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Effective and Ineffective Interventions for Students With Dyslexia

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EFFECTIVE AND INEFFECTIVE INTERVENTIONS FOR STUDENTS WITH

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EFFECTIVE AND INEFFECTIVE INTERVENTIONS FOR STUDENTS WITH

DYSLEXIA

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Abstract

The aim of this thesis is to explore effective and ineffective interventions for students with dyslexia in the areas of teacher knowledge, text readability, computers and technology, and academic interventions. The main findings show that students with dyslexia can be highly creative, and when their interests are combined with educational interventions, they are more likely to respond better to the interventions. Additionally, to improve text readability, using a sans-serif type font such as Arial or Comic Sans, with interspace letters and words, and enlarged font has proven helpful. In regard to computers and technology, students with dyslexia more often prefer simple programs with fewer distractions, and the ability to choose formatting and font options including text and background colors. The use of overlays is an outdated method, and has been proven to be ineffective in improving text readability, and as far as academic interventions go, beneficial interventions include activities to help students with dyslexia organize information, such as concept maps to organize thinking or pictographs to organize how words are spelled.

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CHAPTER I: INTRODUCTION

History of Dyslexia

Adolf Kausmaul, a German physician who defined the word "alexia" as word blindness, has dated the word dyslexia to 1877. Other physicians such as Joseph Dejerine and Dr. William Morgan studied cases where sufferers of brain injuries lost the ability to read, or children with abnormal literacy developments. Over time, physicians have come to an understanding of what dyslexia is. It is estimated that about 15% of our current population has some form of dyslexia (Developmental dyslexia, history of, 2013).

According to the Learning Disabilities Association of America (2020), dyslexia is a specific learning disability that affects people in the areas of reading and language-based processing skills. Ultimately, dyslexia can affect people in the areas of reading fluency, decoding, spelling, reading comprehension, writing, and sometimes speech (Learning Disabilities Association of America, 2020). As of 2018 Minnesota updated special education laws and language about dyslexia, requiring the Minnesota Department of Education to hire a dyslexia specialist in an effort to help schools identify children with dyslexia and related disorders.

According to the PACER website (2020), if a parent provides the school with a diagnosis from the eye care specialist, optometrist, or ophthalmologist, the school will review the impact the diagnosis has regarding a student's access to curriculum and reading progress, provide interventions to develop reading skills that are underdeveloped, conduct a 504 evaluation to develop an accommodation plan to assist the student with reading, and conduct an evaluation for an Individualized Education Program to determine the student's eligibility for special instruction (PACER Center, 2020).

There are many misconceptions about what dyslexia is. Many believe dyslexia consists of writing letters or words backwards, visual problems where letters are flipped or reversed, that it is a gender related disability, it can be outgrown, dyslexic readers can benefit from colored overlays, it is English related, or someone with dyslexia will never learn to read. Washburn et al. (2017) reports that 69% of a sample of educators and administrators believed word or letter reversal was the main criterion for dyslexia and 88% did not feel as if they were prepared to teach students with dyslexia (Washburn et al., 2017).

In fact, while students with dyslexia often do write their letters backwards, or jumble words, it is because students have trouble remember letter symbols for sounds and remember the order of letters in words. Other problems students with dyslexia have can be challenges when learning to speak, learning foreign languages, reading fast enough to comprehend what they are reading, spelling, or pronunciation difficulties (International Dyslexia Association, 2017). Those are just a few of the challenges students with dyslexia face.

With today's access to resources and vast amounts of information, finding accurate, meaningful interventions can be difficult, especially when the interventions are citing similar misconceptions listed above. For example, Dyslexie font is a specialized font designed especially for people with dyslexia. The website's unique design is advertised with features such as heavier bottoms which "prevent the letters from being turned upside down," and different shapes, which minimized "the chance of turning, mirroring and swapping," and longer sticks which "decrease switching and swapping letters while reading" (Dyslexie Font, 2019).

Definitions of Terms

The following terms will be helpful to know throughout the course of this project. Orthography is the way a word is spelled. Serif font refers to fonts with feet attached to the main stroke of letters as with Times New Roman, and Sans-Serif refers to letters without the added feet such as Ariel or Comic Sans. Concept mapping is a method of organizing thoughts or concepts into a visual web of information. The term "multimedia" means using many ways of relaying information or ideas. In the field of education, multimedia can refer to relaying content through the use of computers and technology, hands on methods, verbal communication, oral response, and the use of projects and practice to teach concepts. RAN, or rapid automatic naming, refers to a person's ability to easily and automatically name a letter on sight. Word Correct Per Minute refers to how many words a person can read correctly in a minute. Literacy is a person's ability to read and write. Interventions are the measures taken to improve a content area for a student, or measures taken help a student grow in a content area. Reading fluency is a person's ability to read smoothly, automatically, and with expression, a combination of which, can be instrumental in a student's ability to comprehend a text.

Research Questions

The purpose of this project is to study effective and ineffective interventions for students with dyslexia so I am better prepared to serve students with dyslexia and inform classroom teachers and parents on effective interventions. In addition, how can I, as a special education teacher, differentiate my instruction for students with dyslexia? What are effective interventions for students with dyslexia? What are approaches teachers can take to better educate students with dyslexia and what information is important for

teachers to consider when choosing interventions? What are ineffective interventions for

students with dyslexia? Which interventions should teachers steer away from?

CHAPTER II: LITERATURE REVIEW

Literature Search Procedures

To locate literature used in this thesis, searches of PubMed Central, Education Database, EBSCOhost Academic Search Premier, Wiley Online Library, JSTOR Arts & Sciences XII, Elsevier ScienceDirect Journals, Elsevier ScienceDirect Open Access Journals, SAGE JOURNALS Premier 2019, Sage Journals Open Access Journals, and SpringerLink Journals were conducted for publications on or between the dates 1990 to 2020. This list was narrowed by only reviewing published empirical studies from peer-reviewed journals that focused on literacy and dyslexia or reading disabilities found in online journals that addressed the guiding questions. The keywords that were used in these searches included "literacy interventions dyslexia" "dyslexia interventions" "dyslexia fonts" "technology dyslexia" and "academic interventions dyslexia." The structure of this chapter is to review the literature on effective and ineffective interventions for students with dyslexia in three sections in this order: Teacher Knowledge, Improving Text Readability, Computers and Technology, and Academic Interventions.

Interventions

Interventions are instructional methods meant to improve specific areas of identified needs in students, ranging from class-wide interventions to interventions to interventions tailored specifically to a student's needs. For students with dyslexia, that may be training for teachers on dyslexia, font or formatting adjustments, or extra instruction in the areas of reading, writing, or mathematics. In the Response to Intervention model, interventions often start with classroom-based interventions and

increase in intensity as a student shows needs. By the time the student reaches Tier 3 of interventions, poor instruction has been ruled out as a factor, and the student is being evaluated for disabilities if the guardian gives consent (RTI Action Network, 2020).

Teacher Knowledge

It is important for teachers to not only be able to differentiate instruction, but to feel confident they can differentiate instruction. This section will discuss the importance of teacher training and the strengths teachers may find in their students with dyslexia, whether it is an above average IQ or a more creative student. After all, individualized, student-centered instruction is not only about a student's weaknesses, but their strengths as well.

The first step a teacher can take in creating interventions for students with dyslexia, is to consider their own knowledge and training. Research conducted by Kormos (2017), aimed to look at language teachers' self-confidence, self-efficacy, and attitudes with education practices when instructing students with dyslexia before and after a free-online training course (Kormos, 2017).

The online course on dyslexia had 18860 enrolled teachers of language. Nine-thousand-seven-hundred-six learners engaged with at least one of the instructional steps, 2499 completed all the tasks and 4770 were socially active. One-thousand-one-hundred-eighty-seven participants responded to the pre-course interview, and 752 responded to post-course survey (Kormos, 2017).

The researchers asked how attitudes toward inclusion, self-efficacy beliefs and concerns about inclusive language teaching differ at the beginning and end of the online course. The researchers found significantly higher outcomes in the area of attitude and

self-efficacy belief, while concerns were significantly lower by the end of the course. There was not a significant change for attitudes and concerns. The researchers analyzed the relationship between self-reporting course participation and post-course attitudes and concerns regarding inclusion and self-efficacy beliefs when teaching students with dyslexia. There was no significant effect in attitude, but there was a significant effect in self-efficacy beliefs (Kormos, 2017).

The researchers also examined previous training and knowledge about dyslexia and how it played a role in pre-and post-course attitudes toward inclusion, self-efficacy beliefs and concerns regarding inclusive teaching. The pre-course attitude score and the post-course attitude score did not show any significant change. The pre-course concerns and post-course concerns showed a significant change, with more participants having fewer concerns about teaching students with dyslexia. Participants with no previous experience teaching students with dyslexia or less knowledge of the disability were significantly more concerned about inclusive education. Participants with less training and knowledge about dyslexia had significantly more concerns than those with more training (Kormos, 2017).

Lastly, the researchers reviewed how teaching background affects attitudes and concerns. The results showed that English-as-an-additional-language teachers were significantly more concerned than teachers of modern languages. Results also showed primary teachers were more self-confident than early education teachers and higher education teachers. Special education teachers held significantly higher self-efficacy beliefs than those in early childhood and higher education. The pre-course self-efficacy beliefs of a teacher with more than 10 years of teaching experience were significantly

different from those between 5 and 10, and those with less than 5 years. By the end of the course, there was no longer an influence of background or experience (Kormos, 2017).

After considering their own strengths and weaknesses, teachers may want to look to the students' strengths. In a study conducted by van Viersen et al. (2016), researchers studied students with dyslexia and high IQ. This group of researchers worked to determine if gifted students with dyslexia are compensating with gifted-related strengths in order to read. There was also concern that students with dyslexia and high IQs may be easily overlooked if they are compensating in their abilities to read. The concern is that students with dyslexia and higher IQ might not receive treatment since they do not meet the standards of low achievement.

After reviewing the results, the researchers found that gifted children with dyslexia had similar low scores on rapid automatized naming compared to children with average intelligence but less severe deficits in their verbal short-term memory and their phonological awareness. For all the groups, rapid automatized naming was a high-risk area for both dyslexic children with average IQ and dyslexic children with a high IQ. The researchers' hypothesis that children with high IQs and dyslexia would perform better in reading and spelling than other average IQ students with dyslexia, but lower than typical students was confirmed. In addition, the researchers' hypothesis that students with dyslexia and high IQ's have dyslexia-related weaknesses, for instance, in rapid automatized naming or phonological awareness, was also confirmed (van Viersen et al., 2016). To understand and intervene for a student with dyslexia, a teacher must look at the whole child, strengths and weaknesses included.

Students with dyslexia can also be highly creative. Kapoula et al. (2016) designed a study to test the creativity in dyslexic students as compared to typical students. The research team hypothesized that schools that adapt their educational approach to the need of students with dyslexia would promote creativity in the students as measured by the Torrance Test of Creative Thinking (Kapoula et al., 2016).

In the first part of the study, researchers used three groups of young adults who were students from three universities in Paris, including a university devoted to decorative art: *Ecole Nationale Supérieure des Arts Décoratifs* (ENSAD), a university devoted to industrial creation and design: *Ecole Nationale Supérieure de Créations Industrielles* (ENSCI) and an engineering university: *Ecole Nationale Supérieure des Techniques Avancées* (ENSTA) (Kapoula et al., 2016).

The Torrance Test of Creative Thinking was administered by trained school personnel. The test was simultaneously administered in quiet rooms via pencil and paper with clear instructions. The test used was an age-normed test (up to age 18) with three tasks, ten minutes each. The evaluators were three authors who were students in psychology and trained in the analysis of the Torrance Test. The authors were blind to which students were dyslexic or non-dyslexic. The test measured four areas of creativity: fluency, flexibility, originality, and elaboration (Kapoula et al., 2016).

Amongst the universities, ENSAD scored significantly higher in all areas except flexibility compared to ENSTA. ENSAD and ENSCI were similar in all areas except elaboration, where ENSAD scored significantly higher. ENSCI also scored significantly higher than ENSTA in all creativity areas. When the researchers compared the group with children and teenagers against dyslexia and those with other dysfunction from Paris,

students with dyslexia scored higher in all creativity areas except fluency. Comparing dyslexic students and non-dyslexic students from BRUXELLES, dyslexic students scored significantly higher in all areas. Comparing dyslexics from Belgium and students from ENSAD, ENSAD scored significantly higher in elaboration, but nearly tied in originality, total, and fluency. Dyslexic students scored significantly higher in flexibility. Of the three schools for children and teenagers and dyslexia, Belgium scored highest in creativity in all areas, OISE was second highest, and Paris scored the lowest (Kapoula et al., 2016).

Overall, students with dyslexia were found to be highly creative in comparison to typical university students and their typical peers. The researchers theorize this could be the case since students with dyslexia have to learn to approach reading and writing differently than their typical peers, but more studies would have to be conducted to determine if their theory is correct (Kapoula et al., 2016).

To play off the creative strengths of students with dyslexia, another researcher, Dimitriadi (2001), studied two students' responses to authoring a multimedia program in a multisensory environment as a way for them to develop their own ideas and emphasize their creative process. The aim of the project was to explore whether a multimedia authoring package could motivate children with dyslexia to participate in language activities and develop authoring skills (Dimitriadi, 2001).

The researcher focused on two students with dyslexia: a girl, age 10, and a boy age 8 who were brother and sister. The students met with the researcher for 50 minutes twice a week for 22 sessions. The children worked with the researcher in their home environment after school. The researcher used Hyperstudio, a content-free program running on most platforms, which allows children to combine multiple elements

including video clips, graphics, text, sound, and animations to make a series of cards. The sessions were videotaped, and at the beginning and end of each session the children were asked for their opinions on whether they liked or disliked elements of the session, and to discuss what would happen in the next session (Dimitriadi, 2001).

The whole project worked through processes of compositional writing, issues involved in the development of compositional writing, and evaluation criteria. The project also focused on planning and drafting, composition, revision, proof-reading, and handwriting presentation. When the project was complete, a month later the researcher administered a reading and writing assessment (Dimitriadi, 2001).

The researcher noted the children were motivated throughout the project as they created and manipulated ideas through the software program. The results of the final reading and writing skills assessment showed partial improvement in spelling patterns in each of the students. The children were also able to fluently read the passages they had constructed as well as the technical words of the program (off screen when presented on a piece of paper). The children were also able to map an outline of the project on paper and discuss how they designed each card (Dimitriadi, 2001). While the researcher used only two participants, the researcher showed that there are tools out there to foster creativity in students and motivate them in language learning and processes.

Improving Text Readability

Numerous studies have been conducted to explore ways of improving text readability. These are simple interventions where text can be adjusted through font-type, formatting, font and background color, but before educators or parents rush to buy a

specialized dyslexic font-type, or insist that their student must use overlays when reading, there are several studies to take into consideration.

In Rello and Baeza-Yates' (2016) study, "The Effect of Font Type on Screen Readability by People with Dyslexia," Rello and Baeza-Yates (2016) reviewed the correlation between 12 fonts and reading time, fixation duration, number of fixations, comprehension, and preference when reading from a computer screen (Rello & Baeza-Yates, 2016). The researchers used 22 females and 26 males with a diagnosis of dyslexia, ages 11 to 50. The control group consisted of 49 people without dyslexia, 28 of which were female and 21 who were male (Rello & Baeza-Yates, 2016).

The fonts in the study were chosen based on access to readers and commonality as well as reports from previous studies. While there are several fonts designed specifically for people with dyslexia, Open Dyslexic is open sourced, allowing people to download it without paying. Arial and Times were chosen because they are the most common fonts on digital and printed texts. Verdana was chosen as a recommendation from the British Dyslexia Association, while Helvetica and Myriad were chosen for their common use in graphic design. Courier is a mono spaced font, Garamond was chosen because it is claimed to be a legible font for printed fonts, and CMU is widely used in scientific publishing and default of the typesetting program TeX (15:4). Along with these chose fonts, the researchers also chose to research the italicized fonts of Open Dyslexic, Times, and Ariel because they had not found previous research measuring the readability of italicized fonts (Rello & Baeza-Yates, 2016).

To determine the effectiveness of each font, each participant was asked to silently read twelve texts while being timed and then complete the comprehension control

questions immediately following each text. The participants' eye movements were tracked using Tobii 1750, an eye-tracker software individually calibrated for each participant which measured the participant's fixation on words. Participants with dyslexia fixate on words and letters more frequently and for longer durations compared to participants without dyslexia (Rello & Baeza-Yates, 2016). In addition, the participants were also given a survey to determine their preference of fonts.

Results show there was a significant effect of font type on reading time, where Italicized Arial had the longest reading time for all participants and Arial font had shorter reading times (Rello & Baeza-Yates, 2016). For participants with dyslexia, Courier had the lowest fixation duration, even against Open Dyslexic, a font designed specifically for people with dyslexia. Courier also had the lowest fixation duration for participants without dyslexia (Rello & Baeza-Yates, 2016). However, when looking at fixation frequency, CMU had the smallest mean for the number of fixations, where Open Dyslexic had the second smallest mean for the number of fixations for participants with Dyslexia. For participants without dyslexia, Arial and Times showed fewer fixations than the other fonts. As far as preferences went, participants with dyslexia preferred Verdana, Helvetica, and Arial while disliking Garamond, and participants without dyslexia also preferred Verdana, Helvetica, and Arial while disliking Open Dyslexic and Open Dyslexic Italicized (Rello & Baeza-Yates, 2016).

Overall, the research found that font types impact text readability in people with dyslexia and without dyslexia. This research could impact decisions made by web designers and developers, content producers, and even the fonts teachers or educational developers use in presentations and digital standardized tests. The results were similar in

reading duration, fixation duration, and fixation frequency, where preference was slightly different. Courier, Helvetica, Arial, and CMU lead to better objective readability for participants with dyslexia. For people without dyslexia, Arial, CMU, Courier, and Verdana lead to better objective readability (Rello & Baeza-Yates, 2016). Essentially, "what is good for people with dyslexia regarding font types is also good for people without dyslexia" (Rello & Baeza-Yates, 2016, p. 15:2), meaning this research-based information could be used as an educational intervention for all student to improve screen readability of texts.

Ismail and Jaafar (2018) looked at font type in addition to font size. This study was smaller with 30 participants, ages 10 to 12, from four different primary schools. Fifteen of the students were dyslexic, 14 of which were male and one of which was female. The researchers reviewed the fonts Comic Sans Ms, Arial, Verdana, Tahoma, Trebuchet Ms, Courier New, Georgia, and Times New Roman. To test the participants, the researches assessed using slides containing about 60 words. The words were a combination of consonants and vowels displayed in a variety of different fonts and font sizes including 12 point font, 14 point font, 20 point font, 24 point font, and 28 point font (Ismail, 2018).

The participants were recorded reading a slide aloud and then assessed for reading time and mistakes. Afterward, a questionnaire was used to determine the participant's preferences. For the reading time, Comic Sans Ms showed the best results for students with dyslexia with 82.47 seconds. Tahoma being the second best with 83.80 seconds. The font that produced longer reading times for students with dyslexia was Times New Roman with an average reading time of 86.40 seconds. In students without dyslexia,

Times New Roman was better than Comic San Ms by .13 seconds. Comic Sans Ms also

produced fewer reading mistakes in students with dyslexia, where Times New Roman

and Comic Sans Ms were tied with .07 reading mistakes in students without dyslexia.

When the researchers used Arial, Verdana, and Courier New, the participants had longer

reading times and produced more reading mistakes in this study (Ismail, 2018). This is

different from Rello and Baeza-Yates' (2016) study where they showed Arial and Courier

were favorable fonts.

As far as font size is concerned, the researchers showed similar results between

students with dyslexia and students without dyslexia. Twelve-point font produced the

highest reading times and reading errors. Whereas 24 and 28 point fonts produced lower

reading times and fewer reading errors. The researchers were able to show a suitable font

type for readers with dyslexia is Comic Sans Ms with a font size of 24 (Ismail, 2018).

Rello and Baeza-Yates (2017) produced another study in which they tested

several formatting options on computer programs in an effort to find more readable texts

on screens for people with dyslexia. The researchers used 92 participants (46 with

dyslexia and 46 without for a control group) from ages 13 to 37 years of age. In this

study, there were eight experiments. In part of the study, the researchers reviewed

whether background and text color play a role in the readability of a text. In this

experiment, gray text on white background was tested as well as gray background and

white text, black back ground with white, off-black background and off-white text, black

background and yellow text, blue background with white text, black background with

crème text, dark brown background with light "mucky" green text, brown background

with "mucky" green text, and blue background with yellow text (Rello & Baeza-Yates, 2017).

In addition, font size, line spacing, paragraph spacing, and column width was tested. The researchers looked at size 14, 18, 22, and 26 font. The character spacing reviewed was -7%, 0%, 7%, and 14%. Line spacing with values of .8, 1, 1.2, and 1.4 was assessed. Paragraph spacing was also tested with .5, one, two, and three lines. Column width of 22, 44, 66, and 88 characters per line was tested. To measure the effects of each of these, the researcher measured eye fixations with an eye tracking software. Participants with dyslexia show to have more fixations and longer fixations when they read (Rello & Baeza-Yates, 2017).

Looking at the results, the researchers found no significant interaction effects of text and background colors in regard to eye fixation duration. However, participants, both dyslexic and non-dyslexic, expressed through the preference survey that pure black background made the text significantly more readable. People with and without dyslexia found pure black background significantly more readable than text presented with different gray scales (Rello & Baeza-Yates, 2017).

Font size yielded more significant results with the eye fixation software, showing that participants had longer eye fixations with the 14-point font than with the 18, 22, and 26-point font. Participants also had a higher preference for the larger fonts. Character spacing was similar. Participants had longer fixation with closer character spacing. The character space that yielded the longest eye fixation was -7% and +14% yielded the shortest eye fixation durations. However, neither group had a preference of character spacing or reported any option easier to read. Line spacing, column width, and paragraph

spacing yielded no significant effects to fixation duration and participants had no preference (Rello & Baeza-Yates, 2017).

In other studies, researchers tested the effectiveness of colored overlays on computers. An overlay is like a tinted transparency sheet that can be added over a screen. The researchers formed four groups consisting of Reading-Spelling-Arithmetic disabilities (RSA). Reading-Spelling (RS) disabilities, Arithmetic disabilities (A), and those with an Attention Deficit/Hyperactivity Disorder (ADHD) without learning disabilities. Group A and Group ADHD were observed for a contrast since they struggle with similar spatial and attention deficiencies as those children with learning disabilities (Iovino et al., 1998).

The participants in this study read black lettered text of two tests covered with either a red overlay, blue overlay, or no overlay. According to the results of this study, the overlays produced no significant group to color interaction for the reading response. Color did not make a difference in reading performance in any groups. However, for reading comprehension there was no significant group to color interactions, the blue overlay significantly improved reading comprehension in 57% of participants with and without reading disabilities, 38% had minimal improvement. Four participants had the same reading comprehension scores as they did with no overlay. In regard to overlay influencing decoding deficits, no group to color interaction was identified (Iovino et al., 1998).

The researchers determined that there was no benefit to using overlays specifically for children with reading disabilities. The blue overlays improved reading comprehension in a majority of participants, showing that it did not solely work with

children with reading disabilities, and for other participants it did not work. However, the

blue overlay showed a decrease in reading rate, and the researchers attribute a slower

pace to better reading comprehension (Iovino et al., 1998).

Further research was conducted on overlays by Sioblom et al. (2016), in their

study, "The Effects of Letter Spacing and Coloured Overlays on Reading Speed and

Accuracy in Adult Dyslexia" (Sjoblom et al., 2016). The researchers created four

different conditions to be tested using texts presented on white paper and black ink. One

was text with normal spacing without an overlay, one condition was normally spaced text

with an overlay, another condition was a largely spaced text without an overlay, and a

largely spaced text with an overlay. The texts were presented in a controlled randomized

order with all participants completing all conditions. What was different about this text

compared to the Iovino study from 1998 was the participants chose the colored overlay

from the colors yellow, orange, magenta, pink, purple, sky blue, aqua blue, grass green,

jade green, and celery green with the choice of the dull side or the gloss side. Their

choice was based on their preference (Sjoblom et al., 2016).

To test the effects the overlay on print had on the participants, the participants

read each of the text out loud for a recording. The participants were then scored by

reading time and the amount of errors made. As in the Iovino (1998) study, the overlays

made no significant difference in either the control group or group with dyslexia. Later

confirmed again in Rello and Baeza-Yates's (2017) study, the groups showed there was a

significant beneficial interaction between groups and spacing for participants with

dyslexia. The participants without dyslexia did not significantly benefit from increased

spacing. The non dyslexic participants made significantly fewer errors than participants with dyslexia (Sjoblom et al., 2016).

Wery and Diliberto (2017) conducted a study to test a free specialized dyslexia font, Open Dyslexic, in regard to the reading speed and accuracy in letter naming, word reading, and non-sense word reading. The specialized font was tested against Arial (a sans serif font) and Times New Roman (a serif font) (Wery & Diliberto, 2017).

In each testing session, a student was given a printed real word list, letter naming list, and nonsense list. The student had one minute to name the words on each list. If a student took four seconds to name a word, he/she was prompted to skip that word. A randomizer was used to sequence the test to ensure the order did not affect the decoding rate or accuracy, and each session was audio-recorded while a graduate student not involved with the research calculated the results. With each font, the researchers were careful to match the fonts to the same sizes and spacings as Open Dyslexic (Wery & Diliberto, 2017).

Compared to Arial and Times New Roman, Open Dyslexic proved not to be beneficial for the students in this study. Open Dyslexic produced negative results, and in some cases decreased the students' testing outcomes on all three reading tasks. The researchers found no evidence of Open Dyslexic having a positive effect on reading speed or accuracy. In addition, the researchers found no significant effect of Arial or Times New Roman on reading speed or accuracy (Wery & Diliberto, 2017).

Another study was conducted on the specialized font, Dyslexie, to assess if it is an effective font for people with dyslexia and if so, why it works. For this study, 39 low-progress readers participated from grades two through six. The researchers tested the

participants by having them read four different passages. One in each of the tested fonts: Dyslexie, Arial with standard spacing, Arial with overall increased spacing, and Arial with matched spacing. Each participant was given the text and font in a different and pre-specified order to minimize any affect it could create to the study. Arial was sized with 16-point font to match the height of the Dyslexie font (Marinus et al., 2016).

Per the results, the font, Dyslexie, produced the highest words read per minute at 75.74 as compared to Arial 16-point font with standard spacing which produced 70.44 words per minute. Once spacing was increased, the words per minute increased to 71.77. Once the spacing was matched, the words per minute increased to 73.64. As the character spacing increased, so did the words read per minute. While Dyslexie does improve the participant's reading accuracy and rate, Dyslexie likely works because of the increased spacing between the letters (Marinus et al., 2016).

To test the theory from Marinus et al. (2016), Duranovic, Senka, and Babic-Gavric (2018) replicated the study conducted by Marinus et al. (2016) and investigated whether participants with dyslexia perform better when reading text in Dyslexie than in Times New Roman or Times New Roman with spacing. The researchers hypothesized that Dyslexie and Times New Roman inter-spaced will have no difference if the spacing is what effects readers with dyslexia, and students with dyslexia will read Dyslexia faster than Times New Roman with default inter letter spacing (Duranovic et al., 2018).

The researchers also explored whether Times New Roman and Curlz MT were unfriendly fonts for the participants, even with inter-spaced text. With this part of the study, the researchers hypothesized, "If TNR Italic and Curlz MT are unfriendly fonts, we would predict that the dyslexics read significantly faster and more accurately in the

Dyslexie than in the TNR Italic and Curlz MT inter-spaced fonts. However, for the chronological-age and reading-level groups, we would not find a difference between the aforementioned conditions" (Duranovic et al., 2018, p. 220).

The test was prepared as black print on white paper with 100 meaningful short sentences with 20 per condition equaling about 68 words each. Words, syllables, word frequencies, and grammatical class were all closely matched for each condition. The children were given a pretest assessment to determine their starting rates of words per minute. The dyslexic group had an average of 27.13 words per minute, the chronological age group had 71.65 wpm, and reading-level group had 32 WPM. Reading errors in the same order were also assessed with the dyslexic group starting with an average of 8.48 errors, the chronological-aged group had .17, and the reading-level group had 2.17. The average reading time in the same grouping order was 119.26, 28.13, 88.22, and average nonsense words were 12.52, 1.48, and 6.83. The non-word reading time was 187.04, 46.22, and 120.65, and the average IQ was 29.61, 31.39, and 27.22 (Duranovic et al., 2018).

According to the results, in the chronological age control group, Times New Roman with default settings had the least errors (.91), and Curlz MT interspace had the best reading time (.68), but for this group there was not a significant difference between reading accuracy and scores. Times New Roman Italic inter-spaced font had the worst accuracy rate average with 2.17 errors, and Times New Roman inter-spaced font had the slowest reading speed with .53 words per second (Duranovic et al., 2018).

For the match reading level control group, the best font was Times New Roman inter-spaced producing 4.96 average errors, and the best font for reading speed was

Times New Roman with default settings, where participants read an average of 1.07 words per second. The font yielding the most errors proved to be the Dyslexie font with 14.12 errors, and Times New Roman inter-spaced produced the slowest average reading time of .96 (Duranovic et al., 2018).

For the participants with dyslexia, the Dyslexie font had the least errors with 14.39 average errors and an average speed of 2.04 words per second. Times New Roman inter-spaced came in second with only 16.57 errors. Times New Roman with default spacing had the worst results with 26.22 errors and the slowest reading time of 2.47 words per second. This study shows that readers with dyslexia benefit from fonts with more space between letters and words, and it improves reading speed and reading accuracy (Duranovic et al., 2018).

In a different study, researchers found that Dyslexie does not benefit children with or without dyslexia. Their aim was to investigate whether Dyslexie was beneficial for readers with dyslexia using two experiments. One experiment tested it against the sans-serif font Arial, and the other against the standard serif font Times New Roman (Kuster et al., 2018).

For the first experiment, a Three Minute Test was conducted to determine the word reading skills of the participants. One group was asked to read the Arial font first and then the font Dyslexie, while the other group read Dyslexie first and then Arial. The time between the two sessions was one to two weeks. After the second session, the participants were asked which font they preferred (Kuster et al., 2018).

The researchers found that the order of the cards did not affect the scores the participants received. The reading speed on the second time was faster in both groups

compared to time one, and the errors were reduced from the first to the second time, but not significantly. In their analysis, the researchers determined there was no significance in reading speed between the Dyslexie font and Arial Font. The researchers also found most participants preferred Arial above Dyslexie (Kuster et al., 2018).

In the second experiment, the texts were printed in Arial, Dyslexia, and Times New Roman. Participants were tested in three different times with one and two weeks between test sessions. After the third time, the participants were asked their preference. Thirty-eight-point-one percent of participants preferred Arial, 29.9% showed a preference for Times New Roman, and 11.6% preferred Dyslexia. 19.7% had no preference (Kuster et al., 2018).

For the children with dyslexia, there were only slight differences between words read correctly between fonts. For the dyslexic group, Dyslexie had a range of 47.3 words read correctly and 75.5 words read correctly. Arial had a range of 48.5 and 76, while Times New Roman had a range of 48.3 to 75.6. The results were significant, showing that Dyslexia did not help the students achieve more words read correctly. For children without dyslexia, the range for Dyslexie words read correctly was 52.5 to 86.1, Arial had a range of 51.8 to 82.7, and Times New Roman had a range of 49.0 to 86.2. Again, with non-dyslexic readers, the results were similar in that there were no significant differences between fonts. This study also showed no significant relationship between font and preference (Kuster et al., 2018).

EasyReading is another specialized font developed for people with dyslexia. A group of researchers chose to explore the effectiveness of this font for people with dyslexia. They compared EasyReading against Times New Roman with reading

performance and fluency. The participants of this study were separated into 4 groups: Group 0 (normal reader) with scores above the 25th percentile and average reading scores, Group 1 (students with reading difficulties) with students above the 25th percentile and low reading scores, Group 2 (students with dyslexia) with students above the 25th percentile and two or more deficit performances in the reading test, and Group 3 with students that scored below or equal to the 25th percentile (Bachmann & Megheri, 2018).

The researchers found 235 participants "fully achieved criteria" in fluency and 308 participants "fully achieved criteria" in accuracy for the Times New Roman font. When given the Easy Reading font, 363 participants scored "Fully Achieved Criteria" for fluency, but the number decreased to 271 for accuracy. Two-hundred-seventy-eight participants scored "Sufficient Performance" for fluency and 172 participants for accuracy under Times New Roman Font. When given the EasyReading font, the fluency decreased to 162, and the accuracy increased to 208. The decrease was due to many participants increasing their score to the next percentile when presented with the EasyReading font (Bachmann & Megheri, 2018).

The researchers also reviewed fluency and syllables correct per second when the participants were given an excerpt in Times New Roman. The participants read 3.5 syllables per second, but were able to increase to 4.16 syllables per second with EasyReading. For the word list Times New Roman yielded an average of 3.03 syllables per second and increased to 3.33, and non-words, or non-sense words, Times New Roman had 1.86 syllables per second and EasyReading had 2.04 syllables per second. When looking specifically at the group with participants with dyslexia, the results are similar. The mean syllables per second for the excerpt showed .92 syllables per second

from Times New Roman increasing to 1.13 syllables per second for ER. For the word list, the participants averaged .81 syllables per second with Times New Roman and elevated to .83 for EasyReading, and for non-words Times New Roman averaged .49 syllables per second increased to .53 for ER (Bachmann & Megheri, 2018).

In this case, the specialized font compared to Times New Roman succeeded in helping the readers with fluency and reading accuracy. One thing to keep in mind though, is in Rello and Baeza-Yates's study from 2016, Times New Roman was a font that produced more struggles in many of its participants with dyslexia and participants scored low on it compared to many of the other fonts tested.

Unrelated to font or formatting, is a study that looked at reading position to improve text readability by Manilla and de Braga (2017). Participating this study, were 112 students from Elko institute in grades two through eight, students from Spring Creek Middle School, 10 dyslexic participants, ages 6-37, and 10 typical control participants, ages 6-16. In addition, the researchers worked with eight 6th grade special education students from French Ford Middle school. The researchers hypothesize that dyslexia is of a visual origin and not a language processing disorder. They tested this by using the Positional Reading Arc (Manilla & de Braga, 2017).

For the Positional Reading Arc, the text is moved around in 30-degree increments until the reader can determine which position is most clear. Position A is considered standard reading position, with the text lying flat on the desk. Position C is held straight ahead, with B between A and C. D is 30 degrees above C, and E is 30 degrees above D. The participants then read when the text is at its clearest (Manilla & de Braga, 2017).

According to participant reports from 10 students with dyslexia, all participants found position A words either blurry, scrambled, fuzzy, shuffled, jumping up and down, unclear, and or wavy. One participant labeled position B as the clearest, while the rest noted the words either stopped moving, started to clear, come together, start to separate, and/or scramble less. Four participants labeled position C the clearest, three participants reported Position C and D were the clearest, and one participant labeled D the clearest and one participant labeled E the clearest (Manilla & de Braga, 2017).

Looking at results from grade to grade, the researchers looked at Position A compared to participant's best positional arc and found, in all but two grades, words per minute increased. In the fifth grade, the position decreased participants words per minute from 116.7 down to 116.3 words per minute, and in seventh grade words per minute dropped from 137.8 to 134.3 (Manilla & de Braga, 2017).

With regard to reading errors, the researchers found that reading errors decreased from Position A to participant's best position in six of the seven grades. In grade five, errors increased from 4.4 errors to 4.6 errors. Comprehension errors decreased in grades two through eight from Position A to Best Position for participant. At French Ford Middle School, eight sixth-grade students in special education were first given the Developmental Reading Assessment and were reassessed three months later. One student gained four points (about one third of a year's growth), three students gained 10 points (one year's worth of growth), and four students gained 20 points (about 2 years' worth of growth) (Manilla & de Braga, 2017).

At Spring Creek Middle School, the students were a part of the classroom teaching. Progress was slower than a one-to-one environment. Six teachers taught sixth,

seventh, and eighth grade students. Overall, all treated students improved relative to their peers. The results showed the treated group out performed their regular classroom peers by nearly a factor of two (Manilla & de Braga, 2017).

The articles state, "At the tabletop, dyslexics convey the appearance of having a neurologic disorder where language is neither coded nor decoded properly. However, dyslexia suddenly becomes a visual problem at the appropriate Positional Reading Arc position," (p. 9). One group they tested even showed improvement when classroom reading instruction was incorporated (Manilla & de Braga, 2017).

While there are very few studies on the positional reading arc, it is a simple intervention to try with students with dyslexia. Having students recognize their reading preferences early on, whether it is large font with wide character spacing, Comic Sans or Arial, or white text on black background, will give them a set of tools to work with throughout their education (Ismail, 2018; Manilla & de Braga, 2017; Rello & Baeza-Yates, 2016; Rello & Baeza-Yates, 2017).

Computers and Technology

Technology has been found to be a useful tool for learning, especially in the area of e-learning where a majority of content is online. Educational researchers are consistently reviewing the possibilities of technology in regard to student learning. In the case of dyslexia, several researchers have explored how web design and e-learning effect students with dyslexia, how technology can reduce anxiety, and how the use of programming instruction or the use of mobile applications can improve literacy abilities in students with dyslexia.

Gregor (2003) conducted a study with the purpose of developing and evaluating a high-quality software suite, to enable computer users with dyslexia and give them the ability to configure Microsoft Word for Windows™ using SeeWord to suit their personal reading preferences. Gregor's hypothesis was that if users with dyslexia are enabled to configure word processing software to their own personal preferences, their performance on reading tests would improve (Gregor, 2003).

The researcher studied six male students diagnosed with dyslexia ages 14 to 16. The participants were given six levels of tests with text in increasing difficulty in which the participants had to read aloud. Six of the assessments were given with default settings of black text on white background as a control, and six of the assessments were given with the user preferences. The texts were selected at random from standard instructor reading assessment texts. The participants' errors were recorded and counted from the recording. When participants felt they could not continue, the assessment stopped. The participants were given an hour to adjust the program settings to their preferences. After two days, the students confirmed their settings. After the tests were run, the participants were able to reflect on the process using surveys and interviews (Gregor, 2003).

Users were first tested with standard black on white text and the results are as follows: User 1 went from zero errors in Text 1 to 2.04 in Text 2, 8.11 in Text 3, 17.58 in Text 4, and 17.39 in Text 5, and was unable to read Text 6. User 2 made 7.69 errors in Text 1 and then progressed all the way to Text 6 with 6.85 errors. User 2's lowest error record was 2.22 in Text 2 and the highest was 9.00 in Text 4. User 3 made it through three texts, with zero errors in Text 1, 20.41 in Text 2, and 31.08 in Text 3. Texts 4, 5, and 6 could not be completed. User 4 made it through all six texts with the lowest error

record in Text 6 with 0 errors, and the highest in Text 6 with 6.16 errors. User 5 made it through all six texts with the lowest error record of zero in Text 1 and the highest of 12.23 in Text 6. User 6 made it through four texts with the lowest error count in Text 2 with 6.67 errors, and the highest error count in Text 1 (Gregor, 2003).

According to the results from the "Without Settings" compared to the "With settings" trial, there is not a significant improvement between the two settings. The improvement is small for all users except User 6 who showed slight regression from "Without Settings" to "With Settings." User 1 went from 9.02 average errors to 3.26 with the preferred setting. User 2 went from 5.05 to 2.34, User 3 went from 17.16 to 11.06, User 4 went from 2.7 to 1.95, User 5 went from 5.03 to 2.44, and User 6 went from 11.03 to 17.00 average errors. User 5 and User 6 also decreased from the amount of text they were able to read by 1 (Gregor, 2003).

Overall, SeeWord was beneficial to all but one participant. There are significant improvements when the researchers showed the errors between each text going from with user preferred settings and without. By Text 4, 5, and 6 the improvement of average word errors nearly doubles (Gregor, 2003). This study would benefit from a larger sample size and further study. It shows the importance of letting users choose their reading preference.

Bait (2017) had a similar objective in mind to Gregor (2003), but Bait wanted to determine a favorable web platform design for eBook tools offered to users with dyslexia. Bait aimed to use technology to improve web-based learning for people with dyslexia. Additionally, the researcher wanted to know what the impact would be on the user's health and subject retentions (Bait, 2017).

The participants were asked to navigate and search for a specific page containing a lesson and a specific page containing exercises or tests, and the participants were assessed on the tasks. In the experiment, three randomly chosen e-learning websites were presented to the participants along with a satisfaction questionnaire regarding text readability, images, sound, multimedia, and navigation. The researchers prepared a prototype of their program allowing the user to customize the program including set font size, font color, background color, as well as several other features recommended by other studies on dyslexia (Bait, 2017).

The font size category scored the most positive among users, with 72% of dyslexic rating it positive and 75% of non-dyslexic students rating it positive. In addition, the prototype scored high in the area of back ground images behind text, earning positive ratings from 77% of participants with dyslexia and 78% of typical participants. Text readability, multimedia, and navigation received low scores. Eighty-three percent of people with dyslexia did not like the navigation mechanisms, and 78% of typical students agreed (Bait, 2017).

The researchers learned that the contrast of white background and black texts in websites was too bright of a contrast, causing eye fatigue in users with dyslexia. Avoiding that color combination is advisable. Additionally, animations, flashing text, and videos were distracting for 90% of users with dyslexia and 85% of typical users. Overall, the researchers learned dyslexic-oriented web design could be helpful for people with dyslexia as well as people without dyslexia (Bait, 2017).

Plakopiti and Bellou (2014) also researched two formats of text, printed and electronic, to improve reading ability and comprehension as well as learn about the

impact technology plays on anxiety. They wanted to know if anxiety of children with dyslexia could be reduced during reading and comprehension of an electronic text, compared to the anxiety that occurs during the traditional reading of printed text (Placopiti & Bellou, 2014).

The electronic text was displayed in Microsoft Word on full screen to hide toolbars, menus, and any other thing that might distract the participants. The format of the text was chosen by the research in regard to size, layout, spacing, and orientation. The participants could only select the backgrounds and font color. The background choices were gray, blue, green, and yellow. The color choices for font included brown, blue, and black. In addition, the participants were allowed to use the spelling application to help them. The participants chose the color settings they preferred (Placopiti & Bellou, 2014).

After reading the texts, the students were given a comprehension assessment and an anxiety test before starting using the State-Trait Anxiety Inventory for Children and the Test Anxiety Inventory. At the end of the test, the students were given a final anxiety survey and then interview to gather impressions about the procedure and preferences between type of text and spelling application (Placopiti & Bellou, 2014).

In regard to anxiety, for the paper test, only one participant gave a slightly above average score of 39, two participants gave a score from 40 to 44, ten from 45 to 49, five participants between 50 and 54, and two showed very high anxiety with 55 to 60 points. When the testing switched to the electronic test, there was an average decrease of three points in anxiety. Two participants scored between 35 and 39, five between 30 and 34, eight participants scored between 25 and 29, and five scored between 20 and 24 points (Placopiti & Bellou, 2014).

Another researcher aimed to improve the fundamental writing skills in children with dyslexia through the use of an appealing application program. The application was designed by the researchers and input was given by the children with dyslexia, their parents, and teachers who specialized in the field of dyslexia. Through collaboration, it was determined the application should use Arial font size 14 to16, backgrounds should be light shades of white, pink, and green, the font would be black, the participant's finger would be used to trace letters, no unnecessary images or animations should be used, and texts would have fewer options to choose from (Tariq & Latif, 2016).

The application was designed for children five and under with attractive graphics, using multi-sensory instruction and activities (auditory, visual, and tactile), and the program was created for tablets and smartphones. The app targeted phonemic awareness, reading, and writing. The application accounted for time management, memory pressure, and help the user keep focus with use of attractive graphics. If the participant demonstrated illegible writing, the application prompted for rigorous revision, and the learning was scaffolded. The program focused on upper- and lower-case letters, mathematical numbers, and symbols. It required frequent assessment. The results were displayed on a learning graph and the users earned success stars with a progress and time tracker. Parents and teachers regularly received results, while the users earned rewards through a token system (Tariq & Latif, 2016).

All participants were equipped with the application installed on Galaxy SIII. They were allowed two weeks to explore the application, questionnaires were also distributed to teachers and sent home (Tariq & Latif, 2016).

The researchers learned the application had favorability ratings above 86% in all

areas including reliability, supportability, learnability, efficiency, memorability, user

satisfaction, errors, and intention to use. For app learning content, the researchers showed

the application scored above 81% in learnability, efficiency, memorability, user

satisfaction, supportability, compatibility, intention to use, utility, and satisfaction in

errors. For the learning evaluation of the app, the app received scores above 86% in

efficiency, user satisfaction, utility, reliability, intention to use, supportability, and

compatibility. Lower frustrations were reported in the students using this as well as the

students being able to interpret their achievement scores. Eighty-nine percent of users

found the app to enhance their understanding and productivity of the handwriting skill

(Tariq & Latif, 2016).

Overall, the users, parents, and teachers were satisfied with the program and

found it to be beneficial to the handwriting skills of the participants. The results were

mainly preference and opinion based from the participants, teachers, and parents. An

assessment on handwriting improvement and hand writing knowledge would be ideal to

further prove the benefits of this study (Tariq & Latif, 2016).

Thompson et al. (2018) aimed to evaluate computerized instruction, hope themed

stories, and computer coding using blocks-based language on reading and writing. The

intervention took place in 12 sessions for students diagnosed with dyslexia. The second

aim was to compare the overall performance accuracy of answering comprehension

questions when texts were given one word at a time versus one added word at a time on

the reading comprehension questions. The third research aim was to analyze the

participants' abilities to code correctly in three programming aspects: loop, function, and

conditional. The final aim was to observe students during the discussions of the hope stories and note the effect the stories had on their computer coding activities and motivations to learn and persevere through instruction (Thompson et al., 2018).

Participants were recruited from local elementary schools and middle schools through flyers. Through interviews, the researchers determined no other major factors were interfering with students' reading abilities and the children had a diagnosis of dyslexia through testing. In the study there were six females and eight males ages 9-12 (Thompson et al., 2018).

HAWK© sessions began with computerized handwriting activities on an iPad, and then reading and spelling activities, and ending with activities in syntax comprehension and construction. For the Letters in Motion section, the first six hand writing lessons were in manuscript and the last six were in cursive. Activities included watching the letter being drawn, the participants closing their eyes and writing it, writing the letters named by the computer from memory, studying the individual structures of letters, and then using a paper and pencil to write the entire alphabet by memory. For Words in Motion, the participants worked on manipulating phonemes. At the end of the lesson, participants were asked to spell dictated words on paper, to show they could apply what they learned. For syntax learning activities in Minds in Motion, students learned about musical melody of sentences, combining words, adding glue words, and choosing sentence word order (Thompson et al., 2018).

After the participants completed the computerized reading lessons, they would ready Bucky stories about Buckminister Fuller, a person with educational challenges, eyesight and walking problems, and how he overcame his obstacles. The participants

would then discuss questions posed by the teacher. The participants then engaged in computer coding and programming grounded in human language (Thompson et al., 2018).

From the pretest to the posttest, there were significant improvements in decoding, reading, encoding, and language by ear, mouth, and hand. The results were relevant to the first research aim regarding the effectiveness of the intervention with decoding, but not with reading comprehension. Results showed the average performance on the reading comprehension assessments were higher on the six lessons for one word at a time presentation than on the six lessons for one added word at a time presentation. This finding helped with the second research aim that shows a computer presentation of sentences for learning activities are beneficial to the student when designed to improved student's reading comprehension (Thompson et al., 2018).

The participants demonstrated three kinds of computer coding in KW learning activities: loop, function, and conditional. The results are relevant for the third research aim specific to the evaluation of response to KW coding and programming. Overall, the participants were able to demonstrate accurate performance more often than inaccurate performance. The researchers determined 12 lessons were not enough for the participants to demonstrate mastery, meaning no inaccuracies (Thompson et al., 2018).

Eleven of the students completed surveys. On the surveys, seven students reported they had worked with coding prior to the study. Seven of the students reported they preferred the coding activities, two of the students reported their preference as reading, one participant liked all the activities equally, and another participant did not answer the question (Thompson et al., 2018).

The researchers tested many elements and set the experiment up in such a way that made it difficult to determine which part of the intervention was beneficial for the participants. In addition, the lack of a control group made it difficult to determine if this same strategy would be beneficial for students without dyslexia. However, the researchers proved the benefits of using multiple methods of teaching, including computer programming and relatable stories to encourage learning in a student (Thompson et al., 2018).

Academic Interventions

While it is useful to know of simple interventions for students with dyslexia, such as font and font size, it is just as, if not more, useful for instructors to know which academic interventions are effective for teaching literacy and which intervention are not effective. Researchers have studied ways to improve literacy outcomes in students with dyslexia and reading disabilities the areas of reading, reading comprehension, and spelling.

The researchers van Viersen et al. (2018) researched two pathways in literacy and genetics. The first pathway, oral language abilities, can foster the development of pre-literacy skills (phonological awareness and letter knowledge) which help children decode words and better comprehend what they read. In the second pathway, the continuous influence of oral language abilities is necessary to develop linguistic comprehension, which is important for reading comprehension. The researchers wanted to determine how family risk of dyslexia relates to these pathways (van Viersen et al., 2018).

The results of the study showed that both pathways build on early oral language skills. For the first pathway, verbal IQ predicted phonological awareness and rapid

automatic naming and letter knowledge, and the pre-literacy skills predicted a student's

ability to decode words. In addition, the researchers found that family risk was not related

to general and verbal IQ and vocabulary, but it did affect literacy development and would

ultimately affect a student's reading comprehension (van Viersen et al., 2018).

The researchers found both pathways of reading comprehension, one through pre-

literacy skills and word-decoding ability and the other through language abilities, build

on early oral language skills. In the second pathway, early language predicted later

vocabulary, which, in turn, predicted reading comprehension. Essentially, the more

exposure to language and reading a child receives prior to schooling will benefit a

student's literacy education. The researchers also found that the relationship between

early oral language and word decoding is mediated by pre-literacy skills. In addition, they

show that an independent pathway from early language toward reading comprehension

and that it may run via later language abilities. Lastly, the researchers learned word-

reading fluency did not predict reading comprehension, and did not show a relationship

between general or verbal IQ and reading comprehension mediated by the decoding

pathway. Family risk had no impact on the language pathway (van Viersen et al., 2018).

Using evidence-based instruction is important for students, especially for students

with learning disabilities, because not all instruction is effective. Duff (2014) put together

a study to test out an intervention hypothesized to be effective. The purpose of the study

was to investigate the development of dyslexia and language impairment and to examine

how early intervention would affect children with a family history of dyslexia. The

research team came up with their own curriculum and hypothesized that children

receiving the intervention would make significantly greater progress in reading and

language skills than children not receiving the intervention. They expected that once the control group started receiving intervention, its progress would be comparable to that seen in the experimental group (Duff, 2014).

The team created a new intervention called Reading and Language Intervention, which was implemented by teacher assistants working at the participating schools. The sessions occurred daily with 20-minute individual sessions, 30-minute small group sessions, with two small group sessions and three individual sessions per week. The small groups included two, three or four children with individualized instruction (Duff, 2014).

The researchers found that the experimental group's progress in the first 9 weeks made no significant progress in the areas of early word reading, letter knowledge and phoneme awareness compared to the control group. For word-level reading abilities, there was also to reliable effect of the intervention. By the end of the third test in letter knowledge, the control group scored 30.71 and the experimental group scored 30.09. For phoneme awareness, the control group tested at 10.73 while the experimental group tested at 10.97. For sound deletion, the control group scored 7.6 and the experimental group scored 7.55. Through early word reading, single word reading, nonword reading, prose reading accuracy, orthographic spelling, phonetic spelling, expressive vocabulary, taught vocabulary, listening comprehension, and reading comprehension the two groups were close in score (Duff, 2014).

The researchers also tested 18 weeks of intervention versus nine weeks of intervention, hypothesizing the longer duration would benefit the students. Again, there was no significant difference or effect of the intervention on word level reading abilities.

Ultimately, the researchers learned the family history of dyslexia did not affect the intervention (Duff, 2014).

Other researchers were more successful in their studies of interventions. Helland et al. (2011) explored two different intervention methods for students with dyslexia to determine which method was most effective to teach literacy. The Bottom Up method teaches sound first and then meaning, whereas the Top Down method teaches meaning first and then the corresponding sound. To test this, they used four groups: students at risk (with dyslexia) learning Bottom Up, students at risk learning Top down, and a control group for each method (Helland et al., 2011).

The researchers focused on growth in the areas of phonological awareness, digit span, verbal learning, and letter naming which all contributed to word reading and word spelling. In the area of phonological awareness, the Bottom Up method appeared to work better for both the control and risk groups. In digit span, Bottom Up was also more effective for the control and risk groups. More progress was made than in Top Down. However, when it came to the higher-level processes of verbal learning, letter knowledge, word spelling, and word reading, Top Down interventions were most effective (Helland et al., 2011).

As Helland et al. (2011) stated, "Even though the TD training principle seemed to foster reading and spelling skills more efficiently than the BU principle, both principles should be applied. The early BU effects on the low-level impairments are important because of the consensus that these are benchmarks of dyslexia and that they are basal skills in emergent literacy" (Helland et al., 2011, p. 117).

Gustafson (2011) also studied Top-Down and Bottom-Up reading interventions. These researchers explored the effect of three separate conditions on students with reading disabilities including phonological training (bottom-up), comprehension training (top-down), and a combined training of phonological and comprehension training. The 130 second graders who participated in the study were randomly assigned to one of five groups and given either phonological training, comprehension training, combined training, ordinary special education interventions, or typical classroom instruction (Gustafson et al., 2011).

For the procedure, the students were administered a test by 13 trained psychology students and one of the authors. The team was careful to follow the same test procedure and two researchers were present for each test to ensure continuity. There were two test sessions and pre-interventions in term one. In term two, five weeks later, the children were assigned to groups, and then in the third term, the third test session took place once 25 training sessions had taken place. The reading tests were administered at Times 1 (T1), T2, and T3 (Gustafson et al., 2011).

The tests included Which Picture Is the Correct One, developed by Lundberg, Woodcock Reading Mastery Test–Revised, Word chains test, Test of Word Reading Efficiency, Raven's Coloured Progressive Matrices, Wechsler Intelligence Scale for Children–Fourth Edition, a Swedish standard test of phonological awareness, and Initial Letter Verbal Fluency Test (Gustafson et al., 2011). The training program COMPHOT, focused on phonological training and included four sessions: rhyme, position, addition, and segmentation. The task included exercises with pictures of words that rhymed or had the same initial phoneme, other tasks required students to remove phonemes or segment

words. No sentences or passages were given to the participants. To make the instruction

entertaining and motivating, game-like elements were included. Another feature of the

program included immediate feedback of correct and incorrect answers with

corresponding happy and sad sounds (Gustafson et al., 2011).

For comprehension, the researchers used Omega-IS, which used a top-down

strategy including word and sentence level processing of written language. By clicking

on buttons with words or phrases, the participants were able to form sentences and then

have those sentences read back by the program, and then an animation would play to

illustrate the sentence. The purpose behind this was to offer one-to-one correspondence

between text, speech, and animation. The program would escalate in challenge by adding

more nouns and verbs and built its way up to stories. A third intervention group used

both programs by alternating them every other session. During the last five sessions, the

participants were allowed to choose which program to use (Gustafson et al., 2011).

The researchers learned that the interventions used in the Phonological group,

Comprehension group, and Combined group were comparative to the Ordinary Special

Intervention group and Typical group. The Ordinary Special Intervention group was run

by special education teachers who were allowed to pick from interventions they thought

would work best for the group they trained, and the Typical group had the advantage of

not having reading challenges (Gustafson et al., 2011).

Within the group phonological training, there were significant negative

correlations between reading improvement and two of the cognitive variables: RAN (with

a score of -.44) and pseudo word spelling (with a score of -.52). The Comprehension

group showed no significant correlations. The Combined group combined training

showed a significant positive correlation between reading improvement and working memory (with a score of .48). Within the Ordinary Special Instruction group there were significant negative correlations with short-term memory (-.43) and phonological short-term memory (-.58) and a significant positive correlation with spelling (.46). Typical readers only showed a significant positive correlation between reading improvement and verbal fluency (.43). Overall, the researchers found the students with reading disabilities who were in the combined group to make more progress than any of the other groups (Gustafson et al., 2011).

Ghanaat Pisheh et al. (2017) researched the effect of cooperative teaching on the development of reading skills among students with reading disorders. The teachers were trained using research-based curriculum and came up with interventions to be administered to students with reading disorders in 15 sessions. The interventions began with a test to assess learning. The training was divided into three blocks with specific points of focus. In the first block, the teachers focused on managing the classroom by creating a better learning environment with better learning opportunities and avoiding unacceptable behavior and responding to the behaviors. The teachers also worked to build the student's self-concept, explain to the students the reason for two teachers, the two teacher swapping roles, and grouping the students to teach the students how to work together and create cooperation in the classroom (Ghanaat Pisheh et al., 2017).

The second block focused on educating the peers individually, arranging interesting education experiences, learning how to combine audio and visual instruction, and changing student groups. The third block focused on time management, self-

evaluation, and comprehensive covering to determine where the weak points were

(Ghanaat Pisheh et al., 2017).

As a result of the study, Subject 1's baseline increased from 42 to 62.7 after the

intervention, Subject 2 rose from 35 to 54.3, and Subject 3 increased from 50 to 65.4.

Each of the participants showed significant progress from their baseline scores within the

15-week intervention and has enhanced their reading scores (Ghanaat Pisheh et al.,

2017). The researchers used no control group to compare against, so it cannot be

determined if a student with dyslexia in a classroom with one teacher following similar

instructional techniques and programming could make as significant as progress with the

student.

While there are multiple studies completed on the benefits of co-teaching, this is

one of the few studies that looked reading disabilities and co-teaching. However, in this

study, the researcher only showed that the co-teaching model was beneficial to students

with reading disabilities (Ghanaat Pisheh et al., 2017). It did not show that the co-

teaching model was more beneficial than a one teacher classroom.

Martínez-García et al. (2019) put together a study which aimed to explore

orthographic learning in Spanish children with dyslexia and to test the benefits of

semantic-phonological knowledge in forming orthographic representations of new words.

Essentially, they wanted the students to study word parts, their meanings and spellings,

and be able to improve their ability to read new words (Martínez-García et al., 2019).

The researchers hypothesized children with dyslexia would have problems

creating orthographic representation, even after repeated exposure to the same word.

They hypothesized they would see significant differences between short and long words

in the first block of conditions, but anticipated the differences would become smaller across the block, and possibly disappearing after 16 repetitions. In addition, they hypothesized the decrease of length effect would be greater in the condition with training than the condition without training (Martínez-García et al., 2019).

Sixteen Spanish words with a lexical frequency of zero were selected for this experiment. Half were long (six to seven letters and tri-syllabic) and half were short (four letters and bi-syllabic). Participants were tested individually in a quiet room over five different sessions. On day one, the participants were assessed using standardized tests using the Wechsler Intelligence Scale for Children, a Spanish reading assessment battery, a Spanish writing assessment battery, and a rapid-name test. On the following sessions the experiment was carried out. In Condition 1, participants were instructed on semantic and phonological training before reading was carried out, and in Condition 2, the participants did not receive training. Condition 1 had two phases. The first phase used a computer, and a picture was selected for each word by the researchers. The picture showed the meaning of a word and a recording played so the participant would see the picture and hear the word simultaneously when the button was clicked. The students were then asked to repeat the word aloud. In Phase 1, the participants did not receive orthographic forms of the words. There were six blocks, and each block contained the same eight words in a random order (Martínez-García et al., 2019).

In the second phase, the participants read aloud the words which were presented individually in black, lowercase letters, centered in 24-point Arial font on a white background. The participants were instructed to read fast and make no mistakes. This time there were 16 blocks presented in random order (Martínez-García et al., 2019).

In Condition 2, there was no training and only the reading task. The participants were recorded to analyze for mistakes. The reader could read the word correct. Incorrect reading included hesitations, re-reading a letter, syllable, or fragment that had already been read, or having no response. Reaction times were also gathered (Martínez-García et al., 2019).

In Condition 2, the condition without training, 7.36% of the responses contained errors, whereas with Condition 1, 4.6% of the responses contained errors. Non-responses represented 4% of the responses, but non-responses were more frequent in Condition 1 with 2.29% than in Condition 2 with 1.71%. The reaction times between Condition 1 and Condition 2 were not significant. The results show that reaction time does lesson over time especially with training. By about the eighth block the reaction times for the short words and the longs word were close enough together, where the difference in the reaction time began to disappear. However, the reaction time for long words was still longer than short words (Martínez-García et al., 2019).

Overall, the researchers learned that reading repetition improved reading new words in students with dyslexia if those words contained orthographic representations that have been studied. The researchers showed it takes at least ten interactions with a word for the participant to become familiar with it. There was no triple interaction between length block and condition, however there was a significant effect of the semantic-phonological training, but the gain would be over a longer amount of time. Children with dyslexia need a greater number of exposures to a letter or word than typical children (Martínez-García et al., 2019).

One researcher explored ways to improve reading comprehension of expository texts in poor readers through the use of concept mapping. They studied multi-media concept mapping and digital text-based concept mapping and compared concept mapping to traditional teaching methods.

Morfidi et al. (2018) found 30 fifth grade children from the inner city of Ionia Greece. They were matched on age, gender, and reading ability. There were no significant differences between the three groups formed in the reading comprehension test, or the cloze reading task at the onset of instruction (Morfidi et al., 2018).

The team used the Woodcock Passage Comprehension from the Woodcock Language Proficiency Battery-Revised. Three reading texts were selected on science topics such as rain, earthquakes, and solar radiation. Each text consisted of 200 to 300 words and the readability levels were appropriate for the participant's age level (Morfidi et al., 2018).

Digital text-based concept maps were constructed, followed by multimedia concept maps. The lessons lasted about 40 to 45 minutes and each group would receive three teaching lessons with one lesson for rain, one lesson for earthquakes, and one lesson for solar radiation. Instruction was carried out by a teacher and a researcher. The class was supervised by one of the authors to ensure continuity between lessons. Scaffolding was used in each lesson, adding prior knowledge, revision, and feedback. When concept maps were used, the participants were given short reminders of its use. In the final steps, feedback was gathered and participants ended the cloze reading task (Morfidi et al., 2018).

The first question the researchers asked concerned the efficacy of concept mapping compared to traditional teaching in helping children with reading difficulties comprehend expository texts. Traditional teaching results were not significant before or after instruction. However, both concept mapping approaches produced significant positive results. The results after the teaching nearly doubled in all cases, where with traditional teaching the total scores went up by .9. The scores to from concept mapping increased by 13.5 points and the multimedia concept mapping went up by 11.6 points before to after instruction (Morfidi et al., 2018).

The second area the researchers wanted to explore was if multimedia concept mapping produced differential learning outcomes compared to digital text-based concept mapping (Morfidi et al., 2018.) According to the results, there were no significant differences in results between the two types of mapping, and when the researchers surveyed the participants on their preference between the two types of mapping, the participants showed no significant preference for either (Morfidi et al., 2018).

Another area of challenge for students with dyslexia is spelling. Faber (2006) tested if visualizing and verbalizing methods, requiring problem-solving skills, can help students develop their ability to spell. For example, covering up some letters and having the student write the missing letters. Faber (2006) explored whether this method would significantly increase spelling test performance and decrease error-rates in the participants' spelling (Faber, 2006).

The training cohort was comprised of nine participants in grades three, four, five, and seven who had typical IQs but struggled in spelling. Students were assessed using a pre-test six months prior to the training and then another pretest when the training began,

and then again 40 hours into the training. The spelling words were grade-level words, standardized, and norm-referenced. Data from pre-test one and two served as a base rate or control (Faber, 2006).

The researchers work proved beneficial in helping the students increase their knowledge of spelling in all but two instances. One grade four student increased slightly in errors in one of five comparisons and another grade four student slightly increase in spelling errors in two of five comparisons and remained unchanged in one of five comparisons. Overall, after 40 hours of training students were able to significantly increase their spelling skills (Faber, 2006).

This study would have benefitted from more participants, however, the researchers found significant improvement in the participants. Partial word deletion was an effective way to increase a student's spelling skills (Faber, 2006).

This next study included a reading and spelling intervention for students with dyslexia. The intervention was administered in two interventions, and the researcher wanted to know to what extent children with dyslexia would benefit. In addition, the researcher wanted to know how phonological awareness, rapid automatized naming, letter knowledge, and verbal working memory could be used to predict a student's responsiveness to the intervention (Tilanus, 2019).

The control group was made up of 108 typical second grade readers aged between six and eight years. Three of the children repeated the grade, and the group was selected at random out of a list of schools of the children with dyslexia. The research group consisted of 75 boys and 47 girls aged seven to eight years who all met the formal criteria of dyslexia per the Dutch Dyslexia Foundation (Tilanus, 2019).

Two groups of children participated and were assessed three times. The measures consisted of using standardized assessments to measure decoding, spelling, phonological awareness, rapid automatized naming, letter knowledge, and verbal working memory. The children who were referred to the clinic were students with areas of reading and spelling deficits that had been observed in the school setting. The deficits existed despite intensive interventions in the school. Pretesting in Time 1 was done at the beginning of Grade 2 and the children were eligible for the intervention when they met Protocol Dyslexia Diagnostic and Treatment criteria, and then the children underwent the 2-phase reading and spelling intervention. The goal of the intervention was to allow children to reach a functional level of reading and spelling (Tilanus, 2019).

In the first phase of the intervention the focus was on the phonetic structure of the Dutch words using grapheme-phoneme correspondence and monosyllabic words. The intervention used simple words without digraphs. Once the participants achieved success with the basic sound, they were later introduced to more complex sounds and digraphs. After 12 treatment sessions, the children were reassessed to check for progress. In the second phase, 36 session took place moving from grapheme-phoneme correspondence to applying the learned knowledge to polysyllabic words. Words were broken into phonological units instead of syllables to read words (Tilanus, 2019).

The participants were treated 45 minutes a week with a clinician, using text reading and flashcards. In addition, participants were required to work on the exercises at home for 20 minutes of reading four times and 10 minutes of spelling two times a week. Participants kept a progress journal, and could be dropped from the intervention if home

practice was not completed to keep the integrity of the study. No participants were dropped (Tilanus, 2019).

For word decoding efficiency there were no differences in the growth between typical readers and dyslexic reader in Time 1 (T1) to Time 2 (T2), however, the difference between Time 2 and Time 3 was significant with the advantage going to typical readers. While dyslexic readers did not achieve the highest scores, they did achieve more growth than the control group (Tilanus, 2019).

For nonsense word decoding efficiency, the difference in growth was significant with an advantage for dyslexic reading from T1 to T2. T2 to T3 yielded more growth for typical readers. There was no normalization effect between T1 and T3. For spelling, readers with dyslexia were behind the typical readers at all time, however dyslexic readers achieved significant growth from T1 to T2 and T2 to T3. There was also no normalization in the area of spelling (Tilanus, 2019).

The researchers also looked at individual responses to intervention and looked at the initial data to predict susceptibility to intervention. For decoding efficiency, rapid automatized naming, initial treatment success, and the participant's nonsense word efficiency level directly predicted Time 3 outcomes. In decoding accuracy and nonsense word decoding accuracy, Time 1 was a predictor of Time 3. For spelling, there was no direct effect found between children's initial spelling to the Time 3 outcome (Tilanus, 2019).

Overall, the participants were able to increase their reading and spelling skills after a two-phase reading and spelling intervention. The researchers found the students had made significant progress from the initial assessments to the second phase of

intervention with word and nonsense word decoding in the areas of accuracy and efficiency, as well as spelling. Students with dyslexia were able to improve more in the first phase (12 weeks) vs the second phase (36 weeks), whereas typical readers improved in both phases (Tilanus, 2019).

Another researcher studied the effectiveness of learning word parts to increase spelling abilities. The researchers ran an experiment on an intervention teaching students root words, suffixes, and prefixes, and then combining words. The researchers hypothesized the chronological age group would gain less from the intervention than the other two groups, they dyslexic group and the Spelling Age group (the group that spelled at the same level as the students with dyslexia). The researchers also wanted to test the longevity of the intervention and test the group with dyslexia to explore how much the students had retained (Seymour, 2009).

The researchers separated the participants into one of three groups: the dyslexic group, the chronological age group, and the spelling age group. Each separate study included a pre-test, a training program, and a post test. Delayed post-tests were given two months after the completion of the study to the dyslexic group. Each study lasted about three months. First came the adjective study pretest with 97 pairs randomized, and then the noun study with 100 pairs randomized. The pretests took two weeks each (Seymour, 2009).

The program was designed to teach the participants the structure of the words and how it related to their spelling. The instruction targeted word structure (stem and suffix), stem consistency (when the base and stem are spell identically), suffix consistency where

the suffixes are spelled identically despite their different linguist environments, and derivation rules that create orthographic change (Seymour, 2009).

The sessions consisted of three sections: workshop, discussion, and practice. During the discussion, the student was presented with a card and asked to analyze the word: identify root word and suffix and any possible meanings. The word pairs were printed on different colored cards with the stem on blue, suffixes on green, and letters subject to change rules in yellow (like "happy" and "ness" becomes "happiness"). After the discussion the students would practice by spell each word-pair at least 3 times correctly before moving on (Seymour, 2009).

For the base words: from the pretest to the post test, the Dyslexic participants made a gain of 8.44 in normal base words, 7.56 in words with orthographic change, and 8.01 overall. With the delayed posttest, the gain was 9.55. For the spelling age students (younger aged students) the gains were 9.30 in normal base words, 10.82 in words with orthographic changes, and 10.04. With the Chronological Age control group, the gains were much less with a 1.28 gain in no change words, 5.01 in words with orthographic change, and 3.14 overall. While all groups made progress, the spelling age control group and students with dyslexia made more gain than the chronological age group. The thoughts behind the chronological control group not making significant progress has to do with the learning ceiling and the control students not making as much progress because they were not as behind (Seymour, 2009).

Mavrommati (2002) produced another study on spelling interventions involving research on a pictographic method for teaching spelling to Greek dyslexic children. The researchers set up an experimental group and a control group. In the control group, the

children were taught how to spell using a 60-session curriculum, 40 minutes per session, involving 17 steps of activities including tracing, rewriting, the students tracing the words on each other's backs, cutting, gluing, think-aloud, etc.… The pictograph method researched required ten 40-minute sessions with only five steps of activities (Mavrommati, 2002).

The researchers came up with a test of 100 words and administered it to participants split between three groups. Each group was divided at random into two smaller groups for 12 in each group. Fifty-seven words were taken from the spelling test which every child had misspelled. After one week, the words were dictated again. The words which all the students spelled incorrectly on both occasions were included in the list to be taught with a total of 51 words, rounded down to 50 words. The words were divided into two sets: set A and set B. Each group would be exposed to both teaching methods for comparison. The third group of students would receive no extra teaching of any kind (Mavrommati, 2002).

When the teachers taught the words, they first discussed the challenges of the words (such as a "silent e" or "bossy r"), then the teacher drew a pictographic representation of the word on a blackboard, and explained why the picture had been chosen, relating the picture to the challenges of the words. The instructor then drew pictograms on the letter while the students observed, while explaining the story of the pictograms which was always related to the word. Lastly, the children drew the pictograms on the written word on a piece of paper. The teacher taught three words every nine sessions to cover a set of 25 words in nine days. On the ninth and 10th day, the sessions focused on revision of the taught words (Mavrommati, 2002).

On the first spelling test Set A, the first group using the pictographic method scored 22.92/25 words correct while the second traditional group spelled 7.12/25 words correct. The second pictographic group for the Set B words scored an average of 22.38 words correct out of 25 while the traditional group scored 8.33 out of 25. These results were considered significant (Mavrommati, 2002).

For the next test, results were similar. On Set A, the pictographic group scored 22.65 words out of 25 and the traditional group scored three words correct out of 25 words. On the Set B words, the pictographic group scored 20.83 out of 25 and the traditional group scored 4.67 out of 25. The students using no method scored 1.32 words correct out of 25 correct in Set A and 1.41 words correct out 25 for set B. To rule out any issues or score differences that could have been created by teachers, the researchers also looked at the teacher scores and found no significant differences (Mavrommati, 2002).

The pictographic method is a creative way to teach students with dyslexia a way to remember how words are spelled. It offers a creative process for individualized instruction for our students with disabilities.

CHAPTER III: DISCUSSION AND SUMMARY

Summary of Literature

In the area of teacher knowledge, I first reviewed the necessity to have trained teachers in the area of dyslexia. Giving teachers access to effective training can boost teacher's belief on how effective they can be in including students with dyslexia in their classroom (Kormos, 2017). Giving a teacher the proper resources and tools to use and reflect on their teaching abilities, is the start of the intervention process.

The next step from inward reflection is to reflect on the child's strengths and interests to consider using those strengths to the child's advantage. It can be easy to miss a gifted child with dyslexia, if his or her dyslexia interferes with reading. Just because a student has a reading disability, does not mean they have a low IQ, but rather it could mean the child is compensating and learning in creative ways (Kapoula et al.2016; van Viersen et al., 2016; van Viersen et al., 2018). It is important to look at the whole child and not just the disability.

Dimitriadi is an example of a researcher who played off the creative strengths of the students in a study. The researcher not only gave the students a task to author a multimedia package but also studied the long-lasting effects of the task and found the students with dyslexia could fluently read the passages they had authored weeks later (Dimitriadi, 2001). When interventions make room for creativity, students' strengths, and the students' interest, it can have long-lasting, positive effects on their education. (Dimitriadi, 2001; Kapoula et al.2016; Kormos, 2017; Thompson et al., 2018; van Viersen et al., 2016).

Many of the interventions can be applied to students without dyslexia due to having little to no effect on students, or even, in some cases improving text readability, possibly making the following interventions feasible as class wide interventions. As Rello and Baeza-Yates (2016) put it, "what is good for people with dyslexia regarding font types is also good for people without dyslexia" (p. 15:2).

With regard to making texts more readable to students, fonts to avoid include italicized fonts, serif fonts such as Times New Roman (Bachmann & Megheri, 2018; Duranovic et al., 2018; Ismail, 2018; Rello & Baeza-Yates, 2016). Educators and parents may also want to avoid specialized fonts that cost the use money such as EasyReading or Dyslexie. While certain specialized fonts have been proven to work, the same results can be achieved through simple adjustments to font and formatting (Bachmann and Megheri, 2018; Duranovic et al., 2018; Ismail, 2018; Kuster et al., 2018; Marinus et al., 2016; Rello & Baeza-Yates, 2016; Sjoblom et al., 2016; Wery & Diliberto, 2017). Open Dyslexic, although free, was outperformed by Courier in one study and produced negative results in another (Rello & Baeza-Yates, 2016; Wery & Diliberto, 2017).

Adjustments to formatting include size 18 to 24-point font, inter-letter spacing up to +14%, and avoiding the combination of a white background and black text (Ismail, 2018; Kuster et al., 2018; Marinus et al., 2016; Rello, Baeza-Yates, 2017; Sjoblom et al., 2016). Colored overlays are not necessary as they have been proven to be ineffective in increasing reading speed and reducing reading errors (Iovino et al., 1998; Sjoblom et al., 2016).

Preference plays a major role in whether a feature enhances text readability, whether it is text and background color, reading position, activities, font, or font-size

especially in the area of computers and technology. Many font colors, background colors, and reading positions are not a one-size-fits-all solution, and researchers recognized this and developed programs that allowed participants to adjust settings on websites or e-texts (Bait, 2017; Gregor, 2003; Kuster et al., 2018; Manilla & de Braga, 2017; Placopiti & Bellou, 2014; Rello & Baeza-Yates, 2017; Tariq & Latif, 2016; Thompson et al., 2018). Students exposed to activities of interests, often did well by the end of the studies, whether it was coding on a computer, delivering content in a new and creative way, authoring a website, or the topic of discussion at hand (Dimitriadi, 2001; Morfidi et al., 2018; Mavrommati, 2002; Thompson et al., 2018).

In the case of reading positions, Manilla and de Braga (2017) recommend watching how students prefer to read their text. If educators see them standing above their text, looking straight down, the student is unknowingly showing their reading position preference. For other researchers who developed programs, they based much of their application designs off the preferences reported by teachers and parents, including minimal background distractions and animations while maintain an attractive design. These researchers received positive feedback for their writing application because they abided by preference (Tariq & Latif, 2016).

Lastly, there are intensive and effective academic strategies teachers can use to address literacy needs in the area of phonemic awareness and reading, spelling, and comprehension. In the areas of reading and phonemic awareness, children should start being exposed to reading and language early on (van Viersen et al., 2018), and then when teaching phonemic concepts a blend of the Bottom Up approach (teaching meaning and then content) and the Top Down approach (teaching content and then meaning)

(Gustafson et al., 2011; Helland et al., 2011). A blend of these two methods is also recommended for reading comprehension (Gustafson et al., 2011) and with the reading process practice is key. Students with dyslexia may need more reading repetitions than a typical student to increase their ability to improve in reading, in addition to word studies and repeated exposure to word-parts may also benefit students with dyslexia (Martínez-García et al., 2019; Seymour, 2009; Tilanus, 2019).

Students with dyslexia often struggle in the area of spelling (Faber, 2006; Mayrommati, 2002; Seymour, 2009; Tilanus, 2019). Activities to help teach spelling and word orders include word studies, such as using root words and learning prefixes, suffixes, and words that do not abide by the typical rules (Seymour, 2009). Another activity is letter deletion and using a student's problem-solving skills to fill in the missing letters (Faber, 2006). Another researcher utilized visuals and stories to teach spelling, using pictograph to teach the spelling of words. This method was highly effective for teaching spelling and outperformed the control curriculum (Mavrommati, 2002.)

Comprehension is the ultimate goal of reading, and organizing reading and lessons, and while there are many tools out there to assist students, a concept map is an ideal tool to use because of the positive results it produces, whether it is a multimedia concept map or digital concept map (Morfidi et al., 2018). For comprehension, a blend of the Top Down and Bottom Up approach is recommended where meaning is taught before content and vise-versa (Gustafson et al., 2011).

Limitations of the Research

To locate literature used in this thesis, searches for publications on or between the dates 1990 to 2020 was conducted. This list was narrowed by only reviewing published

empirical studies from peer-reviewed journals that focused on literacy and dyslexia or reading disabilities found in online journals that addressed the guiding questions. Research about literacy interventions used for typical students was not used other than for mentions of control groups within the studies. The keywords that were used in these searches included "literacy interventions dyslexia" "dyslexia interventions" "dyslexia fonts" "technology dyslexia" and "academic interventions dyslexia."

Implications for Future Research

Research on dyslexia can be expanded by further researching the Positional Reading Arc, and testing its limits, including how it affects other learning disabilities. In addition, many of the researchers explored short-term effects of interventions, but few looked at the long-term effects of the interventions. For example, how does formatting and font choices affect the progress of a student with dyslexia when coupled with high quality literacy interventions? Is the student able to make more progress than another student with dyslexia without the formatting and font changes or even text and background changes?

Implications for Professional Application

There is a plethora of information on dyslexia that can be found on the internet, both based on fact or based on misconceptions. This literature review was conducted to help teachers and parents, as well myself, navigate through interventions and determine which interventions would be beneficial to students with dyslexia and which interventions should be avoided or replaced with more effective interventions. I have done so by reviewing several peer-reviewed articles which research suggested interventions for students with dyslexia.

While the research listed in this thesis is not all-encompassing, it can serve as a guide for teachers on which interventions to start. This thesis can be used as a tool to train both teachers and guardians of students with dyslexia. Through high quality training, teachers may feel more confident when teaching, and be able to differentiate instruction more effectively. Additionally, with training, teachers can offer parents and guardians more support and information about how to proceed with a student's education.

For parents and guardians, education about their child's disability plays a key role when making decisions about the student's education. Parents and guardians are important member of the team, who want what is best for their child. Having researched methods of interventions available to discuss with guardians can further educate the team, which can positively impact team dynamics.

Furthermore, the interventions compiled here can lead to changes in curriculum. For instance, Mayromatti (2002) researched the pictographic method for teaching spelling to students with dyslexia and measured it against typical methods for teaching spelling such as writing the word in the air, writing the word on another student's back, or repetitive writing of a word, which are typical interventions often seen in the classroom. The more effective method, proved to be the pictographic method of teaching spelling.

Lastly, education is an everchanging field. Interventions such as overlays were thought to have been effective in helping students with dyslexia read. Several researchers have tested and disproved that method. As new methods arise or old methods become popular, educators can weed out methods that have been disproven or ask questions about why the new methods work.

Conclusion

There is a wide variety of interventions specifically for students with dyslexia, that may also benefit other students. Through a combination of interventions where educators evaluate their own knowledge and evaluate the abilities of their students, many varieties of interventions can occur including academic interventions and interventions to make a text more readable. It is important for parents and educators to scrutinize the value of interventions presented to them and be aware of common misconceptions of what dyslexia is.

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