BuddyBooks™

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1. Introduction for Specialized Reading Teachers

BuddyBooks utilizes AI and Buddy Reading to improve independent practice for students and provide data-driven reading accountability for teachers.

**Buddy Reading:** BuddyBooks uses buddy reading, a proven method of practice for students with reading disabilities. Students read with a computer partner, listening to a passage read to them and then reading the following passage out loud.

**Analyzes Student’s Reading using AI:** BuddyBooks continually analyzes the student’s reading, checking that the student read the words correctly, and identifies words or phonemes where the student had difficulties.

**Teacher Dashboard:** On the web dashboard, you can see how much your students are reading, how fast they are reading, and where they are having problems. You can even listen to samples of their reading,

**Massive Library:** You can assign books from ObjectiveEd’s library, or you can use your Bookshare account to assign any of the 1M+ fiction and non-fiction books. Students are reading the books they enjoy, selected by you, and approved by your school.

**Customized to your student’s needs:** You can personalize BuddyBooks to meet your student’s individual needs. Students can adjust the background color, font color, and word-by-word highlight color, as well as the font size and reading speed of their computer partner.

**Safe and comfortable practice:** By reading with a computer partner, students feel more comfortable making mistakes as they continue to improve. It’s especially valuable for students with reading disabilities who feel nervous reading out loud in the classroom.

2. Foundational Research

This document highlights the foundational research supporting BuddyBooks. It provides an overview of the research underlying BuddyBooks AI–powered intelligent reading system and the research on key elements of literacy instruction for students with a Specific Learning Disability in Reading. It describes the components of the BuddyBooks pedagogy and the research base supporting each component.
Using advanced AI-based Speech Recognition and evidence-based best practices, BuddyBooks is a reliable, independent practice system for students to improve their oral reading skills. BuddyBooks helps students with a Specific Learning Disability in Reading, such as dyslexia.

How it works:

- Using the BuddyBooks teacher web-dashboard, a teacher chooses books from ObjectiveEd’s library, or uses their BookShare account to assign any of Bookshare’s books.
- The student reads the book with a computer partner using a web-browser. The student and computer alternate reading sentences or passages.
- BuddyBooks determines how much, and how well, the student is reading.
- Using the web-dashboard, the teacher reviews the student’s improvement, and can listen to audio clips of the student’s oral reading.
- BuddyBooks identifies to the teacher the areas where the student is having difficulties, so the teacher can provide targeted assistance.
- BuddyBooks includes several research-based remediation methods (section 5) to improve oral reading and fluency during a student’s independent reading time.
4. Theoretical Framework for BuddyBooks

Early Research

Reading is a skill that contributes to knowledge building and sharing. For dyslexic children, mastering this skill is a challenge due to their difficulties. Many have agreed that the theory behind such difficulties is the phonological-core deficits theory (Lundberg, 1995; Shaywitz, 1996; Wolf, 1999; Snowling, 2000; Frost, 2001; Ziegler, 2006). Support has been given in many ways to dyslexic children to teach them to read from teaching using multi-sensory methods to using computer-based applications that include animated characters, text-to-speech (TTS) technology and Automated Speech Recognition (ASR).

ASR is a technology that enables computer or machine to recognize spoken attributes of a human. ASR is used to track reading while the children are reading aloud and add for an interactive application using speech, which enable users to ask question to the application. In addition, pronunciation accuracy is also provided for feedback (Chard, 2002).

By providing the immediate intervention as support, ASR technology has the potential to enhance reading ability for normal children and is a good tool for helping dyslexic children to read (Nix, 1998; Williams, 2000; Hagen, 2004). Furthermore, ASR is found to offer multi-sensory experience to dyslexic children as means of teaching (Raskind, 1999; Higgins, 2000). The multi-sensory experience is created as the child reads aloud a word and sees it being displayed on the computer screen. Automated speech recognition software has shown to be a promising digital technology to enhance students’ reading proficiency (Mostow & Aist, 1999).

Significant progress has been achieved in the field of automatic speech recognition (ASR) and effective spoken dialogue systems have been built and deployed for several applications (Gerosa, 2009). Most of this research effort, however, has been devoted to developing systems targeting adult speakers. Following the first studies that raised attention to the poor performance of speech recognition systems for children, increasing attention has been paid to the area of robust speech recognition technologies for children’s speech in a variety of application scenarios such as reading tutors, foreign language learning and multimodal human-machine interaction systems.

Developmental changes in speech production introduce age-dependent spectral and temporal variabilities in speech produced by children. Such variabilities pose challenges for spoken dialogue system design for children. Early spoken dialogue application prototypes that were specifically aimed at children included word games, reading aids and pronunciation tutoring (Strommen, 1993; Mostow, 1994; Russell, 1996). Significant improvement was made two decades ago, using advanced spoken dialogue interfaces and/or multimodal interaction capabilities (Narayanan, 2002; Hagen, 2003; Bell, 2005, 2007), and data collected from these systems (Batliner, 2004; 2005; Xiao, 2002) have improved our understanding of verbal child-machine interaction.
Recent Advances

Cloud-based ASR, which has been converting adult speech to text for several years, appears capable of accurately converting a child’s speech.

To understand children’s speech, most ASR systems have needed special tuning (Wu, 2019) and were restricted to research labs. This restriction is being eliminated as ASR becomes more accurate: the ASR systems now use transfer learning from adult’s models to children’s models with a Deep Neural Network (DNN) framework for children’s ASR (Booth, 2020; Addlesee, 2020). The use of a DNN framework is now offered by commercial ASR systems, including Microsoft Azure-based ASR (Li, 2020), Microsoft ASR was found to be the commercial ASR system that operated best in real-time, and is responsive, stable, and robust (Addlesee, 2020), and provides comprehensive speech analysis including phoneme identification, timing data, and probability of correctness at both the phoneme and word level.

ObjectiveEd’s prior research verified Microsoft’s ASR works well recognizing children’s speech when ObjectiveEd built Braille AI Tutor (Schultz & Voelk, 2020), funded by a Microsoft AI for Accessibility grant. In both that project and BuddyBooks, we improve the ASR accuracy by giving the ASR a “hint” of what the child will speak.

Computer-based co-reading (computer and student take turns reading) results in increased comprehension and enjoyment, and oral reading improves reading skills and fluency.

When a parent co-reads with a child, the child’s comprehension and literacy improves (McClure 2017; Lauricella, 2014; Evans, 2000; Crossley, 2016). Not only do instruction and practice in oral reading help children in the many situations in which they must read aloud, but oral reading also helps children learn to understand and interpret the texts that they are reading (Harpine, 2019; Alqahtani, 2020; Robinson, 2019). For children with a reading disability, this type of oral reading improves their comprehension, is more effective than silent reading, and when a child has a chance to re-read the same passage, comprehension is enhanced (Heubusch, 1998, Heubusch, 1998, Cole, 2006).

Learning Analytics, such as a graphical web-dashboard, help teachers quickly assess a student’s progress.

Both Barton (2018) and Baker (2018) found that learning analytics can be used to analyze and enhance learning at K-12, and the best types of learning analytics are those that consider data sensemaking heuristics, such as comparing, monitoring, and exploring information displayed by a digital tool (Molenaar & Knoop, 2018). ObjectiveEd has done extensive research in designing a teacher web-dashboard (Schultz & Voelk, 2018).
When working with students with a reading disability, customizing the reading experience and the remediation/feedback for each student improves their reading ability, but it must be based on each student’s individual requirements.

Vaughn (2003) has shown that it is important to provide individualized teaching for students with a reading disability, and that this teaching must provide students with many opportunities to practice and obtain feedback. Hence, any system designed for students with a reading disability must provide the specialized teacher with a comprehensive ability to customize the student’s “reading” experience that matches the student’s individual needs.

Encouragement which emerges from feedback is of paramount importance in special education, and the proper use of feedback will reinforce and develop the learning process through small and successful steps (Soulis, 2009). Giving feedback with a computer, described in the literature as Information and Communication Technologies, plays an important role in the learning process for students with a reading disability (Adam, 2008). Feedback from a computer-based reading system improves both motivation and reduces incorrect readings (Kazakou, 2014).

Corrective feedback in oral reading, regardless of the student’s reading disability, has been shown to improve students reading accuracy when reading passages of text, including (1) correcting errors quickly; (2) requiring students to repeat the correct response; and (3) matching the correction procedure to the instructional situation (Heubusch, 1998; Cole, 2006). Customizing the reading experience to offer pre-listening interventions, where the sentence or passage is read to the student as a model, appears to be effective in improving reading fluency and overall reading abilities (Mize, 2021, Vaughn, 2003, Gooch, 2016, Daly, 1994) for students with a reading disability.

**Computer-assisted instruction, eBooks, and scaffolding**

Computer-assisted instruction that holds promise in remediating reading difficulties is electronic reading environments, which consist of computer-based texts (Shamir & Korat, 2007) known as eBooks. eBooks typically have electronic text that is presented to the reader visually or is spoken to the reader.

The features found in the eBooks provide scaffolds to assist in the reading process (Gonzales, 2014). Scaffolds are defined as a support that enables a child or novice to solve a problem, carry out a task or achieve a goal which would be beyond his unassisted efforts (Wood, 1976) Scaffolds are the appropriate assistance provided for students for them to achieve or accomplish something that normally would be too difficult for them to do independently without these supports. Environments that provide scaffolds for learning are effective because they allow novice learners to solve problems, complete tasks or accomplish goals that they normally could not do independently (Stone, 2002). Scaffolds can also be considered one of the most recommended, versatile, and powerful instructional techniques in education today (Clark & Graves, 2005).
Students with reading disabilities needs access to books used in the classroom

People with low vision and learning disabilities like dyslexia that impede the ability to read traditional print books deserve equal access to the treasure of a high-quality education and the joy of gaining knowledge through books (Turner & Wadors, 2017).

The general education classroom is more diverse than ever, including more students with a wide range of disabilities (Berkeley, 2011). That presents several difficulties for students with sensory or motor impairments (Rose, 2002), as well as more subtle challenges for students with specific learning disabilities such as dyslexia.

The Bookshare collection includes K-12 textbooks, classroom reading books, college and university research books and textbooks, vocational and career-advancement titles, fiction and nonfiction books, and newspapers and magazines (Jones, 2015).

5. BuddyBooks alignment with the research

Oral reading fluency assessment

Reading fluency is how quickly, accurately, automatically, and expressively someone reads. It means that a child can recognize and decode words accurately and automatically and understand the words as they are being read. Children who do not read fluently (choppy readers) must work so hard on the mechanics of reading that there’s no mental energy left to think about the meaning of what they are reading.

This is measured by the number of words a student can read aloud correctly and with natural ease per minute (Valencia, 2010). Measures of words correct per minute (wcpm) are used by literacy and language teachers across the United States to assess oral reading fluency in elementary school students (Armbruster, 2010; Hasbrouk, 2006; Manzo, 2007). Fluency is an essential early literacy skill that has been described as a “bridge” between decoding and comprehension, enabling readers to shift their cognitive resources away from decoding and towards constructing meaning from text (Pikulski, 2005).

BuddyBooks alignment with the research

BuddyBooks provides a continuous assessment of oral reading fluency using Automatic Speech Recognition and AI to listen children as they perform their daily reading assignments. Teachers can monitor the web-dashboard to see words per minute and words correct per minute.
Daily reading duration assessment

While most individuals in Western society have achieved basic literacy skills by adulthood, functional illiteracy, where literacy levels are not sufficient to meet current academic, vocational, and social demands, is a widespread issue (Zbroff & Kaufman, 2016). As research increasingly suggests that literacy skills need to be exercised to be both further developed and maintained (Lawrence, 2015), a regular reading habit can play a valuable role in enabling both young people and adults to meet the ever-increasing literacy demands of contemporary society.

While children are often encouraged to read anything, and diverse text types offer valuable exposure to authentic textual experiences, at this stage, the reading of books is more strongly associated with literacy benefit than the reading of other text types. To date, reading graphic novels, text messages, the internet (Baer, 2007), and comic books (OECD, 2010) have not been found to offer equal literacy benefit, and fiction books are particularly associated with literacy benefits (OECD, 2011).

According to teachers, students should be reading between 15 minutes and 1 hour a day outside of school (85% of teachers expect daily reading in this range), but most of their students are reading less than the 15-minute daily minimum and teachers have no way to verify how much time is actually spent. Seven percent of parents report that their children do not read or look at books alone outside of school. Parents report that a similar number of children are reading or looking at books alone only 5 minutes per day or less (Age of Learning, 2018).

BuddyBooks alignment with the research

As part of BuddyBooks continuous assessment of oral reading, BuddyBooks monitors how much time the student spends reading.

Engagement

Today’s teachers are required to spend most of their English/Language Arts time in teacher-directed instruction with required text, which is primarily informational. Little, if any, time is allocated to self-selected independent reading (Garan, 2008). Sanden (2014) and Lee (2011) maintain that students should be afforded opportunities to read independently in books that interest them to build reading stamina, achievement, and motivation. To ensure successful independent reading, Reutzel (2014) assert that teachers need to have students select books.

BuddyBooks alignment with the research

BuddyBooks provides access to the entire Bookshare library, offering a wide selection of engaging books for the student to enjoy. Teachers and students together can select books, and this choice is aligned with research that indicates increased engagement.
Active Listening & Learning vs. Passive Listening

Active listening is where the student actively participates in the listening process. Nolan (1969) found that for students with vision impairments, active listening improved learning outcomes. One implementation of active listening is where the student is supposed to read the text on a computer display as the computer speaks the text (Jackson, 2012). There are several products that provide this implementation of Listening-While-Reading.

One drawback of these products is that students may be listening to the story without actively reading the text, and this may be related to causal relationship between reading and inhibition mechanisms of visuospatial attention (Facoetti, 2006). Shaywitz (2006) found that attentional mechanisms play a causal role in reading difficulties and interventions that address attention can improve reading in dyslexic students.

BuddyBooks alignment with the research

BuddyBooks requires that the student is actively listening which results in actively learning: the computer’s narration of the story does not proceed without the student orally participating in reading their half of the story.

Motivation

Educators and researchers often distinguish between two types of motivation: **intrinsic** and **extrinsic**. Intrinsically motivated learners are driven by a love for learning and desire for self-satisfaction, while extrinsically motivated learners seek external rewards like praise, high scores, good grades, and money (Corpus, 2009).

Research has shown that both forms of motivation are related to learning, with intrinsic motivation having stronger effects on learning and achievement. A longitudinal study of middle school students found that fifth graders’ intrinsic motivation, perceived competence, and engagement with school were significant predictors of their reading achievement in Grade 8 (Froiland, 2013). Research on motivation and mindset demonstrates that how teachers deliver praise has an effect on students’ beliefs about their own intelligence (Dweck, 2007). Students who are praised for their effort and grit rather than their talent or ability are more likely to develop malleable growth mindsets, resilience to setbacks, and increased motivation to learn (Dweck, 2007).

BuddyBooks alignment with the research

BuddyBooks is a non-judgmental and non-threatening literacy system. BuddyBooks provides effective praise and targeted feedback which motivates the students.

BuddyBooks does not interrupt the reading process to give corrections; students remain engaged in the story. Instead, the presentation and remediation of mistakes are prior to the next day’s reading session.
BuddyBooks is aligned to research on effective use of praise, following evidence-based best practices in praising students for effort, determination, and persistence rather than success or achievement. BuddyBooks praises the student when they show that they are trying to exercise and extend their skills.

**Students with Dyslexia**

Dyslexia is a specific learning disability that is neurobiological in origin that is characterized by an “unexpected difficulty in reading for an individual who has the intelligence to be a much better reader, most commonly caused by a difficulty in the phonological process, which affects the ability of an individual to speak, read, and spell” (Shaywitz & Shaywitz, 2020). Dyslexia can relate to reading comprehension and reduced reading experience that can impede growth of vocabulary and background knowledge (IDA, 2020).

Larson (2015) found that audiobooks/eBooks help students who struggle with reading and need more “reading stamina”. This research explored Immersion Reading: listening to a narration and simultaneously read the digital text with synchronized highlighting. For many students, the combined reading/listening experience supported their reading stamina, vocabulary development, and reading motivation. Esteves (2011) found that the reading abilities of students with reading disabilities improved when using Immersion Reading.

Joseph (2011) found that Self-Monitoring improves reading performance for students with disabilities. For reading, Self-Monitoring is accomplished when a student listens to a recording of their oral reading. Kanani (2017) found that Self-Monitoring improved a student’s reading performance.

**BuddyBooks alignment with the research**

BuddyBooks provides Immersion Reading as an integral component of the buddy reading process. As the computer narrates the story, each word spoken by the computer is highlighted in a karaoke-like fashion.

BuddyBooks provides Self-Monitoring as part of the remediation system. The student can listen to their oral reading when they made a mistake, prior to the next day’s reading session.

6. **Conclusion**

The literacy instruction used in BuddyBooks has been shown to be effective. Combining decades of research in AI-based Speech Recognition and evidence-based best practices. BuddyBooks is a reliable, independent practice system for students with reading disabilities to improve their oral reading skills.


