraints of the technology applied, as well as the social, cultural, and instructional contexts that influenced students' meaning-making. Sample sizes ranged from 6 to 21.

Eleven studies adopted mixed-method designs prioritizing learners' reflective thoughts and the outcomes of their experiences with TARI, with less emphasis on documenting their literacy practices. Researchers frequently used interview transcript data, focus group notes, survey responses, documents, and reading test scores. Although survey data were often analyzed using both qualitative and quantitative methods, researchers seldom identified their analytical framework. Sample sizes ranged from 11 to 134.

Roles of technology

Various types of TARI techniques have been applied, including digital reading platforms offering e-books, tag-based reading systems, annotation systems, multimodal presentation systems, and visual-syntactic text formatting. Educational applications like storytelling, interactive presentations, word boxes, interactive whiteboards, and assistive technologies (e.g., speech-to-text and speech recognition) have also been employed for TARI. Providing a range of options for educators to support ELLs in reading instruction, such TARI technologies have the potential to enhance learners' reading motivation, engagement, self-efficacy, and learning satisfaction; promote collaborative learning; provide scaffolding for reading competencies and language skills; and expand students' semiotic repertoires. The results of some studies suggest that well-planned and well-executed

TARI can help students develop confidence in their ability to read and produce digital texts. However, two studies found no significant differences in learners' decoding patterns, time-on-task, or comprehension performance with the implementation of TARI.

A significant barrier to leveraging the enormous potential of TARI is the lack of relevant training for educators. Teachers need additional support regarding how to use, deploy, and manage these devices, as well as how to equip students with the skills necessary to make technology a facilitator of their literacy development. As such, it is necessary to address the challenges to making TARI a pedagogic transformation rather than merely an enrichment, as well as obstacles to making technology more accessible and cultivating community support.

Discussion and suggestions

In the reviewed literature, technology was primarily utilized to teach traditional reading skills like comprehension, reading fluency, and vocabulary. Although ELLs engage in various web-mediated literacy activities outside the classroom, such as interpreting and producing blogs and videos (Lisenbee et al., 2020), there is limited empirical research on their multiliteracy activities and how diverse semiotic resources contribute to their comprehension of multimodal texts. This reflects the prevalence of the "autonomous" approach toward literacy (Street & Street, 1984), which prioritizes print literacy (Papert, 1993) and marginalizes non-linguistic semiotic resources within pedagogic discourses (Smythe & Neufeld, 2010). This phenomenon can be attributed to various factors, including the separation between "digital time" and "class time" (Smythe & Neufeld, 2010), technical constraints within schools (Martin-Beltrán et al., 2017), and instructors' lack of support in terms of applying digital tools and establishing a high-quality digital space for ELLs (Martin-Beltrán et al., 2017). Future TARI studies should explore new opportunities for fostering ELLs' multiliteracy through technology (Lisenbee et al., 2020), particularly through interactive, constructive, and inquiry-based activities such as podcast production and digital storytelling.

The reliance on standardized test scores to evaluate the effectiveness of TARI emerged as a common theme across many studies. As Anderson and Kachorsky (2019) note, this approach to assessment tends to align with autonomous and standard-based views of literacy that fail to capture the multidimensional nature of reading, including participation, multilingual communication, content creation, problem-solving, and collaboration. To address this limitation, researchers should explore alternative assessment techniques that measure learners' complex competencies and align with the Universal Design for Learning (UDL), such as embedded and portfolio assessments (Office of Educational Technology, 2015). In doing so, TARI research will move beyond the narrow focus on standardized test scores and facilitate a more comprehensive understanding of the impact of technology on literacy development.

Although a few studies have investigated the affective states and attitudes of ELLs towards TARI, there is a need for more comprehensive research in this area to explain how digital content is communicated to learners and how the specific qualities of digital programs, including semiotic resources, impact interaction in the digital space. Such research could foster a better understanding of the intricate relationship between affective and attitudinal factors and TARI, ultimately helping to improve the design of educational digital tools and enhance the quality of learners' experiences.

This review also found a high reliance on quantitative research designs to evaluate the effectiveness of TARI. While quantitative research is essential, the inclusion of qualitative research based on ethnographic observations and in-depth interviews could provide valuable insights into how learners use these devices and uncover new possibilities for interaction (Livingstone & Sefton-Green, 2016). Combining data from both quantitative and qualitative research could help researchers capture the complexities of learning processes in digital scenarios, such as the quality of communication and collaboration, forms of involvement, and the challenges of inequalities. Additionally, a better understanding of learner demographics could inform the development of personalized learning experiences in digital contexts and shed light on how diverse communities engage with these resources.

The current state of affairs calls for enhancing teachers' capacities to teach digital literacy (Jones et al., 2021), implementing multiliteracy pedagogies (Mourão, 2015), and raising teachers' awareness of the potential of technology (Gee & Hayes, 2011). Therefore, teachers should be encouraged to explore the pedagogical possibilities of digital technologies and carefully weigh their advantages and disadvantages. Several research directions have been identified to equip teachers with the knowledge necessary to prepare students for future literacy demands, including exploring teachers' pedagogical roles and practices; promoting collaboration among teachers, administrators, and researchers in support of multimodal education; and developing teacher education programs to empower teachers to act as transformative agents. Nonetheless, it is worth emphasizing that technology is not a panacea (White & Gillard, 2011). Effective TARI implementation necessarily involves extensive research by designers and researchers, meticulous lesson planning and curricular integration by instructors, and systematic planning by the administration (Martin-Beltrán et al., 2017; Sindoni & Moschini, 2021).

Implications

This methodological review synthesized research on TARI for ELLs in the K-12 context. While the results are not intended to be exhaustive, they are significant for technology-mediated reading instruction, which flourished during the COVID-19 pandemic and will continue to be of interest to researchers, instructors, and policymakers. As one of the first comprehensive reviews on

TARI for ELLs, this study elucidates the current state of research on this topic and highlights key limitations, such as the narrow research scope. In addition to exploring and utilizing different methodologies and approaches, future studies should investigate how multilingual learners interact with technology, teachers' understanding of multimodalities and pedagogical practices, and alternative assessment methods. These results have practical implications for both teachers and policymakers. Teachers can broaden their approaches to multiliteracy instruction by incorporating the techniques and strategies suggested in this review into their teaching toolkits. Meanwhile, policymakers should use these results to inform the development of effective strategies to support teachers in TARI and improve multiliteracy instruction for ELLs.

Contributorship

Xinyue Zuo conceived the original idea, searched and screened the literature, and conducted the first round of analysis. She was also responsible for writing the abstract and the bulk of the main body, finalizing the paper, and responding to the reviewers' comments. Denise Ives contributed by finalizing the coding schema, discussing emerging findings, providing critical feedback, and helping shape the design, analysis, and manuscript.

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