

CHAPTER I

INTRODUCTION

1.1 Research Background

Reading proficiency is a fundamental skill in literacy development and a critical determinant of academic success. The ability to recognize, decode, and comprehend written text enables children to access knowledge across disciplines and supports their cognitive, emotional, and social development. However, for children with dyslexia, reading becomes a persistent neurocognitive challenge. Dyslexia is a specific learning disorder characterized by difficulties in word recognition, phonological processing, and spelling, despite having adequate intelligence and opportunities for learning. If not addressed through targeted interventions, these challenges often result in decreased reading comprehension, academic underachievement, and diminished motivation (Almgren Bäck et al., 2024; Clement & Tosin, 2025).

Globally, dyslexia impacts a significant proportion of the school-aged population, with prevalence estimates ranging from 5% to 10% (Song & Mao, 2024). The impact extends far beyond academic metrics; children with dyslexia are particularly vulnerable to social stigma, anxiety, and a persistent negative cycle in which early reading difficulties erode self-efficacy, further diminishing their engagement with literacy tasks (Almgren Bäck et al., 2024). Without targeted, accessible, and continuous intervention, these consequences can compound into adolescence and adulthood, ultimately affecting career opportunities and overall quality of life (Clement & Tosin, 2025).

In the Indonesian context, local data from Buleleng Regency, Bali, illustrates an urgent literacy crisis that demands immediate technological intervention. Recent data released by the Buleleng Education, Youth, and Sports Office (Disdikpora) and the Buleleng Education Council for the 2024–2025 period highlights a startling number of students struggling with basic reading skills. Initial findings in 2024 identified approximately 443 junior high school students facing severe reading difficulties. Subsequent verification by Disdikpora in 2025 confirmed that 363

students required special intervention. Specifically, 155 students were categorized as 'Unable to Read' (*Tidak Bisa Membaca/TBM*), while 208 were classified as 'Not Fluent in Reading' (*Tidak Lancar Membaca/TLM*). This alarming data suggests that a significant number of these children may be struggling with undiagnosed specific learning disabilities, such as dyslexia, having progressed through early education without receiving targeted support.

The Bali Dyslexia Foundation (BDF) has played a crucial role in addressing these regional challenges by providing free services aimed at identifying and supporting children with dyslexia. Over the past six years, BDF has trained over 1,987 local teachers in inclusive education methods across 225 government schools in North Bali. Their targeted screening initiative has reached 8,560 children, facilitating early identification and equipping educators with necessary pedagogical tools. Institutional data indicates that schools participating in BDF's programs have seen an average 45% increase in literacy levels among enrolled students. This localized success strongly aligns with international literature emphasizing the efficacy of multisensory and inclusive learning approaches for dyslexic learners (Clement & Tosin, 2025).

Despite the remarkable progress facilitated by BDF, a significant gap remains in providing continuous support for these children once they leave the foundation's structured environment. Field observations reveal that inclusive schools in Indonesia often lack adequate portable assistive technologies. Current advanced learning tools provided within the foundation such as Virtual Reality (VR) systems and interactive smart TVs are highly effective but inherently location-bound. As established by Almgren Bäck et al. (2024) in their five-year longitudinal study, the benefits of assistive technology interventions are highly dependent on continuous access and the sustained availability of tools across different learning contexts. When children return home or attend under-resourced inclusive schools, they lose access to these specialized technologies, disrupting the consistency essential for literacy progress. Furthermore, successful continuous use of assistive technology is shaped not only by the tools themselves but by contextual factors, including teacher support and the development of meaningful learning strategies (Almgren Bäck et al., 2024). This underscores an urgent need for portable, user-friendly tools that

children, parents, and teachers can utilize independently outside of formal institutional settings.

Research consistently demonstrates that integrating Optical Character Recognition (OCR) and Text-to-Speech (TTS) technologies significantly enhances reading accessibility for children with dyslexia. OCR technology converts printed text into editable digital formats, allowing for customizations such as adjusting font, size, spacing, and contrast that reduce visual stress and cognitive load. Meanwhile, TTS provides auditory access to text, helping children bypass phonological decoding barriers and focus entirely on comprehension (Song & Mao, 2024). This bimodal approach (visual text synchronized with audio narration) allows children with dyslexia to achieve comprehension levels comparable to their neurotypical peers (Keelor et al., 2023; Song & Mao, 2024). Furthermore, Iliska and Gudonienė (2025) assert that AI-powered platforms integrating TTS, adaptive learning, and personalized digital libraries represent a highly promising paradigm, as they allow educational content to be tailored to individual neurodevelopmental needs. Nevertheless, most existing assistive reading applications predominantly offer a passive reading model where the child listens to the content but is not required to actively practice reading aloud.

The critical missing component in existing applications is the integration of Speech-to-Text (STT) technology as an active reading practice mechanism. Previous studies have highlighted STT's significant potential in supporting dyslexic learners with text production and active language engagement (Almgren Bäck et al., 2024). Building upon this premise, STT in a reading assistance context can be innovatively repurposed as an automated evaluator. By recording and comparing the child's spoken output against the target text, the system can categorize each word as correctly pronounced, partially correct, incorrect, or missed. This immediate, objective feedback creates an active multisensory loop: the child visually reads an OCR-processed text, listens to the model pronunciation via TTS, practices reading aloud, and receives real-time phonological feedback via STT. This complete Visual, Auditory, and Kinesthetic-Tactile (VAKT) cycle directly addresses the core phonological and fluency deficits of dyslexia. While tools like ReadSmart (Kuerban et al., 2025) and contemporary dyslexia-friendly mobile applications demonstrate a

shift toward interactive models, none currently integrate all three technologies (OCR, TTS, and STT) into a single, Indonesian-language platform tailored for primary school children.

A second critical gap equally vital but largely absent from current applications is the lack of a comprehensive monitoring system for teachers and administrators. Clement and Tosin (2025) emphasize that the effectiveness of assistive technology relies heavily on educators' ability to integrate it into personalized learning plans using data-informed decisions. Without a centralized monitoring dashboard, educators at institutions like BDF cannot track which students are falling behind, identify systematic phonological errors, or measure engagement consistency. This creates a critical break in the intervention loop: data is generated, but remains unactionable. Iliska and Gudonienė (2025) reinforce that effective technology-enhanced learning requires an ecosystem where educational data is visible, actionable, and systematically utilized to adapt pedagogical strategies.

To address these interconnected gaps, this research proposes the development of DyLearn: a multisensory literacy learning application that integrates OCR, TTS, and STT technologies within a single Android mobile platform, complemented by a web-based administrative monitoring system. The mobile application guides children through a comprehensive reading cycle from digitizing printed text and listening to correct pronunciations, to actively reading aloud and receiving automated phonological feedback. The performance data generated during these sessions is synchronized in real time to a secure cloud database and visualized on a web-based dashboard. This ecosystem empowers teachers, therapists, and parents to monitor student progress through structured indicators, including reading accuracy, fluency, precision, and spelling performance. By bridging the gap between institutional interventions and home-based learning, facilitating active practice, and providing actionable data, this research aims to establish a more inclusive, continuous, and evidence-based framework for supporting children with dyslexia in Indonesia.

1.2 Research Questions

Based on the background presented, the following research questions have been formulated:

1. How is the design and development of a multisensory literacy learning application integrating OCR, TTS, and STT technologies tailored to the specific needs of children with symptoms of dyslexia?
2. How is the design and development of a web-based monitoring system to support teachers and administrators in tracking and evaluating the reading progress of children with dyslexia?
3. What is the response of users children with dyslexia and teachers toward the utilization of the developed application and monitoring system?

1.3 Research Objectives

Consistent with the research questions, the objectives of this study are:

1. To design and develop a multisensory literacy learning application integrating OCR, TTS, and STT technologies to support the reading abilities of children with symptoms of dyslexia.
2. To design and develop a web-based monitoring system that enables teachers and administrators to track and evaluate the reading progress of children with dyslexia in a data-driven manner.
3. To analyze the user response of children with dyslexia and teachers toward the developed application and monitoring system.

1.4 Research Limitations

To ensure the research remains focused and does not deviate from its primary objective, the following delimitations have been established:

1. Target Users This study is focused on children aged 6–12 years who exhibit mild to moderate symptoms of dyslexia. This age range represents the critical early stages of reading development during which structured

intervention produces the most significant and lasting improvements in literacy outcomes.

2. **Application Scope and Core Technologies** The application development encompasses three core assistive technologies: (1) Optical Character Recognition (OCR) for digitizing printed text from physical books and PDF documents; (2) Text-to-Speech (TTS) for multisensory auditory reading support with synchronized word highlighting; and (3) Speech-to-Text (STT) for active reading practice and real-time pronunciation evaluation. This research does not encompass the development of a comprehensive reading instruction curriculum or automated psychological assessment of dyslexia severity.
3. **Language and Typography** The application supports Indonesian-language text only. The application integrates two dyslexia-friendly typefaces: *OpenDyslexic* (an internationally recognized font with heavy-bottomed letterforms designed to prevent visual letter rotation) and *TrikaIndoDyslexic* (a font developed specifically for Indonesian children with dyslexia, incorporating visual mnemonic letter shapes aligned with the phonological structure of Bahasa Indonesia). Support for foreign-language texts or non-alphabetic symbols is not included in the scope of this research.
4. **Development Platforms** This research involves the development of two interconnected systems: (1) a mobile application developed for Android-based devices running a minimum of version 8.0 (Oreo), serving as the primary learning tool for children and teachers; and (2) a web-based administrative monitoring panel accessible via modern desktop web browsers (Flutter Web), designed exclusively for administrators to monitor aggregate student progress and manage the public book library.. Development and testing for iOS, macOS, or other non-Android platforms are not included within the scope of this research.
5. **Testing Scope and Scale** Testing is conducted on a limited scale involving a purposive sample of children with mild to moderate dyslexia symptoms, teachers, and administrators. The evaluation includes: (a) functional testing of OCR accuracy, TTS synchronization, and STT evaluation logic (Black

Box and White Box Testing); (b) usability and user experience validation by media and content experts (Gregory Formula validity); and (c) user response analysis using a child-adapted UEQ instrument (*Smileyometer*) for children and a professional UEQ instrument for teachers. Large-scale randomized controlled trials are outside the scope of this study.

6. **Technology Stack** The application utilizes: (1) Google ML Kit Vision API and Google ML Kit Document Scanner for on-device Optical Character Recognition; (2) *flutter_tts* package supporting Indonesian voice output for TTS; (3) *speech_to_text* package (v7.3.0) for real-time STT-based pronunciation evaluation during active reading practice. This package functions as a platform bridge to the device-native Android SpeechRecognizer API, which is powered by Google's speech recognition infrastructure. Studies evaluating Google Speech Recognition on Bahasa Indonesia have documented recognition rates of approximately 88.11%–94.75% under controlled adult speech conditions (Buana, 2024; Uin Malang, 2023). However, it is well-established that ASR accuracy is substantially lower for children's speech due to higher acoustic variability, irregular pronunciation patterns, and developing vocal tract characteristics (The Learning Agency, 2026; Hussain et al., 2024). This performance gap, compounded by the engine's predictive auto-correction behaviour, is formally acknowledged as a research limitation in Section 5.2.; and (4) Gemini LLM strictly as a backend post-processing layer to clean and reconstruct OCR text output. The application does not include AI for automated psychological diagnosis, complex conversational features, or chatbot interactions.
7. **Dyslexia Condition** This study includes only children with dyslexia symptoms without co-occurring complex learning disorders, such as Attention Deficit Hyperactivity Disorder (ADHD), autism spectrum disorder, or other severe neurodevelopmental conditions, to ensure the research findings remain focused on the specific characteristics and intervention needs of dyslexia.

8. **Monitoring System Scope** The web-based monitoring system is developed as a separate Flutter Web application, accessible exclusively to registered administrators. Teachers access student monitoring features through the dedicated Teacher interface within the mobile application. Its scope is limited to: monitoring individual student reading progress (accuracy, fluency, and STT practice performance); managing the public digital book library (approve/reject/edit book submissions); exporting research data to Excel format for academic analysis; and maintaining an audit log of administrative actions. The monitoring system does not include direct clinical intervention tools or medically validated diagnostic assessments.
9. **Multi-Role System** The application implements a three-tier user role architecture: (1) *Student (Siswa)*, who uses the mobile app for reading assistance and STT practice; (2) *Teacher (Guru)*, who can upload books to the public library, link with students through a secure pairing code mechanism (DYL-XXXXXX), and conduct supervised reading sessions; and (3) *Administrator (Admin)*, who manages the web monitoring panel. The pairing code mechanism is limited to establishing supervised learning sessions between teacher and student accounts and does not constitute a clinical or diagnostic relationship.

1.5 Research Significances

The contributions of this research are as follows:

A. For Researchers

1. To contribute to the advancement of knowledge in educational technology and software engineering by presenting an innovation in the design and development of a multisensory assistive application integrating OCR, TTS, and STT technologies specifically for children with dyslexia in an Indonesian-language context.
2. To expand existing literature on the integration of Speech-to-Text (STT) technology as an active reading practice and real-time phonological evaluation tool in assistive applications for children with special educational needs, particularly dyslexia.

3. To contribute to the growing body of research on web-based monitoring systems for inclusive education, demonstrating how data-driven dashboards can improve the quality of teacher intervention decisions for students with dyslexia.

B. Practical Contributions

1. *For Children with Dyslexia:* To provide an accessible, portable, and motivating multisensory learning companion that supports the full reading cycle from digitizing text (OCR) and listening to model pronunciation (TTS), to practicing reading aloud and receiving immediate phonological feedback (STT) thereby reducing dependence on constant human assistance and fostering greater reading independence and self-efficacy.
2. *For Teachers and Therapists:* To provide a supervised reading companion tool and monitoring dashboard within the mobile application for guided sessions with students, enabling teachers to view individual student radar charts, common pronunciation mistakes, and reading duration through the StudentAnalyticsScreen on their mobile device.
3. *For Educational Administrators and Researchers:* To provide a centralized web-based monitoring system that aggregates student learning data across multiple users, facilitates digital book quality control through a community peer-voting mechanism (*Juri Cilik*), and enables structured data export for academic research, institutional reporting, and educational policy-making purposes.
4. *For Educational Institutions:* To supply a supplementary, technology-enhanced learning medium that can be integrated into inclusive educational interventions for students with dyslexia, reducing the resource burden on teachers while increasing the quality and consistency of support available to each child.

C. Social Contributions

1. To support educational inclusivity in Indonesia by providing a technological solution designed to assist children with special learning needs, enabling

them to engage more confidently in academic activities and social interactions with their peers.

2. To reduce the gap in educational technology access for children with dyslexia in regions with limited specialist resources, such as Buleleng Regency, Bali, by providing a portable, offline-capable tool that functions independently of institutional infrastructure.

