

Using Multimodal Virtual Instruction to Build Preservice Teachers' Knowledge of Dyslexia

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Abstract

Increasing awareness about screening and instructional interventions for students with dyslexia is a necessary component of P-12 teacher preparation. Disparities in reading achievement for students with disabilities, including those with dyslexia, is evidenced in lower literacy testing scores as well as lower high school graduation rates for those with documented disabilities when compared to typical developing peers. Preservice teachers, however, continue to struggle with understanding, identifying, and providing targeted literacy instruction to remediate reading challenges for students with dyslexia. Emerging data on the impact of the COVID-19 school closures on lags in student's reading attainment, further solidifies the need for teacher preparation programs to prepare preservice teachers to implement best practices for supporting students with dyslexia. The purpose of this mixed-methods study was to determine the impact of asynchronous online learning modules on preservice teacher's knowledge of dyslexia. Results indicate that preservice teachers who learn via online sources such as podcasts, infographics, and educational games, statistically increase their knowledge of dyslexia and confidence to work with students. Recommendations for programmatic change and inclusion of online learning about dyslexia for teacher preparation programs are suggested.

Keywords

teacher preparation, teacher knowledge, online learning, multimedia learning

The prevalence and impact of dyslexia on our nation's developing readers remains a pressing issue facing the educational community. Statistics released by the United States Department of Education (U.S. Department of Education, 2021c) estimate that 7.2 million children qualify for special

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educational services as mandated by The Individuals with Disabilities Education Improvement Act (IDEA, 2004), with another 1.5 million children receiving support via Section 504 accommodation plans. According to Moats and Dakin (2008) approximately half of students identified for special education services have a documented learning disability, of which 85% present with reading and language processing deficits including dyslexia. This approximation is supported from work by Cortiella and Horowitz (2014), which indicates that dyslexia is the most common subtype of learning disability identified in schools.

The current definition for dyslexia adopted by the International Dyslexia Association (IDA) in 2002, states:

Dyslexia is a specific learning disability that is neurobiological in origin . . . characterized by difficulties with accurate and/or fluent word recognition and by poor spelling and decoding abilities . . . [that] typically result from a deficit in the phonological component of language that is often unexpected in relation to other cognitive abilities and the provision of effective classroom instruction.

The IDA (2017) suggests that as much as 15-20% of the population is affected by some symptoms of dyslexia, including but not limited to, slow or inaccurate reading, poor spelling and writing, and mixing up similar words. The impact of dyslexia on reading acquisition for school-aged children is unmistakable, particularly in light of stagnating and declining reading test scores across the country and more recently the impact of the COVID-19 pandemic on student learning (Kuhfeld et al., 2021; Lewis et al., 2021; U.S. Department of Education, 2021b).

National and New York State Reading Achievement

Nationally results from the National Assessment of Educational Progress (U.S. Department of Education, 2019) show a year-over-year drop in reading scores, with only 34% of total students scoring proficient and higher on literacy assessments. More concerning, NAEP results indicate an almost 40-point gap difference between students with and without disabilities on 4th and 8th grade reading assessments. Disaggregated NAEP results for 4th grade New York State (NYS) students reveal little deviation between the National sample and NYS students (Table 1). Further examination of the NYS 4th grade students with disabilities subgroup indicates that only 8% of 4th grade NYS students classified with a disability received a score of proficient or higher, whereas nationally the total was 11%. These scores reflect the achievement of New York students living with dyslexia, many of whom receive support services under the IDEA (2004) category of specific learning disability.

While these results are disheartening, scores from the NYS English Language Arts (ELA) assessment provide a slightly different picture of 4th grade students' reading achievement (N.Y. State English Language Arts Assessment, 2021). Proficiency rates across all 4th grade NYS students is 45% (see Table 2). For students with disabilities, the percentage of students scoring proficient or higher is 16%, almost double reported 2019 NAEP scores. With approximately 1.2 million children in New York State are enrolled in grades 3-8, there is a palpable need to examine literacy achievement for all students, but more particularly for students with dyslexia.

Table 1
NYS and National NEAP Scores by Proficiency Group

Subgroup	NYS NEAP 4 th Grade Reading Scores 2018-2019				National NEAP 4 th Grade Reading Scores 2018-2019			
	Below Basic	Basic	Proficient	Advanced Proficient	Below Basic	Basic	Proficient	Advanced Proficient
Total Students	34	31	26	8	35	31	26	9
Students with Disabilities	73	18	7	1	70	18	9	2

Table 2
NYS ELA Scores by Proficiency Group

Subgroup	NY State 4 th Grade ELA Assessment Results 2018-2019			
	Below Basic	Basic	Proficient	Advanced Proficient
Total Students (N= 172,087)	21%	32	32	16
Students with Disabilities (N = 29,790)	51	33	13	3

Results of Poor Reading Achievement

A natural outcome of low literacy achievement is low high school graduation rates, particularly for students with disabilities. High school graduation is the culmination of over a decade of literacy experiences, yet students with disabilities are scoring lower on national and state tests.

National 2018-2019 school year data places four-year graduation rates for all students in the United States at 85.5%, but only 68.2% for students with disabilities (U.S. Department of Education, 2021c, d). In New York state, the 2020-2021 four-year graduation rate for all students was 86.1% vs 64.5% for students with disabilities (N.Y. Dept. of Education, 2021). However, 2020-2021 rates may not provide a complete picture of student achievement as this cohort was not required to complete required New York state regents exams as a result of the COVID-19 pandemic.

Another alarmingly reading outcome trend is the disparity between high school drop-out rates between typical readers and those with dyslexia. Nationally, the dropout rate for youth ages 16-24 is 4.7% as compared to 10.7% for students with disabilities (U.S. Department of Education, 2021d). In New York state dropout rates for students who began high school in 2017 is 4.2% for general education and 7.2% for special education (N.Y. Dept. of Education, 2022.). An additional 24.7% of students with disabilities who entered high school in 2017 remain enrolled in high school without graduating in four years. It is likely that some of these students will graduate high school, as trends suggest that 68% and 69% of students with disabilities graduate high school in either five or six years respectively.

In addition to spending more years in high school, many students opt to complete high school by registering for the Test Assessing Secondary Completion or TASC exam, a General Education Development test or GED alternative. Data from the TASC 2020 technical report indicates that nationally over 52,000 people ages 16 or older enrolled in the test, with 66.63% passing (Data Recognition Corporation, 2020). In New York state, over 33,000 people enrolled to take the test with a 50.13% passing rate, of which 51.8% were between the ages of 16-24 (Data Recognition Corporation, 2020). While the TASC numbers appear promising, they represent a small fraction of individuals who graduate in a given year and do disaggregate data for disability status.

New York state legislators and education advocates have connected the pressing need to advance literacy skills for students with dyslexia (Mugniani et al., 2009). To disrupt the school to prison pipeline (Mallett, 2016) in January 2021, NYS elected officials proposed legislative bill A02062. The bill, with text summary below, requires dyslexia screening and evidenced-based reading interventions for all incarcerated individuals without a high school or GED diploma:

Requires all incarcerated individuals who do not have a high-school diploma or its equivalent to receive a reading proficiency-level assessment and dyslexia screening upon intake; and requires for such individuals who perform below a certain proficiency level to be provided with dyslexia intervention that is evidence-based effective and consistent with science-based research specifically tailored to addressing dyslexia (N.Y. Legis. Assembly, 2021).

The Role of Schoolwide Intervention

While screening NYS inmates for dyslexia and providing access to literacy instruction is commendable, it is disappointing that some of NYS's children reach a point where they leave formal education without critical reading skills. It should be noted that many individuals currently incarcerated attended school before the national implementation of Multi-Tiered Systems of Support (MTSS) (IDEA, 2004; Every Student Succeeds Act [ESSA], 2015). The MTSS framework provides school-based social-emotional learning interventions via Positive Behavioral Intervention Supports (PBIS) and academic supports via the Response to Intervention (RtI) framework. The positive impact of the MTSS model and RtI supports on student reading achievement has been well documented (Choi et al., 2022; Fuchs & Fuchs, 2017; Leonard et al., 2019; Wanzek et al., 2018).

The right to read is fundamental, as evidenced the 2020 Michigan State Supreme Court decision on *Gary et al. vs. Whitmar et al.* which advanced the principle that a basic education must include access to high-quality literacy instruction. As NY legislative bill A02062 demonstrates, lacking literacy skill sometimes results in individuals making the wrong types of choices. Advocates of social justice reforms recognize that a disproportional number of children of color fail to be diagnosed with dyslexia, resulting in delayed or non-existent related services critical to their educational skill attainment (National Center

on Improving Literacy, 2021; Schelbe et al., 2022). To create an equitable and inclusive society, we must advocate that all children, even those with dyslexia, receive high-quality literacy instruction.

Implementing the MTSS framework however remains a challenge. Many school districts underestimate the effort needed to coordinate and implement an effective MTSS program with fidelity (Lenard et al., 2019). The scaling up of MTSS and RtI in schools is labor and time intensive, something known to be short of in most schools. Research suggests that some schools provide partial RtI implementation, employing surface level interventions that fails to impact student reading achievement (Balu et al., 2015). To ensure that MTSS and RtI remain successful, schools must coordinate staffing placements, provide coaching and professional development, and create consistent review plans to analyze data (Arden et al., 2017). One way to meet the goal of successful implementation is to better train PST in both the frameworks and strategies that enhance student achievement. Both PST and in-service teachers therefore require education on dyslexia to be able to identify students, collect data, analyze outcomes, and provide instruction.

Impact of COVID-19 on Literacy Achievement

The impact of COVID-19 school closures on reading achievement for students across the country and NYS is only just emerging. The Center for School and Student progress analyzed student Measures of Academic Progress (MAP) testing scores for 5.5 million school children nationally in grades 3-8 (Lewis et al., 2021). Initial results published in May 2020 show similar gains for students in reading achievement when compared to 2019, even with a shift to online learning (Kuhfeld, 2020). A note of caution is warranted when interpreting these results as these scores were the product of a September - March school year with full in-person instruction. Kuhfeld's 2020 results represent achievement rates for students who had only recently shifted to online learning, mere weeks before MAP assessment occurred.

When comparing 2020-2021 scores to 2018-2019 scores, the last full year of uninterrupted schooling for all children, literacy gains were noted but were of diminished quality (Lewis et al., 2021). Spring 2021 MAP results were lower by between 3-6 percentage points in reading when compared to 2019 numbers. A stall in literacy achievement rates was apparent when comparing data points between winter 2021 and spring 2021, confirming statistical projections of lags in literacy achievement of approximately 63-68% as compared to pre-pandemic levels (Kuhfeld et al., 2021; Lewis et al., 2021).

Larger literacy declines were also noted for students in grades 3-5, an age cohort that missed critical early literacy skill instruction. Younger students and those from lower socio-economic status (SES) homes were most impacted by COVID-19 as shifts to online learning did not promote learning achievement believed to have been possible with virtual instruction (Hammerstein et al., 2021). While the authors note that in some cases online learning was beneficial, they describe that remote learning benefitted students with pre-pandemic familiarity with online platforms thus requiring little technological and instructional onboarding.

Further, students living in lower SES homes lacked access to home-based internet with 83% of parents reporting computers and internet access for their children, as compared to 98% and 97% for parents in the highest SES brackets (U.S. Department of Education, 2021a). Research from the Pew Research Center indicates that 60% of low SES households worried about their ability to pay for

broadband internet during the pandemic (Pew Research Center, 2021), with 67% of parents surveyed in September 2020 reporting that their children's school had moved to remote learning (U.S. Department of Education, 2021b, d). Pew research also reported that 93% of parents experiences some technical difficulties related to remote learning during the pandemic, with 46% of lower SES homes reporting issues as well (Pew, 2021) These findings suggest that students living in lower SES homes may have been negatively impacted by school closures during the COVID-19 pandemic, as they were unable to access school content during shifts to online learning.

Impact of COVID-19 for students with dyslexia. While MAP scores do not disaggregate scores for students with disabilities, the federal Office of Civil Rights (OCR) released compelling data on the impact of COVID on the learning of students with disabilities (U.S. Department of Education, 2021c). As noted earlier, NEAP scores indicate a nearly 40-point difference in reading achievement between typical developing students and those with disabilities. Initial data on COVID's impact on students with disabilities suggests that collectively this cohort failed more classes, experience more mental health challenges, and most importantly lacked access to crucial related services while learning online (Jackson & Bowden, 2021; U.S. Department of Education, 2021b, d; Soria et al., 2021). To turn literacy lags into literacy gains, it is crucial we support the one group of people responsible for teaching reading: educators.

Preservice Teacher Knowledge of Dyslexia

Educators are frontline workers who provide access to literacy tools and texts. They serve as gatekeepers for early reading acquisition by teaching sound-symbol correspondences and providing decoding practice that builds fluency and reading comprehension. More importantly, teachers provide ongoing assessment to determine if students are attaining reading skills. If students fail to progress, teachers pull from their instructional toolkit to remediate and teach necessarily literacy skills. While experienced teachers have years to build their instructional repertoire, PST must learn in their preparatory program how to identify students who are struggling and how to actively participate in the MTSS/RtI model to ensure academic growth. In addition to pedagogy courses and content area instruction, preparatory programs must include information on how to screen for and provide beginning intervention for students with dyslexia.

Preservice Teacher's Misconceptions About Dyslexia

Despite the critical role teachers play in supporting students with dyslexia, research on PST knowledge of reading difficulties reveals mixed results regarding PST dyslexia knowledge. Misconceptions about dyslexia continue to exist and are often linked to the concept of neuromyths (Barr, 2018; Gwernan-Jones & Burden, 2009; Wadlington & Wadlington, 2005; Washburn, et al., 2016; Washburn, et al., 2013; Washburn, et al., 2011; Washburn et al., 2010). Neuromyths are pervasive misconceptions or beliefs attributed to brain functioning. Many preservice teachers also operate erroneously with the neuromyth belief that the basis of dyslexia is word and/or letter reversals or inversions (Ness & Southall, 2010; MacDonald et al., 2017; Wadlington & Wadlington, 2005; Washburn et al., 2011). In one study, as many as 71% of survey respondents indicated that the use of colored overlays could help children with dyslexia read (Washburn et al., 2011; Washburn, et al., 2013).

Similarly, many PST understand dyslexia as a visual - rather than a phonological processing - deficit resulting in reading letters “backwards” (Ness & Southall, 2010; Macdonald et al., 2017; Wadlington & Wadlington, 2005). Dyslexia as a neuromyth perpetuates misconceptions that result in PST teachers lacking the necessary skills to identify students at risk, enact ineffective interventions, and view dyslexia remediation as the purview of special education teachers (Anderson, 2021; White et al., 2020). Misconceptions about dyslexia result in PST misidentifying dyslexia, thus delaying screening for and in many cases denying access to interventions (Washburn et al., 2011; Washburn et al., 2014; Youman & Mather, 2013). By not understanding the varied nature of dyslexia, PST may unknowingly perpetuate poor reading outcomes for students with dyslexia.

Training PSTs About Dyslexia

Alarming, higher education faculty themselves continue to include misconceptions and neuromyths about dyslexia in both their training of and coursework for preservice teachers (Betts et al., 2019). Surveys on attitudes about teaching students with dyslexia reveal that PST felt strongly that they were ill-prepared to teach students with dyslexia and require more extensive training (Gwernan-Jones & Burden, 2009; Petersen et al., 2017). These findings are not surprising as researchers have identified that in-service and PST lack a basic understanding of the linguistic and phonological aspects of early reading acquisition; critical knowledge needed to understand how dysfunction in these areas are precursors for dyslexia identification (Binks et al., 2012; Joshi et al., 2009; Meeks & Kemp, 2017; Washburn et al., 2014).

Lack of teacher efficacy and insufficient linguistic or phonological knowledge may in part explain findings from the National Council on Teacher Quality’s 2020 review of early reading instruction. The report reveals that only 53% of teacher preparation programs sufficiently covered topics related to early reading acquisition (Drake & Walsh, 2020). As a result, graduates of teacher preparation programs and current in-service teachers feel ill-prepared to teach early reading skills. Many are embracing the Science of Reading via social media to learn methods for supporting early readers, as evidence from the Science of Reading-What I Should Have Learned in College Facebook group with over 142,000 followers since August 2019.

Based on the premise that approximately 15% of readers are affected by some symptoms of dyslexia (International Dyslexia Association, 2017), there is a palpable need for PST to understand *before* they enter the classroom how to identify and remediate reading instruction for students with dyslexia. Results from several studies suggests that positive shifts in PST training about dyslexia is occurring. Researchers reported that many PST can accurately identify several significant components of dyslexia (Wadlington & Wadlington, 2005; Washburn et al., 2010; Washburn et al., 2011). More specifically, survey respondents indicated that the presence of dyslexia does not negatively influence IQ, that people with dyslexia can be smarter than average, that dyslexia does not result from inadequate home environment or poor past reading instruction, and that dyslexia can have effects on writing and speaking skills (Wadlington & Wadlington, 2005). Additionally, preservice teachers have shown rudimentary understandings of the relationship between decoding, spelling, and listening comprehension to dyslexia (Washburn et al., 2010; Washburn et al., 2011). Though progress has been made in understanding

dyslexia and its neurobiological roots, there is certainly room to improve PST understandings of the language-based reading disorder.

Study Purpose

To support PST in debunking dyslexia neuromyths and prepare PST to support students with dyslexia, teacher preparation programs must include content and pedagogical knowledge about dyslexia within the existing frameworks of already-packed curricula. The overarching objective of this study was to explore the use of asynchronous multimedia modules as a way to increase PST understanding of dyslexia. Professionals working in teacher preparation understand the difficulty of adding new content to existing preservice programs. Students enrolled in teacher preparation programs must fulfill college core liberal arts requirements as well as education course requirements, often leaving little leeway for additional coursework.

Currently, NYS requires all PST to participate in 12 hours of training for child abuse prevention, school violence prevention, Autism awareness, and dignity for all students outside of formal course structures. However, embedding 12 additional instructional hours in coursework is difficult. Many NYS schools of education outsource requirements to online providers that deliver content modules in either asynchronous or synchronous modes. While imperfect, shifts to online learning during the COVID pandemic illustrate how asynchronous learning can serve as a viable option for delivering content, as long as the content is monitored and feedback provided (Anderson et al., 2020; Castro & Tumibay, 2021).

Recognizing the pressing need to support PST in developing an understanding of dyslexia and the challenges of doing so within the current structures of teacher education, the first author utilized the asynchronous online learning modules concept to create audio-visual content about dyslexia. The goal of the modules was to provide PST with multiple experiences that would deepen their understanding of dyslexia. After the modules were created, the two authors consulted with each other about selected topics, with the first author directing and adapting the modules as needed. Creating the modules was also particularly promising as teacher preparation programs continue to move instruction online for several reasons: (1) to appeal to diverse PST who opt for online programs because of financial, geographic, or time limitations, (2) to meet unusual circumstances like online instruction during the COVID-19 pandemic, and (3) to attract PST who prefer online learning over face-to-face instruction.

Online Dyslexia Modules

A review of online dyslexia modules reveals that 14 freely available modules exist which include learning goals and were developed by reputable educational sources (Anderson et al., 2020). While providing information to participants about dyslexia, Anderson and colleagues (2020) identified several gaps in the modules' design and presentation. Gaps include that only two modules addressed the dyslexia neuromyth, the absence of interactive feedback about content, and the lengthy presentations mostly containing narrated content on slides (Anderson et al., 2020).

To address these concerns, the first author spearheaded a collaborative effort to create 10 self-paced modules in consultation with the second author. The modules included various media platforms such as videos, podcasts, and animated content. The modules were designed to gradually grow understanding of the characteristics of dyslexia, how to identify dyslexia, and finally what instructional supports are

available to support students with dyslexia (see Appendix A for a complete list of module topics). More critically, the modules were created to be asynchronous and included feedback from the first author after every post. Implementation of the modules responds to a statement from Washburn and colleagues (2013), of the “need for PSTs to receive the most recent, accurate, and evidence-based information about the nature and characteristics of dyslexia” (p. 58). By creating additional supports for preservice teachers, the goal is for them to one day better serve their students with dyslexia.

Module Content

In the first module, preservice teachers answered open-ended questions about dyslexia as a way to document their knowledge level prior to completing all modules. The questions covered topics such as characteristics of dyslexia, prevalence of dyslexia, screening for dyslexia, teaching students with dyslexia, and classroom resources. Because one aim of the study was to determine if the modules support changes in preservice teachers’ understanding or misconceptions of dyslexia, participants completed the same questions in the final module.

The other eight modules provided content related to (a) characteristics of dyslexia, (b) screening tools, (c) curriculum, and (d) online resources. Weekly responses and reflections were posted to the course’s online platform. These responses were collected and analyzed based on the research questions. The modules provided content in a variety of media platforms. Participants listened to podcasts, read online content, watched videos of classroom demonstrations, played educational games, and completed dyslexia screeners. Based on Cognitive Theory of Multimedia Learning (Mayer, 2014), multimedia modules promote affective and cognitive engagement (Fredricks, et al., 2004) by minimizing cognitive load and maximizing student learning.

Theoretical Framework

This study was informed by Ajzen’s Theory of Planned Behavior (1991), which posits that our attitudes toward behavior, subjective norms, and perceived behavioral control together shape our behavioral intentions and behaviors. More specifically, this theory suggests that preservice teachers carry a set of intentions towards students with dyslexia related to their understandings of dyslexia. Teacher attitudes are shaped by their feelings of self-efficacy in teaching struggling readers and their power to remediate instruction (Gwernan-Jones & Burden, 2009).

As many in-service teachers report feeling ill-prepared to support students with dyslexia (Gwernan-Jones & Burden, 2009; Petersen et al., 2017), it is critical to begin supporting educators about dyslexia before they enter the classroom. As noted in research on neuromyths by Macdonald and colleagues (2017), 59% of educators and 50% of high neuroscience professionals incorrectly stated that dyslexia is characterized by seeing letters backwards, as compared to the general public at 76%. To effect change in future educators’ beliefs about dyslexia, the research questions guiding this study were as follows:

1. To what extent do multiple modules enhance preservice teachers’ knowledge about dyslexia?
2. What impact do asynchronous online dyslexia modules have on supporting PST self-efficacy of supporting students with dyslexia?

Methodology

Thirty-four undergraduates (32 female, 2 male) at a four-year private liberal-arts college located in the northeastern United States participated in the study. All of the participants were enrolled in undergraduate dual degree, culminating in a Bachelor's of Science in psychology and childhood/students with disabilities (1-6). At the time of the study, all participants were enrolled in a special education methods course focusing on inclusive classroom practices, modifications, and instructional accommodations to support all learners. This was the first special education methods course for all students, except for one PST who was repeating the course. Participants ranged in age from 19 - 22, all identified as White, and none had completed student teaching requirements.

Participant responses were collected via an online learning management system. To minimize researcher effects, all answers were posted asynchronously and outside of classroom meeting times. At the beginning of the semester the 10 modules and their due dates were posted to a discussion forum labelled Dyslexia Modules with the accompanying number, i.e. Dyslexia Module #1. When PST clicked on a module link, they were directed to a discussion page with resources, related internet links, and guiding questions. To complete the module, PST responded to the guiding questions by clicking reply on the bottom of the page. Responses were posted for review throughout the semester.

Completion of the modules was required for the course, with PST receiving 10 points after completing each module, for a total of 100 points. Each response was reviewed by the first author and received comments that provided feedback or clarified misconceptions. All of the comments were later reviewed by both authors using an a-priori coding framework to evaluate PST understanding of content. Modules that included noticeable errors or misconceptions were reworked for future use with incoming classes of PST. Institutional IRB consent was obtained and participants consented to have their data collected and analyzed. All data were kept anonymous. Participation in the modules was 91% with two participants missing only one module. One participant did not complete half of the modules and was dropped from the study.

Data Sources and Analysis

Participants completed a series of 10 online modules (See Appendix A) covering a cross-section of topics related to dyslexia. Created by the first author, the modules piloted course content and delivery format to determine the effectiveness of the format. At the time of data collection, a bill was pending in New York State legislature requiring school districts to provide training for school staff regarding dyslexia and other related reading disabilities. The bill, A080262, subsequently passed (2017). The first author piloted these modules to meet the state mandate to educate classroom teachers about terms, concepts, and instructional supports for students with dyslexia.

When developing the modules, we reviewed the Knowledge and Practice Standards for Teachers of Reading (see Table 3) published by the International Dyslexia Association (IDA) (2018). The IDA standards outline the following required knowledge:

Understand the tenets of the NICHD/IDA definition of dyslexia, that dyslexia...exists on a continuum of severity, be able to identify the distinguishing characteristics of dyslexia.

Because the first module and the last module were the same questions - encouraging participants to see their own learning over time - a coding system was incorporated to evaluate open-ended questions. Participants' responses were examined using the Council for the Accreditation of Educator Preparation

(CAEP, 2018) framework for levels of knowledge for PST (see Table 4). These four performance levels: beginning, developing, competent, and accomplished, are frequently used to evaluate PST' competence in elementary teacher preparation.

The responses were then collapsed into two categories. The first category was knowledge of dyslexia and encompassed questions which assessed preservice teachers' knowledge of the characteristics of people with dyslexia, as well as the phonological and brain-based roots of dyslexia. The second category assessed preservice teachers' knowledge of educational and curricular supports needed in schools to support students with dyslexia.

To quantify the data, each response was coded with one of four levels on the above coding scale. The first analysis examined preservice teachers' responses prior to the completion of the modules (pretest data) and then later examined each response at the completion of the modules (posttest data) using the same coding scheme. The next analysis examined the pretest and posttest means and used statistical analysis software to determine significance. Further, the open-ended responses were examined via grounded theory coding practices to search for overarching emerging themes.

Table 3
Content Domains in IDA Knowledge and Practice Standards

Standard	Title	Key Components Addressed
1	Foundations of Literacy Acquisition	Foundational concepts about reading development and reading difficulties that are derived from interdisciplinary research.
2	Knowledge of Diverse Reading Profiles, Including Dyslexia	Knowledge of diverse profiles of reading difficulty, including dyslexia, very slow reading, and language comprehension problems
3	Assessment	Knowledge of assessment relevant to evidenced based practices with a response-to-intervention (RTI) framework
4	Structured Literacy Instruction	Structured Literacy teaching, offering detailed guidance regarding to the nature of effective instruction in each major skill domain (phonological sensitivity and phoneme awareness, phonics and word recognition, reading fluency, vocabulary, listening and reading comprehension, and written expression). Standard 4 also includes guidance regarding expectations for teachers engaged in fieldwork or practicum (e.g., in interpretation of assessments, planning differentiated instruction, lesson design, corrective feedback, and so forth).
5	Professional Dispositions and Practices	Ethical standards for the profession

Table 4
Coding System Used to Evaluate Candidates' Knowledge

Levels of Teacher Candidate Knowledge	Description
Level 1 The Beginning Candidate	Level 1 implies a Beginning level of candidate performance characteristics, a level in which there is little or no evidence that the candidate meets the component's performance expectation.
Level 2 The Developing Candidate	The Developing Candidate. Level 2 implies a level of Developing performance, a level in which the candidate provides evidence for demonstrating some but not all of the performance characteristics necessary to meet the standard at an acceptable level, and so has not yet provided sufficient evidence of ability for independent practice for all parts of the component performance expectation. (CAEP 2018 K-6 Elementary Teacher Preparation Standards: Complete - 107)
Level 3 The Competent Candidate	Level 3 implies a level of Competent performance in which the candidate demonstrates proficiency—those performance characteristics that meet the component expectations at an acceptable level for a candidate who is just completing an Elementary teacher preparation program, and is ready to begin independent teaching in any K-6 Elementary classroom as a novice licensed K-6 Elementary teacher.
Level 4 The Accomplished Candidate	Level 4 implies an Accomplished level of performance in which the candidate demonstrates performance characteristics that represent exemplary practice for a candidate who is just completing an Elementary teacher preparation program and is ready to begin independent teaching in any K-6 Elementary classroom as a novice licensed K-6 Elementary teacher. Expectations for performance at this level are demanding and candidate performance at this level requires evidence of highly skilled performance for a candidate who is just completing an Elementary teacher preparation program.

Findings

The overarching objective of this research was to explore whether asynchronous multimodal modules increased preservice teachers' understanding of dyslexia. Another major aim was to understand ongoing support to improve preservice teacher's knowledge about dyslexia and self-efficacy for teaching students with dyslexia. The data were examined using paired sample *t*-tests to examine growth of PST knowledge on content and via the PST knowledge scale. When examining the data qualitatively, three major themes emerged - all discussed in detail below. Specific quotes were selected for inclusion in this paper that provided clear insight into beliefs or ideas related to the specific topics. Quotes were also chosen that were indicative of the majority of student responses.

Research Question 1: Overall Growth in PST Knowledge

A paired-samples *t*-test was conducted to compare scores of PST knowledge of dyslexia on the pretest or first module with scores on posttest or last module. A significant difference was detected in the summed mean averages of the pretest scores ($M = 1.43$, $SD = 0.46$) and the summed mean averages of the posttest scores ($M = 2.91$, $SD = 0.25$); $t(31) = -16.87$, $p = .000$. These results indicate the students made statistically significant growth in their knowledge of dyslexia over the course of the 10 modules. More specifically, results suggest that asynchronous online learning modules supports PST knowledge of dyslexia when embedded into teacher preparation coursework.

Growth in Understanding the Characteristics of Dyslexia. Findings indicate that preservice teachers began the ten multimodal modules with minimal knowledge of dyslexia. In module one - asking participants to define the characteristics of dyslexia - preservice teachers operated with rudimentary understandings, as shown in Table 3. However, when looking at the same questions presented in Module 10, participants' knowledge increased (See Table 6).

Table 5
Pretest and Posttest Knowledge Growth (N = 32)

Measure	Mean	SD	SE Mean	<i>t</i>	<i>df</i>	<i>p</i>
Module 1 Pre-post	-1.500	0.718	0.127	-11.811	31	0.000
Module 2 Pre-post	-1.563	0.504	0.089	-17.537	31	0.000
Module 3 Pre-post	-0.969	0.474	0.084	-11.558	31	0.000
Module 4 Pre-post	-1.906	0.390	0.069	-27.639	31	0.000
Module 5 Pre-post	-1.500	0.508	0.090	-16.703	31	0.000
Module 6 Pre-post	-1.625	0.660	0.117	-13.930	31	0.000
Module 7 Pre-post	-1.719	0.532	0.092	-18.602	31	0.000
Module 8 Pre-post	-1.688	0.644	0.114	-14.812	31	0.000
Module 9 Pre-post	-1.688	0.535	0.095	-17.841	31	0.000
Module 10 Pre-post	-1.781	0.553	0.098	-18.232	31	0.000

Table 6
The Growth in Participants' Knowledge of the Characteristics of Dyslexia

Question Presented to Participants	Mean Score of Participants' Responses for Module 1	Mean Score of Participants' Responses for Module 10
What is dyslexia? Provide a definition.	1.07	2.61
What are the characteristics of dyslexia?	1.43	2.96
Who can have dyslexia?	2.00	3.00
How common is dyslexia?	1.07	2.96
How long can dyslexia last?	1.57	3.00

Pretest findings. At the onset of the modules, preservice teachers demonstrated beginning PST level of knowledge about dyslexia. The qualitative responses signify that PST either lacked overall knowledge or guessed and intuited answers. The responses below indicate participants' assumptions and/or previous experience as the basis for generalized answers. The selected quotes are indicative of the wider responses collected by the participants, mainly a lack of in-depth knowledge on the topic.

- *Interestingly, I have never come across someone in my circle or even my extended circle with dyslexia. Therefore, I do not believe it is common.*
- *Dyslexia - I think - can last a while. It is more seen in children, I think that it never really goes away but you can train the brain to live with it and be able to read better.*
- *Anyone can be diagnosed with dyslexia but I am pretty sure it is more common in boys than girls.*

Additionally, PST associated dyslexia as a disability largely relevant during childhood years. Several participants wrote that identification occurs during the elementary school years with severity peaking in early grades, as demonstrated in this response: "Anyone can have dyslexia, it is usually diagnosed in early education and then they are provided the correct help." Across similar responses, participants demonstrated a lack of understanding of dyslexia as a lifelong condition.

Posttest findings. After participants completed the final module, mean scores indicated that participants were approaching or had achieved level three proficiency regarding knowledge of dyslexia's characteristics. An important area of growth came around participants' knowledge of the frequency of dyslexia occurrence, with participants pointing out higher occurrence rates than originally thought. In fact, many participants self-corrected their responses by acknowledging newly acquired information, as shown here:

In Module 1, I explained that I do not know anyone that is dyslexic which is why I believed it was uncommon. However, I now am aware that about 5-10% of the population has been diagnosed with dyslexia. In school, 15-20% of special education students (out of 13-14%) are diagnosed with dyslexia. While these percentages are high, interestingly, many individuals go through life undiagnosed with dyslexia so these percentages realistically may be even higher!

Preservice teachers also recognized the pervasiveness of dyslexia and its transcendence across gender, race, and socioeconomic status. Further, they revised their understanding of the dyslexia's duration, recognizing that dyslexia is a life-long disability that requires remediation early on. The following statements show newfound knowledge about dyslexia's occurrence as a lifelong condition:

- *Anybody can have dyslexia - not just one type of race or socioeconomic status. Dyslexia can run in families and people can go undiagnosed at a young age until they are older.*
- *Dyslexia can last a person's entire lifetime. There are modifications and accommodations that teachers and professors can implement to help students with dyslexia, however, it will never go away*

The most substantial growth pertained to the characteristics and causes of dyslexia. When asked to define dyslexia and list characteristics, participants identified dyslexia as a neurologically-based disorder represented by deficits in phonological processing. Preservice teachers pinpointed the specific deficits that underlie dyslexia, as exemplified in this response:

At the start of this course, I was only aware that dyslexia is simply a disability that involved trouble interpreting and distinguishing numbers or letters while reading and writing. However, I now have a more solid definition embedded in my brain. Dyslexia is a learning disability due to a problem in regard to phonological processing that directly impacts the language skills of an individual, but does not alter their general intelligence.

Increased Knowledge about Support Students with Dyslexia. At the start of the modules, PST lacked knowledge about instructional supports and how to assess for dyslexia. Over the course of the modules the levels of knowledge increased, as reflected in Table 7.

Table 7

Growth in Participants' Understanding of Support Structures for Students with Dyslexia

Question Presented to Participants	Mean Score of Participants' Responses for Module 1	Mean Score of Participants' Responses for Module 10
What is Orton Gillingham?	1.18	2.79
How do teachers assess for dyslexia?	1.25	2.91
What teaching methods or tools help students with dyslexia?	1.21	2.91
How are schools meeting the needs of students with dyslexia?	1.29	2.96

Pretest findings. Qualitative findings shed light on the participants' understandings of reliable ways to assess for dyslexia. Several participants wrote of the need for testing to determine dyslexia, but none identified specific assessments or screening tools. One participant wrote, "I know that there are certain assessment tests but I am not sure what they are called or how they work. Assessment can also

start out as being observational and seeing that there are some deficits.” When participants did identify assessment tools, they largely focused on observational measures such as running records.

I can assess for dyslexia by conducting multiple running records and collecting writing samples from that particular child. Dyslexia should not only be looked for in English, but also math and science. Tools such as running records would be helpful in aiding a student with dyslexia because of its ability to allow teachers to spot specific struggle areas a student is having.

Another area of relative weakness pertained to effective research-based practices to improve reading instruction. Participants instead identified multiple accommodations or modifications that support student learning. Another practice or tool repeatedly mentioned was technology. Participants explained that students could use text-to-speech tools, as well as enlarged letter fonts or iPads. Their lists of accommodations and modifications did not specify how these tools support students with dyslexia in a classroom of 25 children. Participants were also unable to name specific techniques or instructional programs that support teaching students with dyslexia. Participants’ answers about instructional support were limited to the following: extra time to read, audio books and audio recorded access to lessons, and text-to-speech digital tools. Absent in their responses were specific curricular supports, such as multisensory structured literacy instruction.

Posttest findings. After completing the modules, PST progressed from no knowledge of literacy approaches to providing in-depth responses of instructional methods for students with dyslexia. They referenced systematic, structured, and sequential multisensory instruction that include cyclical review of previously learned skills. In addition to multisensory reading instruction, participants also discussed the role of phonemic awareness training. As one participant masterfully wrote,

There are many important aspects of Orton-Gillingham including that it is multisensory, systematic, structured, and sequential. Additionally, the OG approach focuses on the most basic foundational skills of phonemic awareness, which is necessary for students with dyslexia. This is where the main difficulty begins, and if these skills are not mastered, there is no way students will be successful.

These data indicate that the online modules provided preservice teachers with new knowledge about specific teaching methods such as multisensory instruction, using educational games and websites, and providing multisyllabic word reading instruction. Furthermore, participants developed rudimentary understandings about assessing dyslexia through targeted assessments of phonological processing and spelling, rather than observational tools like running records.

Research Question 2: Preservice Teachers’ Self-Efficacy

Our second research question addressed ongoing support to build PST self-efficacy for supporting students with dyslexia. The final open-ended questions were analyzed as the pretest question did not address concerns about implementation of module content. Reflections from the last module offer a snapshot of PST who felt more prepared and confident meeting the needs of students with dyslexia. They discussed their ability to recognize signs of dyslexia in order to provide immediate support, as one PST wrote, “I’m glad these modules made me much more aware for the students in my [our] classroom

one day, to be able to point out symptoms of dyslexia before they truly become a harmful issue to a student's grades and abilities in the classroom."

Data support the use of online asynchronous learning as a way to build content knowledge on dyslexia (Anderson, 2021). Participants wrote how the various online resources such as websites, podcasts, educational games, and infographics supported their development of content knowledge and instructional supports. They discussed how they began the modules with misconceptions about dyslexia, such as that students with dyslexia flip letters around. Responses indicated that the modules provided a solid introduction to foundational knowledge of the topic and allowed for preservice teachers to pace their learning over the course of the semester. Finally, the cyclical nature of the modules, in which content was introduced and reviewed throughout the semester, allowed participants to develop a deeper and long-lasting understanding of the nature of dyslexia.

I am proud of myself and all that I have learned through these ten modules. The first module said not to google anything about dyslexia before answering these same questions. It was a struggle for me not to cheat being that I knew very little. This time around, I had so much information in the back of my mind that I did not have to search for anything. However, I went back to past modules to refresh my memory of specific links and sites. I often did further research and looked at multiple links to truly learn as much as I can about students with dyslexia in the classroom.

Though participants grew in their knowledge, they acknowledge gaps in their understanding of dyslexia, particularly how to provide targeted instruction using multisensory techniques. Across the data, participants had lingering concerns about their abilities to teach students with dyslexia. Recognizing that they will encounter students with dyslexia in their future classrooms, participants were eager to learn more about dyslexia supports. Several participants established goals about attending professional development trainings or referring back to the resources in the modules when teaching a student with dyslexia. They were optimistic that the modules provided them with more knowledge of dyslexia and established a beginning understanding how to teach their future students. As one participant wrote:

The main takeaway I had from these modules is that as a future educator, I need to educate myself on methods that I could use in my classroom. There are many affordable resources that educators could use in their classroom that would have a positive impact on a student with this disability. Overall, these modules were a step in the right direction in making me a better future educator.

One unexpected finding to emerge from the responses was the need for social-emotional support for students with dyslexia. Although a module on social-emotional implications of dyslexia was not included, participants wrote with great sensitivity about the emotional needs of students who struggle. They also wrote about the role they play in motivating their students and providing instructional supports so that their students are not discouraged. One student's empathetic response particularly highlights this finding.

I learnt that dyslexia is more than just inside the classroom it can affect a person's entire life and we will simply never be able to understand a day in the life of a child with dyslexia but all we can do is make ourselves fully aware of all the ways to help.

Our data suggest that PST who participated in a series of asynchronous online modules not only increased their knowledge of identifying dyslexia and implementing supports for students, but also developed more self-efficacy and confidence to teach students with dyslexia. These results offer promising implications for the role of multimodal digital instruction to better prepare PST in the standards set forth by the IDA.

Discussion and Implications

Educators continue to be frontline workers who advocate for students with dyslexia. They are dedicated to learning outcomes for their students and work tirelessly to support their reading achievement. Yet, educational outcomes for students with dyslexia continue to lag behind their peers. One source attributed to this lag is the endorsement by many educators of neuromyths that perpetuate misconceptions dyslexia (Anderson, 2021; MacDonald et al., 2017; Washburn et al., 2013; White et al., 2020). Misinformation about the nature of dyslexia results in students failing to receive effective instructional support needed to succeed. It is clear from research that PST do not receive appropriate training necessary to prepare them for identifying and instructing students with dyslexia (Anderson, et al., 2020; Ness & Southall, 2010; Gwernan-Jones & Burden, 2009; Wadlington & Wadlington, 2005; Washburn, et al., 2016). One potential way to change poor educational outcomes is to better train future teachers about dyslexia, thereby preventing neuromyths from entrenching in teacher's minds.

Results from the 2019 NEAP and 2018-2019 NYS ELA exams reveal that students with disabilities continue to lag behind their same aged peers. Poor literacy achievement may in part explain lower four-year graduation rates for students with disabilities and the need for NYS legislation (A02062) to screen incarcerated individuals for dyslexia and provide reading remediation to those who qualify. More Recently, COVID-19 school closures and shifts to online learning adversely impacted reading achievement for all students (Lewis et al., 2021), but particularly for students with disabilities who lacked access to crucial services (Jackson & Bowden, 2021; U.S. Department of Education, 2021b; Soria et al., 2021). Further internet access issues during the pandemic which resulted in "the homework gap" (Pew Research Center, 2021), particularly those from low SES homes, further compounds the need for better understanding of early reading achievement and supports for those who have yet to learn to read. Clearly students with dyslexia are not achieving the literacy outcomes they so desperately need.

The modules described in this paper disrupt dyslexia neuromyths by providing PST with a framework for screening, assessing, and instructing students with dyslexia. Our work offers promising findings about the potential of asynchronous multimedia modules to help PST develop a holistic understanding of dyslexia. While several freely available online modules exist, gaps have been noted in their design and presentation (Anderson et al., 2020). The modules described here addressed these gaps by providing feedback, increasing the length of time spent on topics, and included multiple media sources to deliver content. The modules curated content to from multiple sources in order to provide multiple entry points for PST to engage with topics related to dyslexia in the classroom. (Interested parties may contact the first author for further information and access to the modules.) Embedding modules within a mandatory education course allows schools of education to identify and address misconceptions about dyslexia in the middle of PST preparation, before PST are in the field. Results indicate that PSTs grew in the following areas of knowledge:

- Identifying dyslexia as a neurologically-based reading disorder
- Overcoming neuromyths and misconceptions about dyslexia

- Recognizing the frequency, pervasiveness, and duration of dyslexia
- Understanding effective instructional approaches to supporting students with dyslexia

These findings are particularly promising as teacher education programs continue to offer online instruction for several reasons: (1) to appeal to diverse PST who opt for online programs because of financial, geographic, or time limitations, (2) to meet unusual circumstances like online instruction during the COVID-19 pandemic, and (3) to attract PST who prefer online learning over face-to-face instruction.

It also appears that these multimedia modules enhanced PST content knowledge when compared to levels set forth by the Council for the Accreditation of Educator Preparation (CAEP, 2018). Overall, participants' responses moved from levels of 'beginning' to 'developing' knowledge. Furthermore, these multimedia modules support future teachers in meeting competencies set out by the International Dyslexia Association; in particular, these experiences contributed to PST knowledge in IDA Standard 2 (Knowledge of Diverse Reading Profiles, Including Dyslexia) and IDA Standard 4 (Structured Literacy Instruction). We recognize that vital elements of the IDA standards need further coverage in online modules. For example, IDA Standards 3 and 4 were not covered in sufficient depth. Though participants developed a cursory overview of multisensory reading instruction, they did not yet show understandings about the nature of overarching Structured Literacy approach and its essential components.

Though our multimedia modules helped participants develop procedural knowledge of dyslexia, PSTs also need significant practical experiences that may exceed the purview of online work. Several responses across multiple modules expressed a desire to work with students with dyslexia to better move the ideas from the module into practice. Many of these experiences provide PST with hands-on practical experience/s that help them develop competent knowledge.

- Individual and small-group intervention with students diagnosed with dyslexia
- Participation / collaboration in assessing students suspected of being dyslexic
- Shadow teachers and educational psychologists who service students with dyslexia and/or work in schools specializing in dyslexia
- Staffing intensive reading clinics, which provide evaluations and instruction based on student needs.

Limitations

Several limitations regarding the modules and study results should be noted. First, the data were collected from a relatively small sample in only one geographic area. Despite efforts to reduce coercion, there is the possibility that participants provided answers that they thought were desired. Third, the researcher-created modules were meant as an overview to a variety of dyslexia related topics. The modules may not have provided enough targeted information on specific topics or include questions that elicit in-depth responses. A possible next step would be for dyslexia researchers to externally review and validate the module's content and learning targets.

Conclusion

Our data suggest that PSTs who participated in online modules increased their knowledge about dyslexia. They develop foundational knowledge necessary to identify and support students with dyslexia in their future classrooms. These results also offer promising implications for the role of multimodal digital instruction to better equip PST with skills for teaching students with dyslexia. We cannot understate the importance of helping preservice teachers develop knowledge about dyslexia as a routine part of their preparation programs.

A well-informed teacher bears enormous responsibility for identifying challenges in children's reading acquisition and development. If teachers are unaware of the characteristics and causes of dyslexia, they may fall back on the "wait and see approach" that delays evaluations and services for students in need of support. In these multimodal modules, we see the promise for new ways to better inform teachers as they begin their career, as well as ways to provide time-efficient and low-cost professional learning for teachers already in the field.

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