REVIEW OF PSYCHOPEDAGOGY
REVISTA DE PSIHOPEDAGOGIE

ISSN 2784 – 3092
ISSN – L 2784 - 3092
psychopedagogy.unibuc.ro

DOI: https://doi.org/10.56663/rop.v11i1.40

Using Assistive Technology to Improve Decoding Skills in Special Educational Needs (SEN) Students

Calotă Ruxandra
University of Bucharest, Faculty of Psychology and Educational Sciences, PhD(c)

Abstract

While text-to-speech and other related read-aloud tools have been used before to foster reading comprehension skills in Special Educational Needs (SEN) students, they have been mainly used to translate written text into spoken text, thus enabling poor readers to follow along. This study examines the impact of using such tools to design an adaptive learning curriculum that aims to improve decoding skills by integrating high-frequency words into technology-enhanced phonics lessons.

Results suggest this technique is effective in facilitating a better understanding of high-frequency word structure in students with learning disabilities, but less so in strengthening their ability to decode nonsense words.

Keywords: assistive technology, reading skills, intellectual disability, special educational needs

Introduction

Developing literacy and reading skills is a vital part of the elementary curriculum. These skills are the first to be taught, as they are the foundation of all subsequent learning. Poor readers fail to grasp key concepts, fail tests and ultimately fail to meet academic milestones. For Special Educational Needs (SEN) students, reading comprehension skills facilitate not only academic achievement, but also a deeper understanding of the world, independence and inclusion, thereby making these skills the focus of early intervention and indeed throughout their school years.

The most important skills responsible for promoting reading comprehension are word decoding and listening comprehension, in fact word decoding is viewed by many (Gentaz et al., 2015) as the main predictor of reading comprehension skills during early school years. But word decoding skills are themselves dependent on certain cognitive skills that are often impaired in SEN students (Aaron et al., 1999). In order to effectively decode written words, students have to master the alphabetic principle and demonstrate phonological awareness. There is evidence that phonological skills enhance as vocabulary grows (Chambrè et al., 2020) and vice versa, therefore a learning program focused on facilitating the recognition of familiar words could prove effective in promoting phonological awareness.

Assistive Technology

Assistive technology is a broad term that describes any device (hardware or software, high-tech or low-tech) that is designed to maintain or improve impaired functional capabilities of people with disabilities. In particular educational settings such as schools that cater to the needs of SEN students, assistive technology can support those who experience difficulties with reading, writing, etc. through the use of specialized learning materials, specialized curricular software, communication programs and much more.

Previous research (Nordström et al., 2019) analyzing the relationship between the use of assistive technology and reading skills has been conducted with positive results for several indicators of

ISSN 2784 – 3092
ISSN – L 2784 - 3092
psychopedagogy.unibuc.ro

efficiency: ability to assimilate text (72%), redressing reading difficulties (82%), text assimilated (68%), text comprehension (46%) and improved motivation (54%).

Moreover, by using assistive technology tools to compensate for impaired functions, SEN students can focus on more complex learning tasks (Wood et al., 2018). For example, through the use of text-to-speech software, they manage to bypass the difficult task of decoding words and focus on comprehension, which is a superior skill, thus facilitating and accelerating learning.

There are a number of evidence-based teaching strategies that incorporate technology-enhanced educational materials to facilitate learning and promote engagement with learning tasks, but fewer studies considered, though, how SEN teachers apply these instructional strategies to adapt curricula and personalize learning for their students. For example, there are ample studies (Perelmutter et al., 2017) suggesting the use of text-to-speech software might improve comprehension skills in students with reading difficulties, but those studies are mostly confined to investigating the effect of applying read-aloud functions to printed text. Few studies examine the integration of such tools with traditional strategies for an enhanced effect on learning. With regards to that, a 2018 systematic review (Stetter) noted the need to shift our research interest from experimental studies that focus on technology to studies that take into account the human factor, namely how educators use technology in instruction to promote academic achievement. Research into the use of digital tools to enhance literacy acquisition for older students revealed similar findings in terms of reading comprehension (Moran et al., 2008), the authors stressing the need to broaden the scope of such interventions to include other aspects of reading, such as metacognitive, affective, and dispositional outcomes.

Word-Decoding Skills

Max Coltheart in ”The Science of Reading: A Handbook” uses the terms “lexical” and “non-lexical” to distinguish between the two strategies employed by children for decoding words in reading (Coltheart, 2005). The lexical strategy refers to looking up words in the mental lexicon and the non-lexical one refers to the process of applying a series of decoding strategies, namely graphemic parsing, graphophonemic conversion, and phoneme blending, respectively, in order to make sense of the word.

The mental lexicon is mainly comprised of familiar words, hence the popularity of using high frequency words in reading instruction (Foster, 2017). According to Ehri's theory of word recognition development (Ehri & McCormick, 1998), these two strategies are in fact interdependent factors conjoining to elicit better reading performance: decoding skills are used to commit vocabulary to memory and vocabulary is used to read words by analogy. Ultimately, familiarity with target words helps children learn spelling patterns that will be used for more efficient decoding. At least one experimental study (Hickey, 2007) successfully tested this theory by attempting to promote high-frequency word recognition in emergent readers through the use of a special corpus of books.

A considerable advantage of using this method lies in the fact that high frequency words are processed more rapidly than low frequency words through sight-word reading (or global reading, as it is sometimes called) based on previous knowledge of the word, whereas unknown words are slowly decoded.

One technique that has been successfully applied to facilitate decoding unknown words is using syllables as processing units in word recognition instead of phonemes. There is strong evidence (Müller et al., 2020) to suggest that syllabic segmentation is an effective technique to enhance

ISSN 2784 – 3092
ISSN – L 2784 - 3092
psychopedagogy.unibuc.ro

word recognition skills in students with special needs by bridging the gap between single-letter phonological recoding and direct word recognition. As single-letter phonological recoding is severely hindered by poor working memory skills in SEN students, this gap needs to be addressed in order to accelerate the literacy acquisition process.

Working memory is defined as ”a processing resource of limited capacity involved in the preservation of information while simultaneously processing the same or other information” (Swanson et al., 2009). Poor working memory skills observed in children with learning disabilities impede on the process of sequentially converting graphemes into their phonological counterparts and then assembling them into spoken words. A frequent sign of deficit in this area can be found in children who start decoding words by slowly advancing each grapheme-phoneme correspondence, but by the end of the word they have already forgotten previous successful conversions and they have to start over. Using syllables as processing units instead of phonemes can partially make up for this deficit.

In the process of decoding words, working memory is closely linked to visual attention span, described as the number of distinct visual elements which can be simultaneously processed at a glance (Onochie-Quintanilla et al., 2017). In neurotypical children the phonological representation of words is activated via rapid direct-retrieval mechanisms, while those affected by learning disorders will be left struggling.

One solution might be color coding syllables in words to facilitate the decoding process. New research (Pinna & Deiana, 2018) suggests color can induce the idea of wholeness, thereby speeding up the process of word recognition, as children no longer see words as comprising of graphemes, but of syllables, which helps compensate their poor working memory skills and lack of visual attention span.

Through the use of text-to-speech apps like Immersive Reader, these proven techniques can be combined in phonics instruction lessons so that students can benefit from a powerful visual and auditory cue to better understand the structure of the presented word and further develop decoding skills on that knowledge.

Research suggests systematic phonics instruction can be effective in teaching decoding skills even to students with moderate and severe intellectual disability (Sermier Dessemontet et al., 2019), although better results have been observed in one-to-one type of interventions, which are often expensive and inaccessible. One of the advantages of using a digital learning program based on assistive technology is that it can be accessed remotely to reinforce knowledge retention.

Method

As this research was designed as a small-scale preliminary study meant to evaluate its potential for a future full-scale project, the chosen sampling method was convenience sampling, for reasons of accessibility and ease of data collection. The study group consisted of 10 students attending “Constantin Păunescu” Special School (7 boys and 3 girls), a heterogeneous group of similar age, but different cognitive profile, as it is often the case with special schools’ student population. The main criteria for inclusion were the presence of reading difficulties as expressed in poor academic test performance.

The students were assessed before and after the implementation of the learning program using an adapted Early Grade Reading Assessment (EGRA) test comprised of four skills that also served as dependent variables:

1. Letter Name Knowledge (100 items)

ISSN 2784 – 3092
ISSN – L 2784 - 3092
psychopedagogy.unibuc.ro

2. Initial Sound Identification (10 items)
3. Familiar Word Reading (50 items)
4. Non-words Decoding (50 items)

Four skills were eliminated from the test, as they were not the focus of this study: Oral Passage Reading, Reading Comprehension, Listening Comprehension and Dictation.

Given the heterogeneous nature of the study group, we also assumed that the students' level of general intelligence, as expressed in their IQ score, is in a statistically significant relationship (of direct proportionality) with the level of their decoding skills.

As expected, the initial testing results revealed the highest scores for Letter Name Knowledge variable (over 60% of the maximum score given) and the lowest for the most complex of the assessed skills, namely Non-word Decoding (less than 30% of the maximum score given). The other two variables (Initial Sound Identification and Familiar Word Reading) both scored less than 50% of the maximum score given. The mean values obtained are presented in the table below:

Table 1. Pre-Test Descriptive Statistics

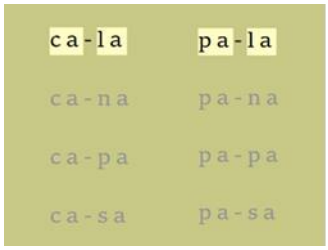
Variables	N	Minimum	Maximum	Mean	Std. Deviation
Letter Name Knowledge	10	18	100	62,40	32,070
Initial Sound Identification	10	0	9	4,50	3,028
Familiar Word Reading	10	0	45	21,50	17,174
Non-Word Decoding	10	0	38	15,90	14,910
Valid N (listwise)	10				

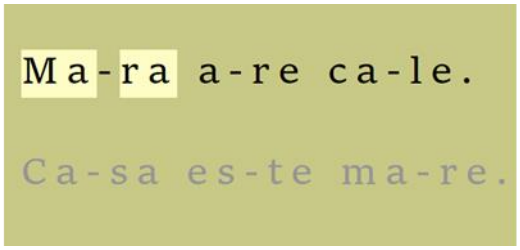
Pre-test mean values for each variable

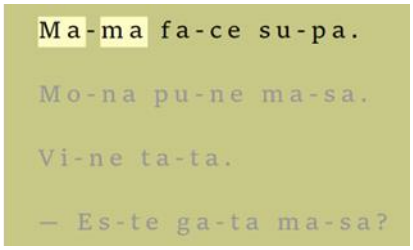
It is worth mentioning at this point that reading skills in SEN students vary widely depending on a complex of factors that cannot be reduced to poor cognitive skills. There are several other developmental disorders that impede on the acquisition of reading and comprehension skills due to the way they affect motivation and behavior, such as attention deficit hyperactivity disorder (ADHD) or autism spectrum disorders.

The purpose of this quantitative, quasi-experimental study was to assess the impact of using technology-enhanced phonics instruction on the development of word decoding skills.

The technologically-enhanced learning activities designed to improve word decoding skills were carried out during the Language and Communication classes over the course of three months. The intervention mainly consisted in teaching literacy through the use of supported eText (text-to-speech) that allowed students to visualize word structure in familiar words. This was achieved by employing two techniques simultaneously, namely syllable segmentation and reading aloud through Immersive Reader, a text-to-speech tool integrated in Microsoft Office.







The intervention was created based on previously posited hierarchies of syllabic difficulty (Lee, 1987) that were adapted to the Romanian language:

ISSN 2784 – 3092
ISSN – L 2784 - 3092
psychopedagogy.unibuc.ro

1. Syllable Reading (CV, VC)
2. Syllable Reading (VC)
3. Word Reading (VV)
4. Word Reading (VC)
5. Word Reading (CVCV)
6. Word Reading (CVC)
7. Word Reading (CV-CVC)
8. Word Reading (CVC-CV)
9. Word Reading (CVC-CVC)
10. Word Reading (CV-CV-CVC)

The intervention was integrated with theme lessons as a distinct segment of each lesson aimed at reinforcing spelling for vocabulary words related to various topics. Additionally, one-to-one interventions were carried out every week during school-based speech therapy sessions according to specific IEP goals for reading comprehension and fluency.

Findings and discussion

Data analysis and interpretation following retesting sought to measure the extent to which the reading program based on text-to-speech software determined changes in the students' test performance for all four variables. As the study had a repeated measures design, the chosen statistical method was the t-test for paired samples. The statistical findings are illustrated in the tables below:

Table 2. Paired Samples Statistics

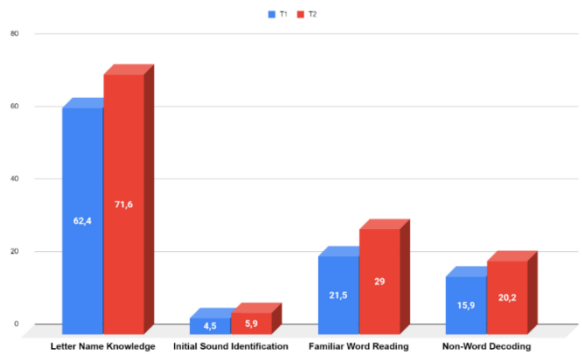
		Mean	N	Std. Deviation	Std. Error Mean
Pair 1	Letter Name Knowledge T1	62,40	10	32,070	10,141
	Letter Name Knowledge T2	71,60	10	29,960	9,474
Pair 2	Initial Sound Identification T1	4,50	10	3,028	,957
	Initial Sound Identification T2	5,90	10	2,961	,936
Pair 3	Familiar Word Reading T1	21,50	10	17,174	5,431
	Familiar Word Reading T2	29,00	10	18,184	5,750
Pair 4	Non-word Decoding T1	15,90	10	14,910	4,715
	Non-Word Decoding T2	20,20	10	17,681	5,591

Mean values for all variables pretest-postest

The mean values indicate significant differences between pre-test and post-test scores for all variables. The lowest scores were obtained for non-word decoding skills, while the highest for letter name knowledge. A graphic illustration of the overall compared results for all variables is shown below:

Figure 1

Mean Values Pretest-Posttest for All Variables



ISSN 2784 – 3092
ISSN – L 2784 - 3092
psychopedagogy.unibuc.ro

Table 3. Paired Samples Correlations

		N	Correlation	Sig.
Pair 1	Letter Name Knowledge (T1) & Letter Name Knowledge (T2)	10	,981	,000
Pair 2	Initial Sound Identification (T1) & Initial Sound Identification (T2)	10	,911	,000
Pair 3	Familiar Word Reading (T1) & Familiar Word Reading (T2)	10	,988	,000
Pair 4	Non-Word Decoding (T1) & Non-Word Decoding (T2)	10	,993	,000

Correlation coefficient for each pair of variables

The statistical data presented suggests a good correlation between the use of supported eText and the development of decoding skills in SEN students, namely r = 0,98 for the first variable, r = 0,91 for the second variable and r = 0,99 for the third and fourth variable. Further evidence of the efficiency of the program is the reported p of 0,0001 for all variables, which indicates the results were highly significant.

Table 4. Paired Samples Test

		Paired Differences					t	df	Sig. (2-tailed)
		Mean	Std. Deviation	Std. Error Mean	95% Confidence Interval of the Difference				
					Lower	Upper			
Pair 1	Letter Name Knowledge T1 – Letter Name Knowledge T2	-9,200	6,408	2,026	-13,784	-4,616	-4,540	9	,001
Pair 2	Initial Sound Identification T1 – Initial Sound Identification T2	-1,400	1,265	,400	-2,305	-,495	-3,500	9	,007
Pair 3	Familiar Word Reading T1 – Familiar Word Reading T2	-7,500	2,877	,910	-9,558	-5,442	-8,243	9	,000
Pair 4	Non-Word Decoding T1 – Non-Word Decoding T2	-4,300	3,368	1,065	-6,709	-1,891	-4,037	9	,003

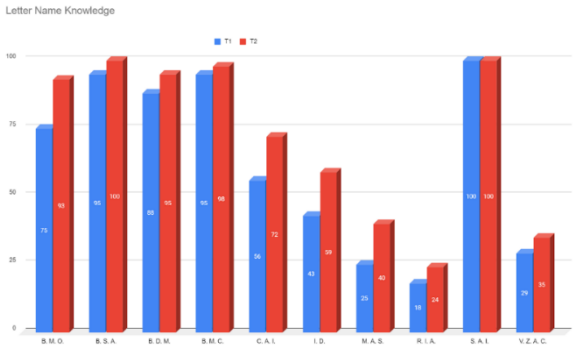
Paired t-test values for each pair of variables

The t-test revealed probability values lower than the significance level for all variables, which indicates a significant correlation:
Letter Name Knowledge (Pair 1) – $t(10) = 4,54$; $p < 0,001$
Initial Sound Identification (Pair 2) – $t(10) = 3,5$; $p < 0,007$
Familiar Word Reading (Pair 3) – $t(10) = 8,24$; $p < 0,001$
Non-word Decoding (Pair 4) – $t(10) = 4,03$; $p < 0,003$

Individual cases analysis reveals a significant increase in Letter Name Knowledge of up to 18 % following the second test, the mean value obtained for this variable being ~10 points, which is indicative of an overall 10% improvement of performance. With one exception, we observe increased performances in all students of the group. We can also note the significant difference between the results obtained by students with moderate mental deficiency and those with severe mental deficiency at both tests, as well as a prevalence of errors in naming lowercase letters.

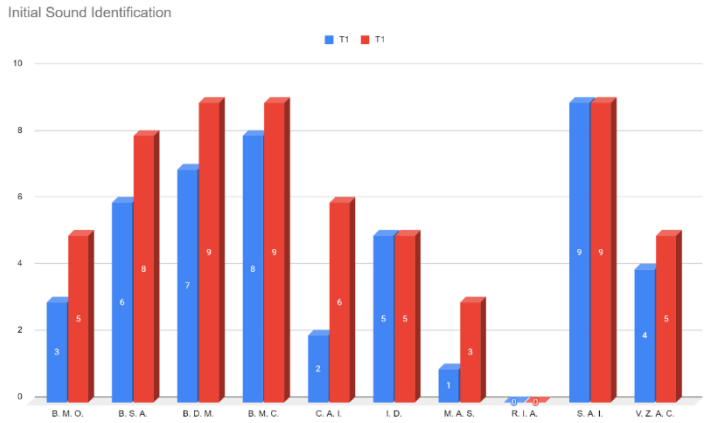
ISSN 2784 – 3092
ISSN – L 2784 - 3092
psychopedagogy.unibuc.ro

Figure 2
Individual Cases Analysis for Letter Name Knowledge



The average scores of 1,4 points, obtained for the Initial Sound Identification variable suggest an overall performance improvement of 14%. Apart from the previously mentioned exception, the results seem to indicate again increased performances for all students, with significant differences depending on IQ, not only in relation to both test results, but also to the general level of progress between the tests. There is also one particular case that is not showing any improvement due to mastering the less complex skills assessed by the test prior to the implementation of the program.

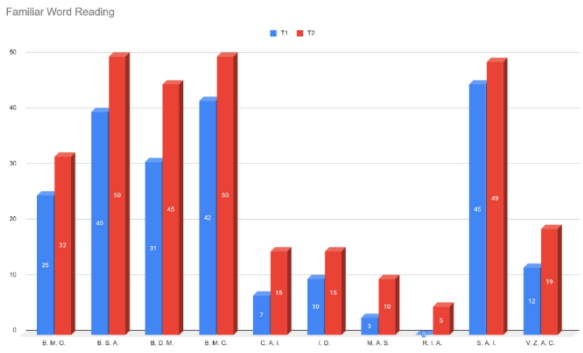
Figure 3
Individual Cases Analysis for Initial Sound Identification



The mean values reported for the Familiar Word Reading variable, of ~8 points, reveal a similar increase in performance of approximately 16%. Although a more complex skill, the improvement is superior to that obtained for lower skills, which can be due to the fact that global word recognition is sometimes employed instead of phonemic analysis by children with poor skills in this area, thus yielding positive results that are not backed by a solid understanding of the sound structure of words.

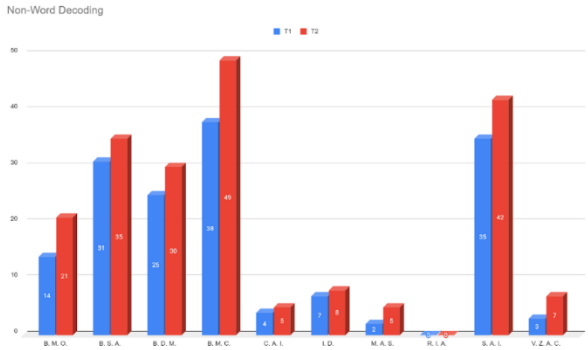
ISSN 2784 – 3092
ISSN – L 2784 - 3092
psychopedagogy.unibuc.ro

Figure 4
Individual Cases Analysis for Familiar Word Reading



The least impact is observed, as expected, on the last variable, Non-word Decoding, that saw an increase of around 4 points, suggesting an overall performance improvement of 8% for this skill. Again, the lowest scores are congruent with IQ differences on both test results.

Figure 5
Individual Cases Analysis for Non-word Decoding



The results obtained for all variables seem to indicate an overall improvement in students' performance by an average of approx. 12% following implementation of the learning program, which is in line with our working hypothesis that "integrating high-frequency words into technology-enhanced phonics lessons will foster better decoding skills in students with intellectual disabilities".

Conclusion

Research limitations are related to the sample size and its lack of homogeneity, as well as using a non-standardized test for assessing the measured variables. Since this experiment was designed as a preliminary study, further investigations need to address these issues to boost the effect size. It is also difficult to ascertain whether same results might be yielded by traditional teaching strategies. However, the findings suggest assistive technology, specifically text-to-speech tools, has the potential to facilitate learning for struggling readers on whom traditional reading strategies are lost due to cognitive differences, sometimes undermining not only the development

ISSN 2784 – 3092
ISSN – L 2784 - 3092
psychopedagogy.unibuc.ro

of their reading skills, but also the acquisition of knowledge and understanding in other subjects. Using supported eText allows them to access learning contents that they couldn't otherwise, thus empowering them to work independently across the curriculum. Moreover, such tools are useful in real life, as well as in school, as they promote a better understanding of the print world for people lacking reading comprehension skills. They are also an excellent tool for promoting inclusion, whether it is for a non-verbal child, for an autistic child or for a child that has yet to master reading skills. Further research should examine the way students use the apps themselves, in learning settings or elsewhere. Also, exploring the theoretical implications of using assistive technology to enhance learning and communication could open new avenues for research.

Reference

Aaron, P. G., Joshi, M., & Williams, K. A. (1999). Not All Reading Disabilities Are Alike. Journal of Learning Disabilities, 32(2), 120–137. https://doi.org/10.1177/002221949903200203

Chambrè, S. J., Ehri, L. C., & Ness, M. (2020). Phonological decoding enhances orthographic facilitation of vocabulary learning in first graders. Reading and Writing, 33(5), 1133–1162. https://doi.org/10.1007/s11145-019-09997-w

Coltheart, M. (2005). Modeling Reading: The Dual-Route Approach. In The science of reading: A handbook (pp. 6–23). Blackwell Publishing. https://doi.org/10.1002/9780470757642.ch1

Ehri, L. C., & McCormick, S. (1998). Phases of word learning: Implications for instruction with delayed and disabled readers. Reading & Writing Quarterly: Overcoming Learning Difficulties, 14, 135–163. https://doi.org/10.1080/1057356980140202

Foster, Michael, "The Effectiveness of High Frequency Word List Instruction on Star Reading Test Scores" (2017). Doctoral Dissertations and Projects. 1631. https://digitalcommons.liberty.edu/doctoral/1631

Gentaz, E., Sprenger-Charolles, L., & Theurel, A. (2015). Differences in the Predictors of Reading Comprehension in First Graders from Low Socio-Economic Status Families with Either Good or Poor Decoding Skills. PLoS ONE, 10(3), e0119581. https://doi.org/10.1371/journal.pone.0119581

Hickey, T. M. (2007). Fluency in Reading Irish as L1 or L2: Promoting High-frequency Word Recognition in Emergent Readers. International Journal of Bilingual Education and Bilingualism, 10(4), 471–493. https://doi.org/10.2167/beb455.0

Lee, J. F. (1987). A Developmental Hierarchy of Syllabic Difficulty. Hispania, 70(2), 357–362. https://doi.org/10.2307/343377

Moran, J., Ferdig, R. E., Pearson, P. D., Wardrop, J., & Blomeyer, R. L. (2008). Technology and Reading Performance in the Middle-School Grades: A Meta-Analysis with Recommendations for Policy and Practice. Journal of Literacy Research, 40(1), 6–58. https://doi.org/10.1080/10862960802070483

Müller, B., Richter, T., & Karageorgos, P. (2020). Syllable-based reading improvement: Effects on word reading and reading comprehension in Grade 2. Learning and Instruction, 66, 101304. https://doi.org/10.1016/j.learninstruc.2020.101304

Nordström, T., Nilsson, S., Gustafson, S., & Svensson, I. (2019). Assistive technology applications for students with reading difficulties: Special education teachers' experiences and perceptions. Disability and Rehabilitation: Assistive Technology, 14(8), 798–808. https://doi.org/10.1080/17483107.2018.1499142

Onochie-Quintanilla, E., Defior, S., & Simpson, I. (2017). Visual multi-element processing as a pre-reading predictor of decoding skill. Journal of Memory and Language, 94. https://doi.org/10.1016/j.jml.2016.11.003

Perelmutter, B., McGregor, K. K., & Gordon, K. R. (2017). Assistive Technology Interventions for Adolescents and Adults with Learning Disabilities: An Evidence-Based Systematic Review and Meta-Analysis. Computers & Education, 114, 139–163. https://doi.org/10.1016/j.compedu.2017.06.005

Pinna, B., & Deiana, K. (2018). On the Role of Color in Reading and Comprehension Tasks in Dyslexic Children and Adults. I-Perception, 9(3), 2041669518779098. https://doi.org/10.1177/2041669518779098

Sermier Dessemontet, R., Martinet, C., de Chambrier, A.-F., Martini-Willemin, B.-M., & Audrin, C. (2019). A meta-analysis on the effectiveness of phonics instruction for teaching decoding skills to students with intellectual disability. Educational Research Review, 26, 52–70. https://doi.org/10.1016/j.edurev.2019.01.001

ISSN 2784 – 3092
ISSN – L 2784 - 3092
psychopedagogy.unibuc.ro

Stetter, M. E. (2018). The Use of Technology to Assist School-Aged Students with High Incidence Special Needs in Reading. Education Sciences, 8(2), Article 2. https://doi.org/10.3390/educsci8020061

Swanson, H. L., Xinhua Zheng, null, & Jerman, O. (2009). Working memory, short-term memory, and reading disabilities: A selective meta-analysis of the literature. Journal of Learning Disabilities, 42(3), 260–287. https://doi.org/10.1177/0022219409331958

Wood, S. G., Moxley, J. H., Tighe, E. L., & Wagner, R. K. (2018). Does Use of Text-to-Speech and Related Read-Aloud Tools Improve Reading Comprehension for Students with Reading Disabilities? A Meta-Analysis. Journal of Learning Disabilities, 51(1), 73–84. https://doi.org/10.1177/0022219416688170