The Impact of Dyslexia on the Effectiveness of Online Learning: A Systematic Literature Review

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Abstract

Dyslexia can have an impact on online learning outcomes. However, few studies have examined the association between dyslexia and online learning effectiveness. This systematic review focused on the effects of dyslexia on online learning effectiveness to conduct research in three major categories: analysis of impact, analysis of dyslexia on online learning, and analysis of interventions. A screening of two bibliographic databases identified 37 articles that met the inclusion criteria. The study determined that dyslexic learners are uncomforted with online learning and suffer from frustrated self-confidence and decreased academic performance in the learning process. It even affects the learners' evaluation of themselves and causes a decrease in self-efficacy. Among these, research on influencing factors can be divided into two dimensions: internal and external factors. Dyslexic learners are influenced by both the type of dyslexia and their psychological characteristics, as well as by teachers, teaching strategies, online educational environments, and educational media. These influences provide intervention strategies, such as developing customized online learning systems for dyslexic learners and exploring interventions in telerehabilitation medicine. However, no intervention strategies involve adjustments to the internal psychology of dyslexic learners and external support systems. Therefore, more research is needed to explore the differential impact of dyslexia on online learning and to understand the factors that produce this impact to provide a theoretical basis and direction for the generation of instructional strategies for dyslexics and the adaptation of online learning for dyslexics.

Keyword: online learning, dyslexia, new media, education, systematic literature review

1. Introduction

The worldwide prevalence of dyslexia ranges from approximately 5% to 15%, and in the context of the total global population base, dyslexics have become a large group. The concept of dyslexia originated in the late 1880s, and the International Dyslexia Association defined dyslexia as a specific learning difficulty of neurobiological origin (Artiles et al., 2020; Shaywitz, 2020; Cano et al., 2022). It is characterized by deficits in identifying written words, decoding, reading, and spelling skills (Roitsch &Watson, 2019; Snowling et al., 2020). Moreover, dyslexia is also categorized as a learning disability. The Diagnostic and Statistical Manual of Mental Disorders (DSM-V) defines dyslexia as a pattern of learning difficulties characterized by the presence of word recognition difficulties as well as spelling errors (Snowling & Hulme, 2012; Muktamath, 2022).

Dyslexia can be divided into acquired dyslexia and developmental dyslexia. Acquired dyslexia is associated with organic lesions (De Bleser & Luzzatti, 2008) and involves alterations in neurological traits in the brain (AJAX, 1964; Galaburda, 1993). Developmental dyslexia are primarily a phenomenon in which children with average intelligence develop without significant neurological or organic impairments. Their reading level significantly lags behind their corresponding intelligence level or physiological age (Gunnel, 2006; Peterson& Pennington, 2015; Lin et al., 2020).

With the development of online education, it has been customized to meet the needs of different learners (Tang et al., 2021). However, a particular group of learners, dyslexic learners, and the state of online education have entered the research field. Some dyslexic learners are poorly adapted to online learning and experience problems such as frustrated self-confidence and decreased academic performance in the learning process (Shaw, 2022; Al-Dawsari & Hendley, 2021; Maskati et al., 2021) Current research on dyslexia has focused on interventions (Fallon, 2020; Zuppardo et al., 2021; Dahl-Leonard et al., 2023) that link online learning as a novel intervention to dyslexia, but ignore the impact of dyslexia

on online learning outcomes. In a weakly instructed learning environment such as online learning, the acceptance of online learning by dyslexics exhibits a significant disadvantage that urgently requires the attention of researchers and theoretical support. Therefore, this paper focuses on developmental dyslexia, exploring the online learning effectiveness of people with developmental dyslexia and the impact of dyslexia on online learning to uncover the internal logic between the two and thus suggest optimizations for online learning.

1.1 Objective

The open nature of the Internet age and the promotion of lifelong education (Blaschke, 2021; Huang, 2021) have placed dyslexic learners in the domain of online education, but some learners with dyslexia are not comfortable with online education (Jan 2023), and dyslexia negatively affects their online learning outcomes (Fallon, 2020). Related theoretical studies have focused on developing online learning as an effective intervention for dyslexia, ignoring the impact of dyslexia on online learning outcomes (Zuppardo et al., 2021). Therefore, in this paper, we review the literature on the impact of dyslexia on online learning, summarize the impact of dyslexia on online learning, understand the factors and possible interventions to improve the research logic of dyslexia and online learning and help researchers gain a deeper understanding of the impact of dyslexia on online learning, the mechanisms by which the impact occurs, and the interventions that can be intervened.

2. Methods

2.1 Qualification Criteria

The PICOS (Population, Intervention, Comparison, Outcomes, and Study Design) approach was used to establish eligibility criteria. In particular, the population sample had to consist of people with developmental dyslexia, and studies involving only people with organic dyslexia was excluded. Interventions focused on the impact that dyslexia have on online learning, and studies involving only dyslexia through online learning were excluded. There were no restrictions on the type of comparator. Outcomes focused on the harmful effects of dyslexia on online learning, where adverse effects (psychosocial, learning outcomes) were the dependent variables. For the study design, studies had to be published in Chinese, English, or French peer-reviewed journals. The article excluded: book chapters, studies in non-peer-reviewed journals, dissertations, theses, dissertations, review articles, reviews, editorials, letters to the editor and unpublished data were not included in this review.

2.2 Search Strategy

The electronic databases used in this paper are mainly Scopus and Web of Science. The index terms were set to "dyslexia" and "online learning," Searches were conducted for five years of literature from McKenzie et al.'s PRISMA 2020 Statement: Updated Reporting System Review Guidelines. These searches were completed on January 3, 2023.

2.3 Study Screening

First, these articles are original research and do not involve the secondary review of potential research categories. All studies had to include original data to synthesize the reviewed information accurately. Second, all articles were required to include dyslexics and online learning. Articles only addressed algorithms about information networking domains, such as inferring the link between developmental dyslexia and online learning by constructing models. Dyslexia appearing in other scenarios, such as instrumental acquired dyslexia were excluded as they were not relevant to the topic of this article.

The first screening required all articles to be from within the six years 2017-2022 and included dyslexia, and online learning. The articles were screened under these restrictions and then further screened for two additional indicators. In the second screening, articles were excluded if they did not have significant relational factors, even if they mentioned dyslexia and online learning, and were within the appropriate scenario. This was because the study was explicitly focused on impact factor analysis. Finally, full-text screening included reading the articles to determine the relevance of their findings. All records with insufficient information or data that did not provide relevant or citable information were excluded.

Table 1. The search strings.

| Database	Search string
Scopus	(TITLE-ABS-KEY (online AND learning)) AND (dyslexia) AND (LIMIT-TO (PUBYEAR, 2023) OR LIMIT-TO (PUBYEAR, 2022) OR LIMIT-TO (PUBYEAR, 2021) OR LIMIT-TO (PUBYEAR, 2020) OR LIMIT-TO (PUBYEAR, 2019) OR LIMIT-TO (PUBYEAR, 2018) OR LIMIT-TO (PUBYEAR, 2017)) AND (LIMIT-TO (PUBSTAGE, "final")) AND (LIMIT-TO (DOCTYPE, "ar")) AND (LIMIT-TO (SUBJAREA, "SOCI")) AND (LIMIT-TO (LANGUAGE, "English"))
Web of Science	Results for ((TS=(online AND learning)) AND TS=(dyslexia) and Article or Review Article (Document Types) and English (Languages)

Prisma search
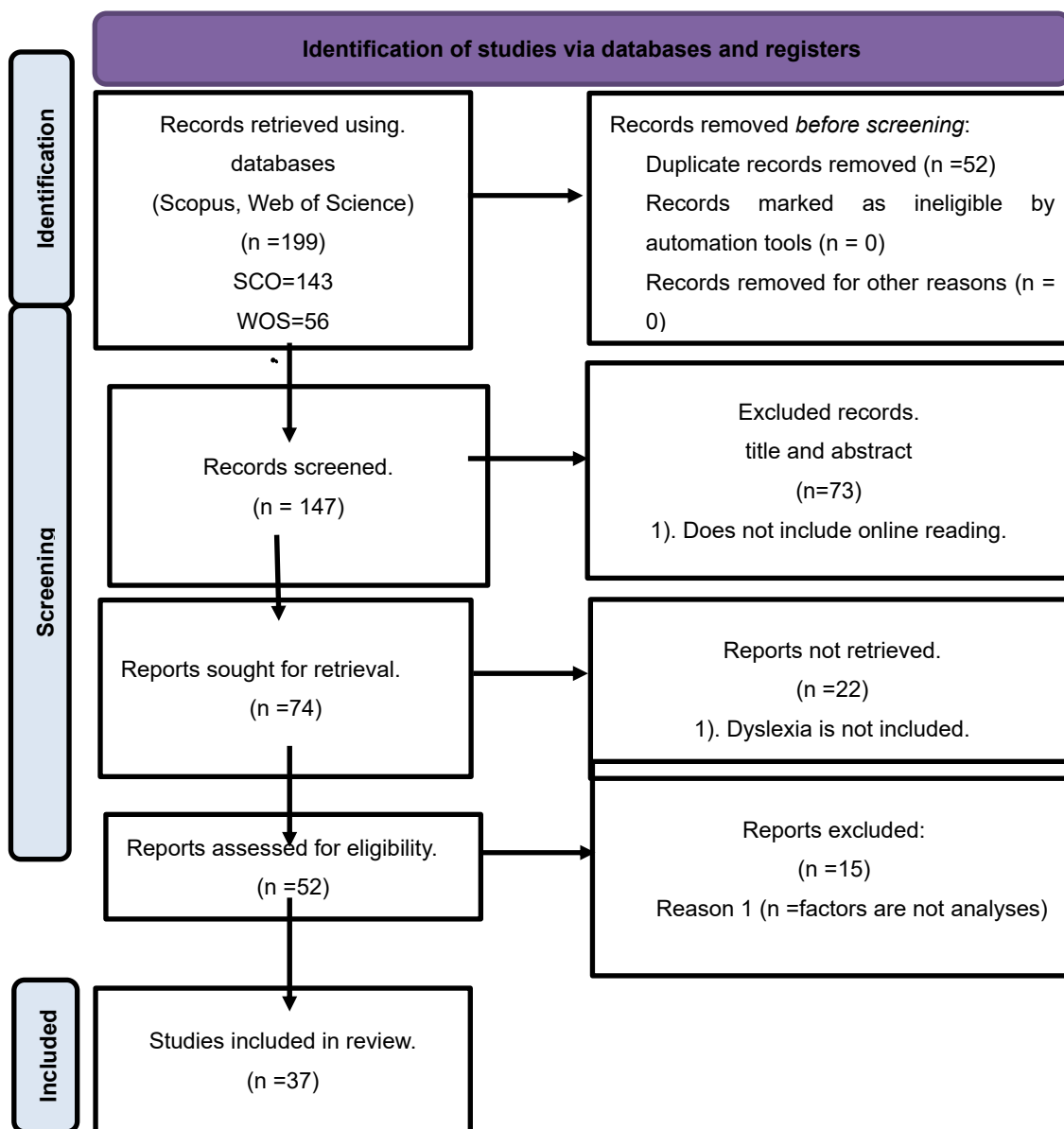
Figure 1. Search Flow Chart

3. Result

3.1 Characteristics of the Study

Thirty-seven studies screened since 2017-2022, Sixteen focused on the effects of online learning for people with dyslexia (Lebenicnik & Starčič, 2020; Pang& Jen, 2018; Alghabban et al., 2017; Heraty, 2021; Ziadat, 2021; Zawadka, 2021; Fung, 2022; Alghabban & Hendley, 2022, July; Sari et al., 2021; Shawaqfeh et al., 2020; Forteza-Forteza, 2021; Alghabban, 2020; Ayed H, 2021; Anette Andresen, 2018; Laura R. Hennessy, 2022; Dawson, 2021) to quantify and analyze the effectiveness of online learning of dyslexic students by comparing their learning effectiveness with that of regular students or by recording the performance of dyslexic students.

Twenty-eight studies have focused on the effects of external factors on the online learning outcomes of dyslexics when they act on them, and the exogenous factors involved are broadly: teachers' cognitive, behavioral, and instructional strategies (Kormos & Nijakowska, 2017; Novembli & Azizah, 2019, April; Heraty, 2021; Ibrahim, 2021), the learning environment and learning resources in which dyslexic individuals live (Pang & Jen, 2018; Lerga et al., 2021; Cancer et al., 2021; Thompson & Copeland, 2020; Forteza-Forteza, 2021; Kim, 2020), dyslexia-related learning system development (Alsobhi & Alyoubi, 2019; Alghabban et al., 2017; Burac & Cruz, 2020, April; Fung, 2022; Alghabban & Hendley, 2022, July; Cain & Fanshawe, 2021; Sari et al.,2021; Rodríguez-Cano, 2021; Bhavana Srivastava, 2020), the

use of web-based multimedia (Lebenicnik & Starčič, 2020; Ventura, 2017; Politi- Georgousi & Drigas, 2020; Benmarrakchi, 2021; Eliane Segers, 2018; Angel Jaramillo-Alcázar, 2021), the use of mobile learning models and the implementation of the concept (Novembli & Azizah, 2019. April; Alghabban et al., 2017).

Fourteen studies focused on the impact of dyslexic individuals' factors on the effectiveness of online learning (Pang & Jen, 2018; Lebenicnik & Starčič, 2020; Maurer-Smolder et al., 2021; Ventura, 2017; Heraty, 2021; Ziadat, 2021; Zawadka, 2021; Alghabban & Hendley, 2022, July; Cain & Fanshawe, 2021; Shawaqfeh et al., 2020; Soriano-Ferrer, 2021; Alghabban, 2020; Lilli Kimppa, 2018; Andresen, 2019), such as the requirements of different impairment types for online learning, the dyslexic person's physical and mental condition, and the reading strategies used.
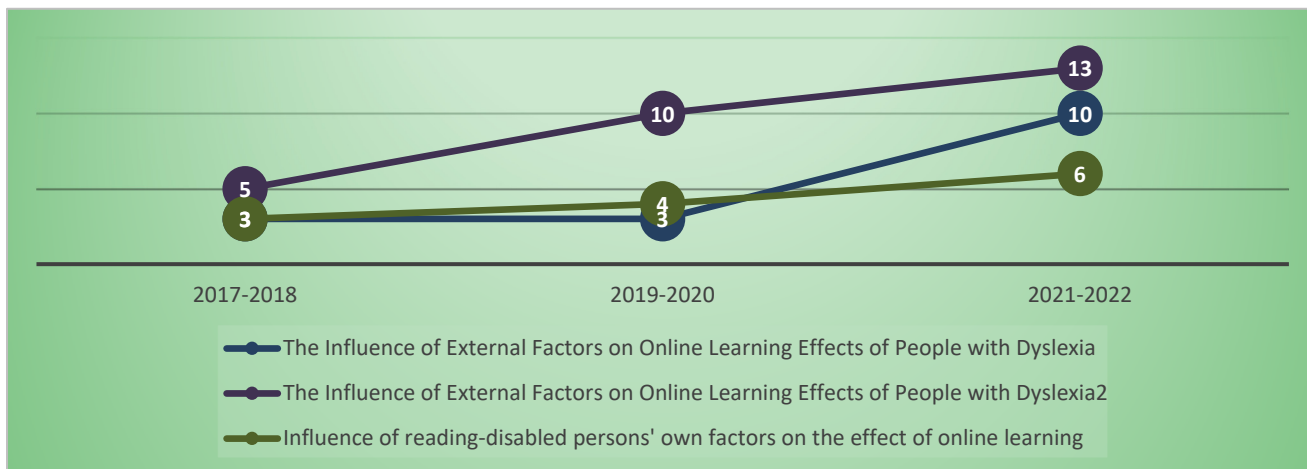

Figure 2. Dyslexia article publication time

It can be found that researchers have focused on factors related to the effect of online learning on dyslexics. A review of the literature reveals that most researchers have tacitly assumed that dyslexia affect online learning and treated it as the background and premise of the study. Research hotspots focus on how dyslexia affect online learning and what kind of impact it has. Since the effect of dyslexia on online learning can be visualized through measurement, among the 37 papers divided into qualitative and quantitative research methods, 7 papers used qualitative research methods such as case studies, interview studies, and documentary analysis methods, and the other 30 papers used quantitative research methods. 7 papers used questionnaires, and 23 papers used experimental methods. The study was conducted by experimental method.
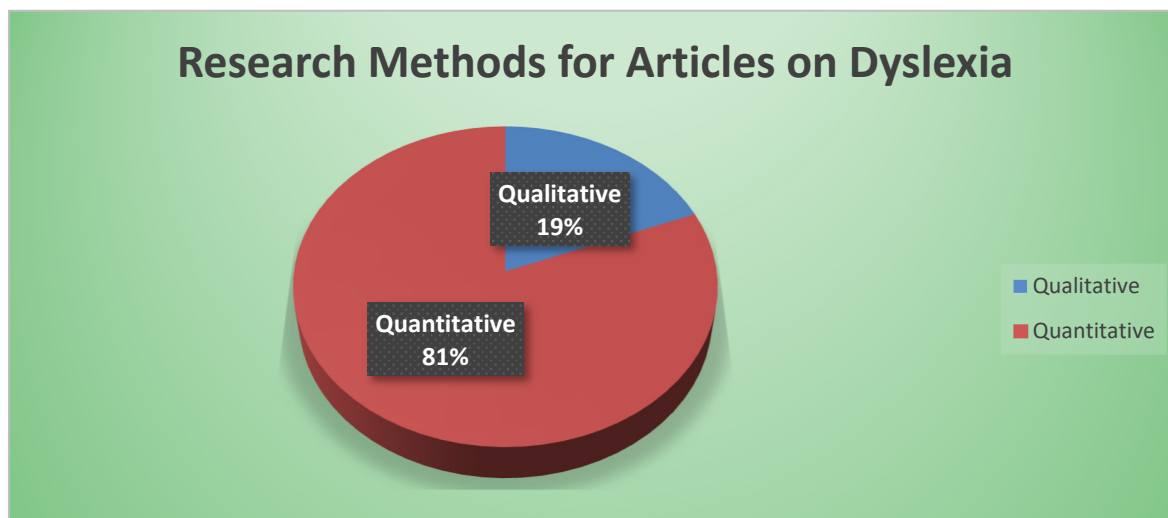

Figure 3. Percentage of research methods

Demographic

In the study of dyslexia and online learning, there were no strict restrictions on the age and gender of the study participants. The differences in the researchers involved in the studies mainly focused on the types of dyslexia, such as those who had difficulty identifying written words, those who had difficulty decoding reading, and those who had difficulty with spelling

skills. One study included students with low reading scores but no precise diagnosis of dyslexia, as study subjects (Joanna, 2020).

3.2 Effects of Online Learning for People with Dyslexia

The group characteristics of the person with dyslexia are manifested as difficulties in recognizing written words, decoding reading, and spelling skills) (Ameen, 2022). Online learning is a comprehensive project that includes both the learning and exercise of the above skills and includes Advanced tasks based on the above skills (Yustina, 2020). In addition, the definition of the learning effect itself is diverse, including task- and achievement-oriented judgment effects and sensory effects oriented by learners' subjective cognition. When judging the online learning effect of the learner, usually according to the needs of the research, a specific situation is created to examine the learning effect.

In the relevant literature, the following types of learning effects were measured: Ten questionnaires (Kormos & Nijakowska, 2017; Ziadat, 2021; Zawadka, 2021; Burac & Cruz, 2020, April; Shawaqfeh et al., 2020; Ibrahim, 2021; Forteza-Forteza, 2021; Soriano-Ferrer, 2021; Ziadat, 2021), three structured interviews (Pang & Jen, 2018; Maurer-Smolder et al., 2021; Laura, 2022), 12 task completion, the time required, and thinking patterns used ratings (Alsobhi & Alyoubi, 2019; Lebenicnik & Starčič, 2020; Alghabban et al., 2017; Heraty, 2021; Fung, 2022; Alghabban & Hendley, 2022, July, Sari et al., 2021; Cancer et al., 2021; Alghabban, 2020; Eliane Segers, 2018; Anette Andresen, 2018; Andresen, 2019), 15 theory-guided experiments and observations (Novembli & Azizah, 2019; Ventura, 2017; Lerga et al., 2021; Cain & Fanshawe, 2021; Rodríguez-Cano, 2021; Politi-Georgousi & Drigas, 2020; Thompson & Copeland, 2020; Gyore& Kubinger-pillmann, 2022; F Benmarrakchi, 2021; Lilli Kimppa, 2018; Kim M, 2022; Dawson, 2021; Angel Jaramillo-Alcázar, 2021; Bhavana Srivastava, 2020).

There are two dimensions to task completion and time required: the actual and experimental tasks. However, as the primary mode of operation of such experiments is parallel, the implication is that multiple dyslexic people are given separate online tools to examine their learning outcomes. The main variable controlled for in the experiment is the difference in learning tools and the learning effect as a control outcome. Therefore, it is still classified as task-oriented and does not separate and emphasize the experimental properties it possesses. Researchers are now gradually expanding their research horizons, although the traditional task-oriented, statistical-quantitative assessment of learning effectiveness remains the dominant tool. In contrast, some studies have begun using qualitative research. When examining the effectiveness of online learning for people with dyslexia, researchers have focused more on theoretical dimensions to compartmentalize and standardize learning effectiveness, and on subjects' cognitive and personal emotions from a subjective perspective.

3.3 The Subject of Measuring the Effect of Online Learning

When assessing the effectiveness of online learning for dyslexics, the subjects also have multiple characteristics, mainly including dyslexics (Kormos & Nijakowska, 2017; Pang & Jen, 2018; Alsobhi & Alyoubi, 2019; Lebenicnik, 2020; Maurer-Smolder et al., 2021; Alghabban et al., 2017; Heraty, 2021; Lerga et al., 2021; Ziadat, 2021; Zawadka, 2021; Fung, 2022; Alghabban & Hendley, 2022, July; Cain & Fanshawe, 2021; Sari et al., 2021; Cancer et al., 2021; Shawaqfeh et al., 2020; Rodríguez-Cano,2021; Politi-Georgousi & Drigas, 2020; Thompson & Copeland, 2020; Ibrahim, 2021; Soriano Ferrer, 2021; Alghabban, 2020), teachers (Heraty, 2021; Lerga et al., 2021; Burac & Cruz, 2020, April; Rodríguez Cano, 2021; Thompson & Copeland, 2020; Ibrahim, 2021; Forteza-Forteza, 2021) and parents (Ziadat, 2021; Forteza-Forteza, 2021; Soriano-Ferrer, 2021; Ayed H 2021) in three categories. Among them, the reviews of teachers and parents appear mainly in the state of aiding the dyslexic review, i.e., the reviews of parents and teachers are a validation or supplement to the dyslexic review, and the subject of the review is always the dyslexic herself.
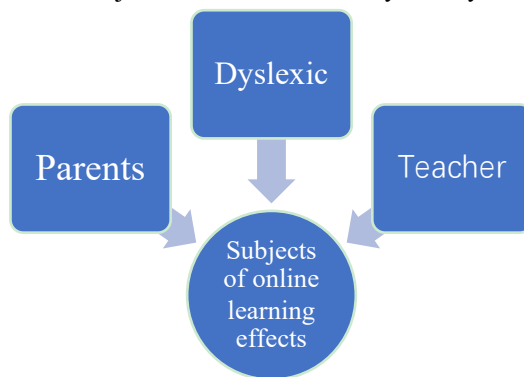

Figure 4. Measurement subject

3.4 Types of Measurement of Online Learning Effectiveness

We can classify the effectiveness of online learning for dyslexics as attitudinal (Kormos & Nijakowska, 2017; Maurer-Smolder et al., 2021; Ziadat, 2021; Burac & Cruz, 2020; Rodríguez-Cano, 2021; Ibrahim, 2021; Forteza-Forteza, 2021; Ayed, 2021), mission-based (Alsobhi & Alyoubi, 2019; Lebenicnik & Starčič, 2020; Alghabban et al., 2017; Zawadka, 2021; Fung, 2022; Alghabban & Hendley, 2022; Sari et al., 2021; Cancer et al., 2021; Alghabban, 2020; Benmarrakchi, 2021; Eliane Segers, 2018; Anette Andresen, 2018; Andresen, 2019; Dawson, 2021; Bhavana Srivastava, 2020), experiential (Pang & Jen, 2018; Maurer-Smolder et al., 2021; Zawadka, 2021; Burac & Cruz, 2020). Shawaqfeh et al., 2020; Thompson & Copeland, 2020; Ibrahim, 2021; Forteza-Forteza, 2021; Soriano-Ferrer, 2021; Lilli Kimppa, 2018; Laura & Hennessy 2022; Jaramillo-Alcázar, 2021) and cognitive (Novembli & Azizah, 2019; Ventura, 2017; Heraty, 2021; Cain & Fanshawe, 2021; Rodríguez-Cano, 2021; Politi -Georgousi & Drigas, 2020; Gyore & Kubinger-Spillman, 2022; Kim M, 2020), among other classifications.

The attitudinal approach refers to the attitudes of dyslexics, their teachers, and parents toward online learning, both before and after exposure. The experiential approach refers to the perceptions of dyslexics, their parents, and teachers about online learning, such as the perceived difficulty of online learning. Attitudinal and experiential learning effects ultimately return to dyslexics themselves and are studies of the subjective dimensions of the learning process and learning outcomes of dyslexics (Kormos & Nijakowska, 2017; Pang & Jen, 2018; Maurer-Smolder et al., 2021; Ziadat, 2021; Burac & Cruz, 2020; Shawaqfeh et al., 2020; Politi-Georgousi & Drigas 2020; Thompson & Copeland, 2020; Forteza-Forteza, 2021; Soriano-Ferrer, 2021). Task-based learning effectiveness refers to how well dyslexic individuals complete or accomplish online learning tasks. Cognitive learning effectiveness, on the other hand, refers to the researcher's observations of dyslexics' learning effectiveness through observation or testing. Both are detached from dyslexics and are studies of learning effectiveness from an objective or other measurement perspective (Alsobhi & Alyoubi, 2019; Lebenicnik & 2020; Novembli & Azizah, 2019; Alghabban et al., 2017; Ventura, 2017; Heraty, 2021; Lerga et al., 2021; Fung, 2022; Alghabban & Hendley, 2022; Cain & Fanshawe, 2021; Sari et al., 2021; Cancer et al., 2021; Politi-Georgousi & Drigas, 2020; ANN, 2022; Gyore & Kubinger-pillmann, 2022).
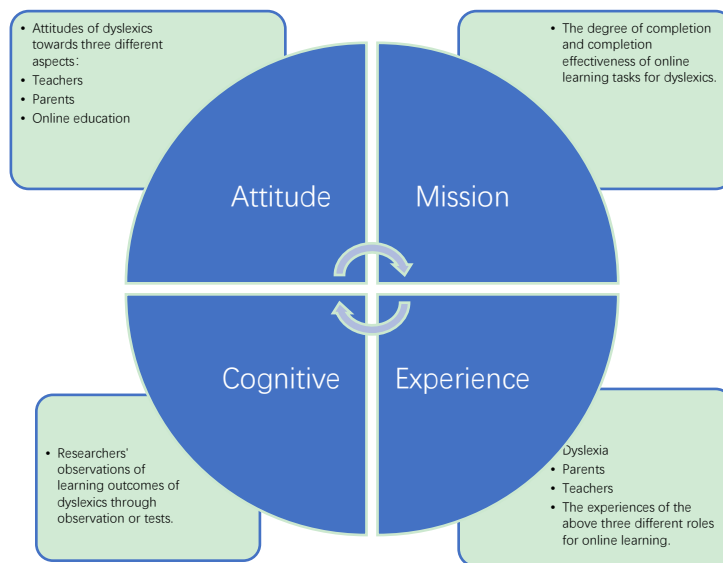

Figure 5. Types of measurement of online learning effectiveness

3.5 Measurement Results of Online Learning Effectiveness

Since the online learning approach involves independent reading as a context, researchers have used the low-quality performance of people with dyslexia in online learning as the premise of their studies to explore factors that enhance the quality of online education for dyslexics (Kormos & Nijakowska, 2017; Alsobhi & Alyoubi, 2019; Lebenicnik & Starčič, 2020; Maurer-Smolder et al., 2021; Novembli & Azizah, 2019; Alghabban et al., 2017; Ventura, 2017; Heraty, 2021; Lerga et al., 2021; Burac & Cruz, 2020; Cain & Fanshawe, 2021; Sari et al., 2021; Cancer et al., 2021; Rodríguez-Cano, 2021; Politi-Georgousi & Drigas, 2020; Thompson & Copeland. 2020; Gyore & Kubinger-pillmann, 2022; Ibrahim, 2021; Ibrahim, 2021; Alghabban, 2020; Bhavana Srivastava, 2020; Jaramillo-Alcázar, 2021; Kim M, 2020; Ayed H, 2021).

Qualitative studies on the topic of this study, such as researchers' observations and evaluations of dyslexics' online learning (Anette Andresen, 2018) or dyslexics' self-reported subjective perceptions (Laura R. Hennessy, 2022), have also received negative feedback (Ayed H. Ziadat, 2021), i.e., that online learning difficulties (Dawson, 2021), and even psychological

problems of dyslexics (Soriano, 2021). In addition, some researchers have verified through experiments or tests that dyslexic people have lower online learning ability (Pang& Jen, 2018; Ziadat, 2021; Zawadka, 2021; Fung, 2022; Alghabban& Hendley, 2022; Shawaqfeh et al., 2020; Dawson, 2021; Andresen, 2019; Laura R. Hennessy, 2022; Anette Andresen, 2018; Eliane Segers, 2018; Lilli Kimppa, 2018; Benmarrakchi, 2021).

Different barriers have been found to cause different distress to learners (Alghabban, 2020). For example, decoding dyslexia affects learners' reading ability and comprehension (Alghabban & Hendley, 2022, July), making it difficult to understand and promptly follow up on texts learned online (15). Dyslexia also affects learners' attitudes (Cain & Fanshawe, 2021), learning experiences (Shawaqfeh et al., 2020), learning outcomes, and others' evaluations (Ziadat, 2021; Ayed, 2021), which can be both mentally and physically stressful for learners (Joanna, 2021), which can be a catalyst for low online learning outcomes.

3.6 Factors and Interventions That Influence the Effect of Dyslexia on the Effectiveness of Online Learning

Once researchers became aware of the difficulties of online learning for dyslexics, the focus of research shifted to the exploration of influencing factors and interventions, and of the 37 papers covered in this article, 29 focused on exploring factors that influence the effectiveness of online learning for dyslexics (Kormos & Nijakowska, 2017; Pang & Jen, 2018; Lebenicnik & Starčič, 2020; Maurer-Smolder et al., 2021; Heraty, 2021; Lerga et al., 2021; Ziadat, 2021; Zawadka, 2021; Shawaqfeh et al., 2020; Politi-Georgousi & Drigas 2020; Thompson &Copeland, 2020; Ibrahim, 2021; Soriano-Ferrer, 2021; Forteza-Forteza, 2021; Ayed H, 2021; Lilli Kimppa, 2018; Eliane Segers, 2018; Anette Andresen, 2018; Shaw, 2022; Andresen, 2019; Dawson, 2021), 18 papers focused on creating measures to intervene online learning for people with dyslexia to enhance learning outcomes and perceptions of learning for people with dyslexia (Alsobhi & Alyoubi, 2019; Novembli & Azizah, 2019; Alghabban et al.,2017; Ventura, 2017; Burac & Cruz, 2020; Fung, 2022; Alghabban & Hendley, 2022; Cain & Fanshawe, 2021; Sari et al., 2021; Cancer et al., 2021; Rodríguez-Cano, 2021; Gyore & Kubinger-Spillman, 2022; Alghabban, 2020; F Benmarrakchi, 2021; Kim M, 2020; Angel Jaramillo-Alcázar, 2021; Bhavana Srivastava, 2020).

3.7 Factors Influencing the Effectiveness of Online Learning for People with Dyslexia

The exploration of the factors influencing the effectiveness of online learning for dyslexics can be divided into two types of internal and external factors; internal factors include the type of impairment (Ziadat, 2021) and psychological characteristics of dyslexics (Zawadka, 2021; Shawaqfeh et al., 2020; Forteza-Forteza, 2021; Soriano-Ferrer, 2021; Shaw, 2022). External factors include teacher factors (Kormos & Nijakowska, 2017; Thompson & Copeland, 2020; Ibrahim, 2021; Kim M, 2020), teaching strategy factors (Maurer-Smolder et al., 2021), online education environment factors (Pang & Jen, 2018; Heraty, 2021) and educational media factors (Lebenicnik & Starčič, 2020; Lerga et al., 2021; Politi-Georgousi & Drigas 2020; Andresen, 2019).

Among internal factors, the type of dyslexic impairment can impact online learning effectiveness (Ziadat,2021). For example, impairment in decoding reading can make it difficult for learners to understand the deeper meaning conveyed by the reading. Moreover, dyslexics experience more significant stress when faced with online instruction (Zawadka, 2021), such as anxiety, depression, and other emotions (Soriano-Ferrer, 2021; Laura R. Hennessy, 2022), even as their sense of self-worth and ability to learn diminishes (Shawaqfeh et al., 2020), and these psychological changes will make learners struggle more in online learning contexts (Forteza-Forteza, 2021).

Among the external factors. Dyslexics feel better about online learning when teachers have higher self-efficacy, adopt inclusive attitudes, and are trained to plan online teaching activities (Kormos & Nijakowska, 2017; Kim M, 2020). Therefore, if teachers and students are trained in advance to understand the basics of online learning platforms (Thompson & Copeland, 2020), and teachers are prepared to apply online learning (Ibrahim, 2021), the online learning of dyslexics can be enhanced. Research in online educational settings has found that video conferencing and forums are superior to text chat for dyslexics (Pang & Jen, 2018; Dawson, 2021) and that giving dyslexics more resources (e.g., audio) can help them learn better online (Heraty, 2021).

Research on educational media factors has focused more on the media tools used by dyslexics. Studies have found that multimedia learning materials are not entirely appropriate for dyslexics because dyslexics learn equally well in the visual and auditory modalities (Lebenicnik & Starčič, 2020). Therefore, assistive technologies should be used to provide practical assistance to dyslexics (Lerga et al., 2021), such as screening and targeted interventions for dyslexics through mobile applications to enhance online learning for dyslexics (Politi-Georgousi & Drigas, 2020; Bhavana Srivastava, 2020), or using Serious Game to influence the cognitive domains of dyslexics (Angel Jaramillo-Alcázar, 2021).

Research on instructional strategy factors, on the other hand, has focused more on traditional instructional cognition. Studies have found that traditional ways of putting in time and effort are ineffective in supporting online learning for dyslexics (Maurer-Smolder et al., 2021). Therefore, traditional instructional strategies are hardly helpful for online learning of dyslexics.
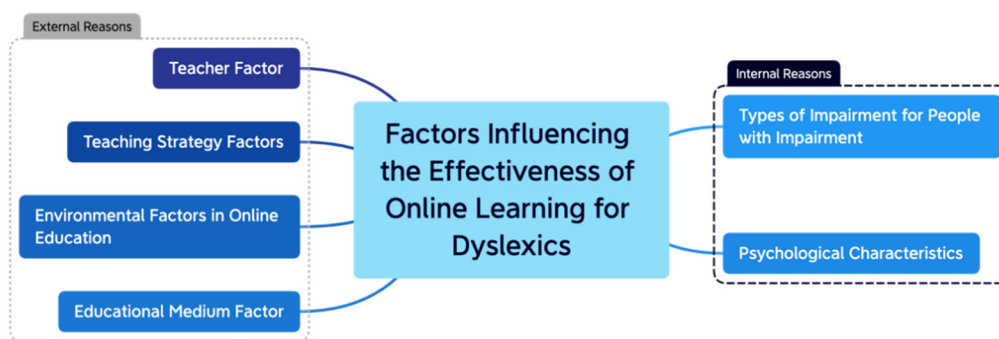
Figure 6. Factor influencing the effectiveness of online learning for Dyslexics

3.8 Interventional Online Education for Dyslexics Conducted

The fundamental difference between online and traditional education lies in the difference in medium. Online education is based on information networks, while traditional education is based on offline classrooms. Therefore, the intervention studies on online education for dyslexics focus on the information network aspect. The interventions can be summarized into three main types of interventions: technological interventions, strategic interventions, and theoretical interventions, where technological interventions are software development-led interventions. Strategic interventions involve developing and implementing intervention strategies for individuals with dyslexia. On the other hand, theoretical interventions involve theory-led interventions that involve the transfer of theory. The three types of interventions are primarily found in a hybrid format.

Among the 18 studies related to technological interventions and strategic measures, 10 were the development of e-learning systems, such as adaptive educational hypermedia systems (Alsobhi & Alyoubi, 2019), mobile learning systems (Novembli & Azizah, 2019; Alghabban et al., 2017), Whats App (Ventura, 2017), personalized reading enhancement app (IREAD) (Burac & Cruz, 2020), portfolio mobile app (Fung, 2022), personalized e-learning system (Alghabban & Hendley, 2022; Bhavana Srivastava, 2020), Learning Management System (LMS) (Cain & Fanshawe, 2021), interactive multimedia (Sari et al., 2021), and virtual reality software (Rodríguez-Cano, 2021).

The development concepts of the systems above can be divided into two types: The first one is a customized system for dyslexics (Alsobhi & Alyoubi, 2019; Burac & Cruz, 2020; Fung, 2022; Alghabban & Hendley, 2022; Sari et al.,2021; Rodríguez- Cano, 2021; Bhavana Srivastava, 2020), i.e., the system is structured and developed according to the needs of the dyslexic person, for example, the adaptive educational hypermedia system is to distinguish the type of impairment of the dyslexic person and to target learning and training to them. The second type is assistive systems for dyslexics (Novembli & Azizah, 2019; Alghabban et al., 2017; Ventura, 2017; Angel Jaramillo-Alcázar, 2021), which enhance the online learning of dyslexics by assisting them in their learning, such as What's App is a platform for dyslexics to ask for help and communicate with each other, so that they can solve the difficulties they encounter in online learning through peer interaction or help from others. However, some researchers have transferred other areas to this study, such as exploring the possibility of enhancing online learning for dyslexics through telerehabilitation medicine (Cancer et al., 2021) or transferring materials and teaching methods from Moodle, a software package for creating online courses or websites, to online learning for dyslexics (Gyore & Kubinger- Spillman, 2022).
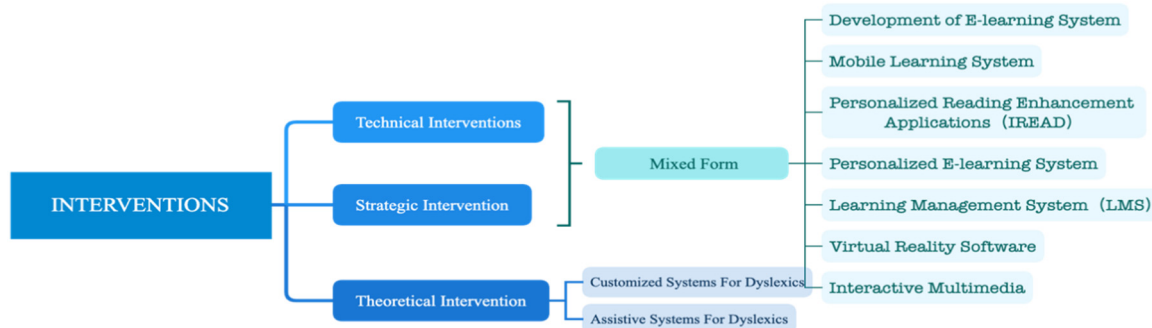
Figure 7. The factor of interventional online education for dyslexics conducted

4. Discussion

There are three main dimensions of research on the effects of dyslexia on online learning. The first one is to explore the specific impact of dyslexia on online learning effectiveness, which is mainly expressed in the form of research on the online learning effectiveness of dyslexic people and the elaboration of the low performance of dyslexic people in online learning. The second one is to explore the causes of the impact of dyslexia on online learning effectiveness and clarify the mechanism of dyslexia affecting online learning effectiveness, mainly from two ways: intrinsic factors, and extrinsic factors. The third one is to explore intervention tools to adapt to dyslexia and enhance dyslexic online learning. These intervention tools are mainly of three types: technological intervention (software development), strategic intervention (developing and implementing strategies), and theoretical intervention (theory transfer). The studies are mainly oriented toward feasibility and practicality and attempt to enhance the online learning ability of dyslexics from a practical perspective. Researchers are fully aware of the problems of dyslexics in the online learning environment and have built a theoretical system based on the logic of "problem formulation-analysis-solution."

Research deficiencies still need to be addressed. For most researchers exploring the impact of dyslexia on online learning effectiveness, the influencing factors will involve the subjective perceptions of the dyslexic person himself or herself and even studies based on first-hand materials provided by the dyslexic person. However, few studies conducted on intervention tools provide psychological help for dyslexics. *What's App* provided a platform for dyslexics to communicate and seek help, but it was a passive type of psychological intervention that required dyslexics to seek help independently and lacked active care for dyslexics.

5. Limitations and Future Research

As the literature review is limited to specific databases, the review does not include information on surveys and other studies of other primary and secondary databases. This approach narrows the scope of information that can be analyzed in the study to the largest and most valuable databases, but it may overlook potentially valuable data. The breadth of research will be increased in future studies, and the number of databases will be increased. For future research, the studies in question lacked a psychological dimension to the interventions regarding resource settings, so that future research may encompass psychological resources into the intervention strategies for dyslexia. In addition, the forms and scope of online education will continue to grow as the informational functions of online education are explored. How to effectively respond to the changes in online education and provide adequate support for dyslexics is also an issue that needs to be explored in future research.

6. Conclusion

Dyslexia can harm learners' online learning activities. Online learning activities are more dependent on the comprehension of learning materials and task-based assessment, and this characteristic undoubtedly puts a great deal of stress on dyslexics both physically and mentally, reducing their self-efficacy and learning effectiveness in online learning. Without the help of scientific teaching strategies, a sound online education environment, appropriate online education media, and teachers, dyslexic learners may have difficulty learning.

Social support for dyslexics should be provided on an ongoing basis, and the online educational environment should be structured so that each person with dyslexia can receive targeted assistance. Teachers should be confident implementing online instruction for dyslexics, prepared for online education, and develop modern, scientifically based educational strategies.

Dyslexics should choose an appropriate online educational medium based on their type of impairment and needs. As can be seen, interventions for online learning for dyslexics require a concerted effort from multiple parties. The psychological interventions for dyslexics have not received much attention in the research on interventions, which is a deficiency. Follow-up research should focus on the psychosocial factors of dyslexics and the operational model of multiparty interventions to improve the study.

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