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Effect of Mobile Application Mediated Learning in Literal Reading for Students Diagnosed with Cerebral Palsy Literacy

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ABSTRACT
This experimental study evaluates the effectiveness of the mobile application, *bacakanbuku*, in promoting literacy development among children with cerebral palsy who also experience intellectual challenges. The application provides leveled narratives designed to support word recognition and literal comprehension. Using a one-group pretest–posttest design with 11 participants, the study administered assessments before and after the intervention to determine the application's impact. A paired-sample ANOVA was employed to analyze the data and assess improvements in word recognition and literal comprehension. Findings reveal that repeated interventions can enhance both skills, suggesting that the application is a reliable tool for children with special needs. However, the study acknowledges limitations related to unmeasured factors that may have affected participants' developmental progress. Overall, the results highlight the importance of word recognition, word count, and oral comprehension for students with cerebral palsy, highlighting the value of frequent read-aloud activities with clear intonation and contextual emphasis. The audiobook feature within *bacakanbuku* aligns well with the needs of elementary-age learners with cerebral palsy, and the study's novelty lies in implementing an Android-based audiobook platform tailored for this population.

KEYWORDS
Mobile Application; cerebral palsy; literacy development; word-recognition; literal comprehension.

INTRODUCTION

Cerebral palsy (CP) primarily affects mobility and posture (Craig, et. al., 2021; Sankar & Mundkur, 2005), with students experiencing muscle control impairments that hinder movement and body positioning (World Health Organization, 2004). The term cerebral refers to the cerebrum, the area of the brain involved, and CP is classified according to the location and severity of the brain injury, the body regions affected, and the type of motor tone irregularities present, including spasticity, dyskinesia, ataxia, and mixed forms (Allen et al., 1983). Rosenbaum et al. (2006) report that approximately 20% of children with CP exhibit severe symptoms accompanied by communication impairments, making it challenging for teachers to provide support that extends beyond these limitations. CP students may also experience cognitive and attentional difficulties (Rosenbaum et al., 2006), which restrict their ability to engage in essential cognitive processes such as attention, learning, problem-solving, and decision-making. These challenges directly affect word recognition, the retention of current information, and the acquisition of new knowledge (Craig et al., 2021). CP is a neuromotor condition that primarily affects the motor system, muscle tone, and postural development in children (Mehmood et al., 2024). Its impact varies according to individuals' mobility challenges, the specific bodily regions involved, and the severity of impairment.

CP is associated with functional limitations across cognitive, self-care, mobility, and social domains (Asbell et al., 2010; Mehmood et al., 2024; Tzuriel, 2013). International consensus defines CP as a group of persistent mobility and postural disorders that restrict activity and stem from nonprogressive disturbances in the developing fetal or immature brain. These motor impairments often co-occur with sensory, perceptual, cognitive, communicative, and behavioral difficulties, in addition to epilepsy and secondary musculoskeletal complications (Patell et al., 2020). CP arises from brain injury or atypical brain development linked to disruptions during prenatal, perinatal, or postnatal stages (Salfi et al., 2019), resulting in deficits in mobility, coordination, balance, and posture (Tzuriel, 2011). Globally, 1.5 to 4 per 1,000 live-born infants are diagnosed with CP. Prevalence estimates range from 1 to 5 per 1,000 live births in Indonesia, and in the United States, one in four children with CP does not achieve basic reading proficiency by eighth grade (Mardiani, 2006; Salfi et al., 2019). CP is caused by brain injury or abnormal brain development, with the neurological damage producing physical effects that disrupt balance, coordination, posture, and movement (Peláez-Sánchez & Velásquez-Durán, 2023). The three primary forms of CP—spastic (70–80%), dyskinetic (10–20%), and ataxic (5–10%)—may also appear in combination (Miller et al., 2015). Children with CP frequently experience additional conditions such as seizures, intellectual impairments, and a range of functional challenges, including difficulties with chewing, swallowing, speaking, communication, vision, hearing, perception, growth, dental health, digestion, sleep, learning, and behavior (Arciuli & Bailey, 2019; Bernardini et al., 2014; Bílková et al., 2022; Critten, 2013). Although many students exhibit severe physical and speech impairments, they continue to acquire individual vocabulary and related subskills, yet comprehension of connected text has historically received limited attention (Brown, 2014; Sanberg, 1998). Although research on CP continues to expand, limited evidence exists on how age-appropriate language and reading skills relate to working memory capacities in children with CP (Loewen et al., 2020; Peláez-Sánchez & Velásquez-Durán, 2023).

Prior studies indicate that reading comprehension is a persistent challenge for students with CP (Asbell et al., 2010; Critten, 2013; Patell et al., 2020), with school exposure and home literacy environments affecting outcomes (Patell et al., 2020). Children with CP who rely on augmentative communication often demonstrate significantly delayed or absent reading and spelling development, progressing far below expectations given their intelligence and vocabulary. Difficulties with reading, phonological awareness, and reading acquisition are also common (Asbell et al., 2010). Approximately 59% of children diagnosed with CP experience challenges in reading, writing, or mathematics (Micheletti et al., 2024). Those with both CP and learning impairments show weak working memory, normal phonological awareness, and low performance IQs, whereas children with CP alone tend to exhibit mild working memory difficulties, reduced phonological awareness, and typical performance IQ, with no differences observed between groups in linguistic intelligence (Asbell et al., 2010; Micheletti et al., 2024; Patell et al., 2020). This study examines the reading literacy of elementary school children with CP in Indonesia and addresses a theoretical gap in prior research, which has shown that students with cerebral palsy in secondary school have not received reading interventions aimed at improving text comprehension and word recognition. A further gap concerns the limited knowledge base surrounding effective instructional practices for students with CP, as opportunities for developing expertise in educating this population remain restricted within the Indonesian context.

Our argument centers on supporting children with CP in understanding what they read, as their experiences highlight persistent challenges with word meaning and text interpretation. During reading activities, instruction emphasizes recognizing words and grasping their meanings, and the intervention is delivered through a workshop that provides strategic hints to help students infer meaning from the text. Patell et al. (2020) and Williams and Subasno (2020) note that individuals with cerebral palsy vary in their mobility, with some requiring occasional assistance and others needing continuous support, and intellectual disabilities further limit certain functional abilities. Additional conditions such as epilepsy, vision loss, and hearing impairments may also occur. Although treatments can enhance quality of life, they do not cure CP. Symptoms may change as children grow, but the condition itself does not worsen, remaining relatively stable over time (Mehmood et al., 2024; Umek et al., 2005). CP is one of the most challenging disabilities for educators, reading specialists, and researchers, as much of the existing knowledge on reading diagnosis, instruction, and remediation does not apply to individuals with severe multiple disabilities. Many children with severe CP remain nonliterate (Mehmood et al., 2024; Patell et al., 2020), creating substantial barriers because reading often represents their primary pathway to social participation. Meaningful engagement requires communication, and individuals with significant speech impairments must rely on written language or communication technologies as substitutes for spoken speech, both of which typically require foundational literacy skills (Critten, 2013). Critten (2013) notes that limited knowledge exists on how to teach reading to children with severe CP, presenting a important instructional challenge. Encouragingly, a study involving 22 adults with serious physical and speech impairments, including CP, found that they were able to read and write and provided detailed accounts of how they acquired literacy skills, offering rare insight into the connection between CP and literacy development (Shadiev et al., 2018). Surprisingly few participants attributed their literacy success to school-based instruction, instead emphasizing their own determination along with parental support and high expectations (Ehri & Snowling, 2004). Although substantial instructional time was provided, Michelitti (2024) reported that students with severe speech and physical impairments primarily learned individual words and subskills, with limited emphasis on connected-text reading. He also observed minimal group work and frequent teacher–student interactions. A related study on writing instruction for students with similar disabilities found the training beneficial (Muller et al., 2015), yet students had limited opportunities to produce their own written work due to the high degree of teacher control over the learning process. This study contributes to classroom-based literacy research by building on the work of instructional and cultural overview of a CP classroom that shape literacy learning. Tzuriel (2011, 2013) found that children with cerebral palsy struggle to acquire alphabet names and sounds, and often have difficulty retaining common sight words such asthe, and, andwe. These challenges extend to copying or reproducing letters, as students frequently cannot perceive or follow the shapes of the letters accurately. Umek et al. (2005) and Patell et al. (2020) agree that writing difficulties may occur among children with general learning disabilities, yet note that students with CP tend to experience fewer challenges in subjects like science and history, which rely on analysis and problem-solving rather than literacy-specific skills. At the same time, we argue that narrative sharing in the classroom can help students with CP overcome reading and spelling challenges, particularly those related to phonological awareness (Michelitti, 2024; Muller et al., 2015; Sanberg, 1998). Mobile devices have been shown to enhance academic performance, and before their widespread use, literacy was a strong predictor of learning success (Listanto & Firmansyah, 2022; Stern et al., 2018).

Children in early developmental stages require consistent literacy activities, and since the introduction of digital tools, many studies have examined how technology supports literacy development among school-age learners (Machumu et al., 2024; Mohamed Sapawi et al., 2025; Moldagali et al., 2024). Mobile technology has enabled the digitization of literacy programs, and the intervention developed in this study aligns with the needs of children growing up in a digital environment. Mobile tools have assisted educators and supported literacy growth (Ekeh, 2024; Ermerawati, 2019; Loewen et al., 2020; Peláez-Sánchez & Velásquez-Durán, 2023; Segaran, 2014), and several applications have been designed to help children with special needs develop reading and writing skills (Arciuli & Bailey, 2019; Bernardini et al., 2014; Bílková et al., 2022; Sivrikaya et al., 2023; Timberlake, 2020). However, few studies have examined the use of mobile devices specifically to support reading development in individuals with disabilities such as cerebral palsy. This gap presents a new research opportunity. The background of this study, therefore, explores the central topic and informs the development of research questions and methodology. The present study investigates how effectively *bacakanbuku* ("read me the book") improves reading recognition in children with CP and is guided by the following research questions:

1. How does mobile application–mediated learning shape the reading literacy of students diagnosed with cerebral palsy?

2. How does mobile application–mediated learning improve literacy outcomes in students diagnosed with cerebral palsy, specifically in word recognition and literal reading comprehension?

LITERATURE REVIEW

Existing research on teaching children with CP shows that reading literacy is closely connected to predictors of reading potential (Asbell et al., 2010), literacy development patterns (Critten, 2013), clinical factors (Patell et al., 2020), and reading and spelling abilities observed in instructional settings (Sanberg, 1998). However, in Indonesia, limited research focuses on specific instructional strategies designed to improve the reading skills of children with CP. Most available studies address general approaches to reading instruction or broad therapeutic interventions rather than targeted methods for enhancing literacy among CP readers.

Literacy for Cerebral palsy

The type of CP a student experiences considerably affects their literacy development. Following Patell et al. (2020), we define CP as a neuromotor disorder that primarily affects the motor system, muscle tone, and postural development, arising from brain injury or abnormal brain formation. Although neurological in origin, the condition produces physical effects that hinder balance, coordination, movement, and posture. CP is commonly categorized into three primary forms—spastic (70–80%), dyskinetic (10–20%), and ataxic (5–10%)—with some children exhibiting mixed types. Many also experience additional conditions such as seizures, intellectual impairments, and challenges related to chewing, swallowing, speaking, communication, vision, hearing, perception, growth, dental health, digestion, sleep, learning, and behavior (Ehri, 2005; Frith, 1985). Research on the literacy development of students with CP shows that many children can recognize familiar emotive words or logos—such as their names, a favorite café, or a cartoon character—before they can identify individual letters (Ehri, 2005; Frith, 1985). Studies examining letter and logo colors and shapes have found that visual changes often prevent children from recognizing the same word. As children progress, they begin to learn letters, including initials, and form phoneme–grapheme associations (Ehri, 2002), sometimes identifying their names within longer words. However, they often struggle to retain whole words without distinctive visual cues or contextual placement, such as labels above coat pegs (Ehri, 2005). Over time, children develop stronger phoneme–grapheme links and may decode CVC words by sounding out letters, marking the emergence of alphabetic, full-alphabetic, or sequential decoding stages (Ehri, 2005; Frith, 1985; Marsh et al., 1981). They also begin constructing words by blending and articulating sounds (Ehri, 2005). Frith (1985) argues that early writing and spelling experiences reinforce letter–sound knowledge and strengthen both sight-word reading and sequential decoding skills (Marsh et al., 1981). Experts remain uncertain about whether children rely more on visual cues or phoneme–grapheme strategies when decoding words (Ehri, 2005). Children with CP do not consistently progress through the typical stages of analogy building, spelling and decoding development, or forming connections between larger word units such as syllables and morphemes (Ehri, 2002; Frith, 1985; Marsh et al., 1981). In addition to blending phonemes and sounds to form whole words, developing a repertoire of sight words is essential, especially given the many irregularly spelled words in English. According to Ehri (2005), Ehri and Snowling (2004), proficient readers tend to recognize whole words by sight rather than decode them, and they read real words much more quickly than nonwords, which still require decoding.

In reading development, text comprehension is as essential as decoding (Hulme & Snowling, 2009; Nation, 2005), yet many children excel in one area while struggling in the other. Ehri (2005) suggested that curriculum designers and teachers should simply provide texts for children to interpret rather than teach reading through context or visual cues, but this perspective overlooks the importance of enjoyment and skill-building in the reading process. Many struggling readers focus heavily on decoding and therefore have less opportunity to enjoy or comprehend what they read. Effective engagement with text requires sufficient decoding fluency, and children often become frustrated when their accuracy drops below 90% because they cannot decode quickly enough (Ehri & Snowling, 2004). Caravolas et al. (2001), in a longitudinal study of spelling and reading, found that frequent reading strongly predicts reading improvement, indicating that children become better readers as they read more. To encourage this process, reading must be both successful and enjoyable (Smith et al., 2012). Children with CP often exhibit difficulties similar to those observed in children with dyslexia, leading researchers to identify connections between the two groups (Clendon et al., 2021; Fiske et al., 2006; Horberg, 1990). Although some interventions for CP have shown positive outcomes, additional challenges—such as poor visual perception (Novak et al., 2013) and limited spatial awareness (Kern & Friedman, 2018) —may further hinder reading and writing development. These challenges raise important questions about whether children with CP who can speak nonetheless experience specific neurological or cognitive impairments that affect their literacy learning. CP affects muscle tone, posture, and movement as a result of fetal brain injury or abnormalities in brain development, with symptoms typically appearing in early childhood. The condition disrupts muscular control, leading to movement difficulties, and may also influence nearby brain regions and their functions. Importantly, not all individuals with CP have intellectual disabilities, and the condition varies widely in movement patterns, affected body parts, physical presentation, behavioral features, and non-motor symptoms. Children with CP may miss developmental milestones, particularly those related to movement and other foundational skills (Asbell et al., 2010; Critten, 2013; Patell et al., 2020). Table 1 presents the major types of CP along with their subtypes.

Table 1.

Types of Cerebral palsy

General Type of Cerebral Palsy	Subtpye of cerebral palsy
1. Spastic: Tightness and spasms of muscles.	**Movement CP**
2. Dyskinetic: Problems with muscle control.	1. Diplegic, with more damage to the arms than the legs.
3. Mix: Blends dyskinetic and spastic characteristics.	2. Quadriplegic, meaning all limbs are affected.
	3. Having more damage to one side of the body than the other, hemiplegic
	4. One limb is affected by monoplegia. legs that are paraplegic.
	Non-movement
	1. Microcephaly and macrocephaly are changes in the size of the head.
	2. Babies with CP may be fussy or irritable a lot of the time.
	3. Lack of interaction: babies and kids with CP might not react to other people.
	4. Hypotonia: Loss of muscle tone that makes parts of the body look "floppy," which can lead to stiffness or dystonia.

Students with CP frequently present with lower IQ scores, though this varies widely across individuals. IQ reflects a person's reasoning abilities and is assessed through tasks that measure memory, pattern recognition, and problem-solving. In this study, cognitive classification follows the Stanford–Binet criteria, as shown in Table 2.

Table 2.

Scale of Mental Retardation IQ

No	IQ Range	Classification
1	71 to 84	Borderline
2	50-55 and 70	Mild mental retardation
3	35-40	Moderate mental retardation
4	Between 20 or 25	Severe mental retardation
5	Below 20 or 25	Profound mental retardation

In Table 3 below, we serve comparison among exceptional IQ, normal, and mental retardation to give comprehensive perspectives on the classification of IQ.

Table 3.
Criteria of IQ: Exceptional, Generic, and Mental Retardation (Standford Binet and American Standard)

	Exception		Generic Criteria		Mental Retardation	
No	**IQ Range**	**Classification**	**IQ Range**	**Classification**	**IQ Range**	**Classification**
1	180 and up	Profoundly gifted	130 up	Very superior	71 to 84	Borderline
2	160 to 179	Exceptionally gifted	120-129	Superior	50-55 and 70	Mild mental retardation
3	145 to 159	Highly gifted	90–109	High Average	35-40	Moderate mental retardation
4	130 to 144	Moderately gifted.	90–109	Average	Between 20 or 25	Severe mental retardation
5			80–89	Normal or average	Below 20 or 25	Profound mental retardation
6			70–79	Borderline		
7			69 and below	mentally defective		

Children with cerebral palsy have equal right to develop their literacy

Children with CP have the same right to literacy as all other children, and many can learn and thrive with appropriate support. However, a range of motor and postural impairments can limit their participation in learning activities, stemming from non-progressive brain abnormalities occurring during fetal or early childhood development (Sadowska et al., 2020). To determine the suitability of a learning intervention, CP must be classified by motor dysfunction—such as spasticity, ataxia, dystonia, or choreoathetosis—and by anatomical distribution. CP may also involve seizures, musculoskeletal problems, and sensory, perceptual, cognitive, behavioral, and communication challenges (Martinec et al., 2021; Patell et. al., 2020). Beyond mobility difficulties, intellectual impairments can further restrict children with CP from accessing regular schooling and acquiring foundational cultural skills such as literacy and numeracy.

To provide equitable learning opportunities, effective interventions are essential to support the literacy development of children with CP so that it aligns more closely with that of their peers. Literacy skills are critical because they strongly predict academic success. Numerous studies show that children with special needs are likely to experience developmental delays due to their limitations (Carter, 2017; Elton-Chalcraft, 2016; Tonegawa, 2022). These delays may result from various factors, including intellectual challenges that severe speech impairments that restrict clear oral responses (Fiske et al., 2020); slow reading speed and hinder comprehension (Nurwahidah et al., 2021); family-related factors, such as limited parental resources or support, which can further impede educational progress (Pereira et al., 2016), and posture and motor impairments that make it difficult to turn pages or maintain a seated reading position (Yuniarti & Subasno, 2022); To improve learning conditions for children with exceptional needs, particularly those with CP, this study introduces a new approach to supporting literacy development (Tzuriel, 2013). A mobile application replaces traditional printed books with digital texts and substitutes read-aloud activities with listen-and-read-aloud features (Michelitti et al., 2015). The app also strengthens word-recognition skills to support children in learning new words and their meanings, and it includes a literal comprehension component designed to assess how well students understand the meaning conveyed by written text (Shadiev et al., 2018).

Mediated Learning

Mediated learning is a responsive social link between teacher and learner that enhances the student's educational experience. It begins with classroom exchanges in which teachers actively guide students' thinking and engagement (Feuerstein et al., 2002; Tzuriel, 2011). As an intervention approach, mediated learning aims to improve learning outcomes by positioning the teacher as a mediator who supports the student's learning while also identifying the learner's potential strengths and weaknesses throughout the process (Tzuriel, 2013). Cognitive development in early childhood begins through natural interactions between parents and children and later progresses through more structured exchanges with peers and teachers. Within families, learning and cognitive growth occur organically, with mediated learning experiences (MLEs) playing a key role in shaping children's cognitive modifiability—their capacity to alter mental structures and learn from new experiences (Feuerstein et al., 2002; Tzuriel, 2011, 2013). MLE processes transform the quality of interaction between mediator and student by intentionally guiding how the child perceives, interprets, and responds to learning situations. Over time, these mediated experiences become internalized and form an integrated mechanism through which the child continues to adapt and develop cognitively (Tzuriel, 2013). A core principle of MLE theory is that individuals learn through two primary modalities: mediated learning experiences and direct stimulus exposure. Direct exposure refers to unmediated interactions between a person and environmental stimuli. In contrast, mediated learning occurs when an experienced adult—often a parent—intervenes between the child and the surrounding stimuli to intentionally support and shape learning (Feuerstein et al., 2006). The MLE model consists of four components—Stimuli, Human, Organism, and Response—as illustrated in Figure 1.

Figure 1 operates as follows: the stimulus (S) is first directed to the human mediator (H), who then conveys it to the organism (O). The mediator modifies the stimulus in multiple ways to ensure it is presented to the child in a form that can be effectively processed. This involves adjusting the frequency, order, intensity, and context of the stimuli to spark curiosity, increase alertness, and enhance perceptual awareness. Through these modifications, the mediator aims to strengthen or develop the cognitive functions required for understanding temporal, spatial, and cause-and-effect relationships (Feuerstein, 2013). This study defines mobile learning (or M-learning) as the use of mobile applications to access online, blended, and laboratory-based learning environments.

Figure 1.

Mediated Learning Experience Model (Feuerstein, R, Rand, Y. & Feuerstein, R. 2006).

S - H - O - H - R

Multi-device applications allow teachers greater flexibility in determining when and where students learn, while also enabling instruction to be tailored to each learner's needs and abilities (Patell et al., 2011, 2013; Shadiev et al., 2018). Grounded in Vygotsky's view that tools and signs mediate human action within sociocultural and historical contexts, this approach recognizes that all human activities—including thinking—are shaped by socially constructed mediational tools. In mediated learning, questioning rather than answering is often emphasized, as mediators aim to stimulate students' reflective thinking about classroom tasks by encouraging them to consider how and why they arrive at their conclusions (Asbell et al., 2024; Petell et al., 2020). Mediated learning places greater emphasis on cognitive processes than on outcomes, prioritizing the exploration of how and why learners think rather than simply what they produce. By doing so, it shifts learners from passive recipients of information to active participants in their own development. No individual needs to remain constrained by challenges in behavior, academics, or life skills, as each new learning experience enables the formation of alternative neural pathways that support growth and success (Martined et al., 2021). This approach benefits all family members, as mediated interactions can promote positive change across contexts. Parents, in particular, play a crucial role in initiating meaningful developmental progress. Overall, mediated learning provides a framework capable of fostering lasting and beneficial transformation. Feuerstein (1921) and Vygotsky (1896–1934) are foundational theorists in the study of mediated learning, which enhances student learning through intentional, socially guided interactions between teachers and learners. Both scholars draw on sociocultural psychology to understand intelligence and cognition while acknowledging the biological underpinnings of human development. They view mediated learning as essential for adaptation and success. Feuerstein distinguishes between Piagetian cognitive operations and Vygotskian cognitive functions, positioning the latter as prerequisites for higher-order thinking. Both theorists emphasize the internalization of skills through mediation, using scaffolding or apprenticeship models to support learners' cognitive growth. As students develop self-regulation, independence, and creativity, mediated learning can shift the teacher's role from a provider of knowledge to a facilitator of learning (Umek et al., 2005). Mediated learning is also reflected in everyday digital tools such as banking apps, email clients, social media platforms, and gaming environments. These technologies support users in accessing information—such as news or weather—and completing tasks including travel planning and online shopping (Tzuriel, 2011, 2013). Mobile application development itself relies on a wide range of programming languages and frameworks (Feuerstein, 2006). Figure 2 illustrates the general process of mediated learning.

Figure 2.

Typical Process to create mediated learning

1. Asking learners questions instead of providing solutions. Mediators stimulate "thinking."
2. Encouraging students to weigh the importance of lessons or tasks. "How and why?"
3. Taking advantage of educational opportunities when children show curiosity through questions or body language.
4. Requesting analogies or asking them to explain in their own terms.
5. Asking process questions to foster logical thinking in children.
6. Helping kids develop and implement plans to overcome challenges.
7. Assisting children in arranging, deciding, and evaluating possibilities.
8. Helping kids with disinterest, opposition, memory issues, or distractions in learning.
9. Helping gifted students who have challenges in other areas of study or conduct.
10. Helping children with weaknesses in writing, reading, numeracy, verbal communication, and self-expression.
11. Supporting children with goal-setting, planning, and focus issues.
12. Assisting individuals experiencing anger, depression, or anxiety.
13. Working with interpersonal issues or attachment disorders.

Story Telling

Storytelling is a classroom reading activity in which students retell texts or narratives they have read using their own language, with an emphasis on vocabulary development and word recognition (Mello, 2021). It involves conveying a narrative through spoken or physical expression (Craig et al., 2021), with the storyteller drawing on a narrative framework and employing dramatic and cognitive imagery to engage listeners, eliciting both verbal and nonverbal responses (National Council of English Language Teachers, 1992). Storytelling is grounded in four key principles: perspective, characterization, narrative structure, and conflict. Perspective refers to the narrator's point of view, characterization involves creating compelling and relatable characters, the narrative structure outlines the sequence of events, and conflict represents the central struggle within the story. Together, these elements form the foundation of all narratives (Craig et al., 2021). Students with low reading and writing proficiency can be supported and motivated to engage in storytelling activities (National Council of Teachers of English, 1992). In this context, storytelling is defined as conveying a narrative to one or more listeners through speech, body language, and interactive cues. A well-structured story typically includes five elements: the protagonist, the setting, the conflict, the climax, and the conclusion, along with an understanding of the story's emotional tone. To sustain engagement, stories often follow the traditional five-act structure of exposition, rising action, climax, falling action, and resolution. Storytelling can be expressed in multiple forms: verbally, in oral performance settings, visually, through writing, and in digital or online formats (Craig et al., 2021; National Council of English Language Teachers, 1992). Mello (2001) explains that storytelling incorporates narrative structure, dramatic and mental imagery, and expressive elements such as voice, eye contact, gestures, facial expressions, and interaction to connect a story with its listeners. Through vocal expression and gesture, the storyteller conveys meaning, while the audience responds—by smiling, gazing, or squinting—providing immediate feedback on the effectiveness of the performance. According to Craig et al. (2021), storytelling depends on active participation from both teller and listener, fostering social engagement and collaboration that enhance literacy learning. Mello (2021) also describes storytelling as a means of introducing content related to the real world, including diverse cultures, traditions, and values. Although Mello (2001) positions storytelling as an alternative to traditional read-aloud activities, reading aloud remains central within storytelling practice; it requires students to articulate the narrative and often summarize it for the class. This approach can increase creativity and supports learners who struggle with communication, as repeated reading strengthens familiarity and confidence.

METHODS

Research Design

This study employs a quantitative research design using a One Group Pretest–Post-test Design, which involves assessing a single group before and after treatment without the use of a comparison group (Creswell, 2014). Measurements are collected prior to the intervention and again afterward. Experimental research allows investigators to manipulate independent variables and observe changes in dependent variables that result from this manipulation (Ary et al., 2018). In this study, the independent variable is *bacakanbuku*, the reading material used as the treatment following the pretest, while the dependent variables are reading comprehension and word recognition. Conducted in a classroom setting, the study treats students as research participants in accordance with Creswell's (2014) definition of an experiment as a method for evaluating how a concept, practice, or process influences an outcome. Table 2 presents the adapted research categories from Campbell and Stanley (2015) used to structure this study's design.

Table 4.

Research Design

Group	Pre Test	Treatment	Post Test
E	$Y_{1(a)}$	X	$Y_{2(a)}$
	$Y_{1(b)}$	X	$Y_{2(b)}$

Where:

E = Experimental Group

$Y_{1(a)}$ = pretest for word-recognition

$Y_{2(a)}$ = post-test for word-recognition

$Y_{1(b)}$ = pretest literal comprehension

$Y_{2(b)}$ = post-test for literal comprehension

X = treatment

The experimental research is carried out in two phases: the first assesses word recognition and the second evaluates literal reading comprehension, both using a pretest–post-test design. The procedures are as follows:

- A pretest was administered to evaluate students' word-recognition abilities prior to the intervention.
- The *bacakanbuku* application was used to deliver the experimental treatment, which consisted of four one-hour sessions. Timing was adjusted flexibly to accommodate the individual needs of each student receiving specialized support.
- Students selected two treatments using 5-line stories and two using 8-line stories from the four available options. Before beginning, the researcher guided participants in navigating the application and provided exercises prepared by the classroom teacher.
- Each participant completed eight sessions involving activities such as answering literal comprehension questions, engaging in word-recognition games, and listening to audiobooks. Session timing remained flexible to fit each participant's specific circumstances.

A post-test was administered to determine the extent to which the application improved students' literacy abilities.

Context of the study

This study was conducted because no existing media adequately supported literacy learning for children with CP. In response, an innovative read-aloud approach was adapted into a mobile-mediated literacy intervention that incorporated a listen-to-read-aloud format with an audiobook feature. This feature was designed to help children with CP develop reading and writing skills despite challenges related to balance, motor function, and cognition. The audiobook allowed students to hear stories read aloud by an adult in real time, and each story segment was accompanied by illustrations to support comprehension. The narratives featured characters with disabilities and included moral themes intended to motivate children with similar experiences. All stories were presented in Indonesian, the children's second language, which they commonly use at home and in school. Figure 3 shows the audiobook used in this study.

The application, *bacakanbuku*—meaning "read me the book'' —is designed primarily to support read-aloud–based literacy development. Figure 1 presents the app's content flow, beginning with the branding screen, followed by user registration or login. The interface provides two categories of stories, consisting of 5-line and 8-line texts, which are appropriate for children with CP who may experience difficulties such as limited concentration (Swanson & Ashbaker, 2000). After selecting a category, users tap a cover page to choose a story and may either read it independently or listen to the narrated audiobook. Word-recognition practice is offered through a quiz in which users match images to corresponding words, all drawn from the story. A separate quiz assesses memory of narrative details by requiring children to pair language with the correct illustrations. These tasks measure the user's ability to recognize words and comprehend text, and scores are generated based on the accuracy of responses.

Figure 3.

Story telling audiobook

Setting and Participants

The study was conducted at a private school in Surabaya, Indonesia, that serves children with special needs. The school provides personalized instruction to accommodate a wide range of cognitive and physical abilities and offers educational programs from early childhood through vocational levels. This research focused on elementary-aged students between 7 and 13 years old. Permission to conduct the study was obtained from both the school administration and the affiliated research institution. The school was selected because it actively implements the School Literacy Movement, mandated by Regulation Number 21 of 2015 from the Indonesian Ministry of Education and Culture, which requires schools to foster a strong reading culture to improve national literacy levels. Despite its commitment, the school faces challenges in meeting the diverse needs of each student. The participants in this study were students with CP enrolled at the school. At the time of data collection, they were in grades three to five and between 10 and 13 years old. Eleven students were selected to take part in the study, and parental consent was obtained through signed consent forms. Participant details are summarized in Table 5 (see appendix).

Table 5 presents all participants identified as having multiple special needs, including CP and accompanying intellectual disabilities. Health records from the school clinic indicated IQ scores ranging from moderate intellectual disability to borderline intellectual functioning. Common learning challenges included difficulties with fluent reading, word recognition, and short-term memory retention. As a result, the use of photographs, illustrations, images, and realia is highly advisable when introducing new material in the classroom. Participants also demonstrated limited comprehension of texts they read or heard and required frequent repetition to support recall.

Research Instruments

This study employed a literal reading test consisting of ten items. Each item assessed two aspects: students' intonation when reading one or two selected words and their ability to state the meaning of a term in *Bahasa Indonesia*. During the intervention, the researcher used five themes derived from the storytelling materials. Formal item analysis was not conducted; instead, each test item was selected directly from statements presented in the storytelling sessions. A scoring system was applied to evaluate correct word pronunciation in the word-recognition component as well as accurate interpretation of the sentences provided by the researchers.

Data Collection and Analysis

The experimental study was conducted from August to October 2023. Because classroom teachers would be directly assisting students in using the app for literacy activities, the first step involved training them in data-collection procedures. Figure 4 depicts the classroom setting in which the pretest was administered. The pretest took place in a quiet environment to minimize student awareness that their word-recognition and literal comprehension abilities were being evaluated. Using scaffolding strategies, teachers read aloud a printed version of the story, then prompted students to match words with corresponding images, followed by literal comprehension questions to assess vocabulary understanding. Some students had difficulty speaking; in these cases, when presented with two options, they indicated their answers by nodding. The researcher documented this process to ensure accurate interpretation of students' responses.

Figure 4.

Pre-test situation.

After students practiced reading independently with the application during literacy activities, the intervention proceeded according to the instructions provided by both the teacher and the researcher. The app was used to assign reading tasks that matched each student's proficiency level, as illustrated in Figure 5.

Figure 5.

Process to Apply Reading Tasks

A post-test, administered under the same conditions as the pretest, marked the conclusion of the experimental study. Once all data were collected, analysis began with descriptive statistics, followed by the use of paired-sample ANOVA to evaluate the effectiveness of the application. Descriptive statistics were first used to summarize participant demographics and levels of cerebral palsy, addressing the first research question. To answer the second research question, inferential analyses—including chi-square and ANOVA tests—were conducted for hypothesis testing. Normality and homogeneity tests were applied beforehand to ensure that the ANOVA assumptions were met.

RESULTS

This study uses a pre-test/post-test design to evaluate improvements in word recognition and literal comprehension among children with CP following a mobile application–mediated learning intervention. The analysis consists of three main components. First, descriptive statistics summarize participant demographics and baseline performance. Second, before conducting inferential tests, the normality of score distributions and pre–post differences was assessed using the Shapiro–Wilk test. Because the data did not meet the assumption of normality, non-parametric tests were used. The Wilcoxon Signed-Rank Test measured within-subject changes from pre- to post-test for both literacy outcomes, while the Kruskal–Wallis H Test assessed differences in improvement across participant subgroups (e.g., by impairment type, IQ level, or grade). Third, effect sizes were calculated to determine the magnitude of observed changes, and Dunn's test with Bonferroni correction was applied for post-hoc analysis following significant Kruskal–Wallis results.

Demography of Participants

Table 6 indicates the demography of the participants. The analysis includes initial kinds of impairment, gender, age, grade, and level of IQ.

IQ was retrieved from the school document. It was measured using the Stanford Binet method. And it was very restrictive so that only converted qualitative data could be released by the school.

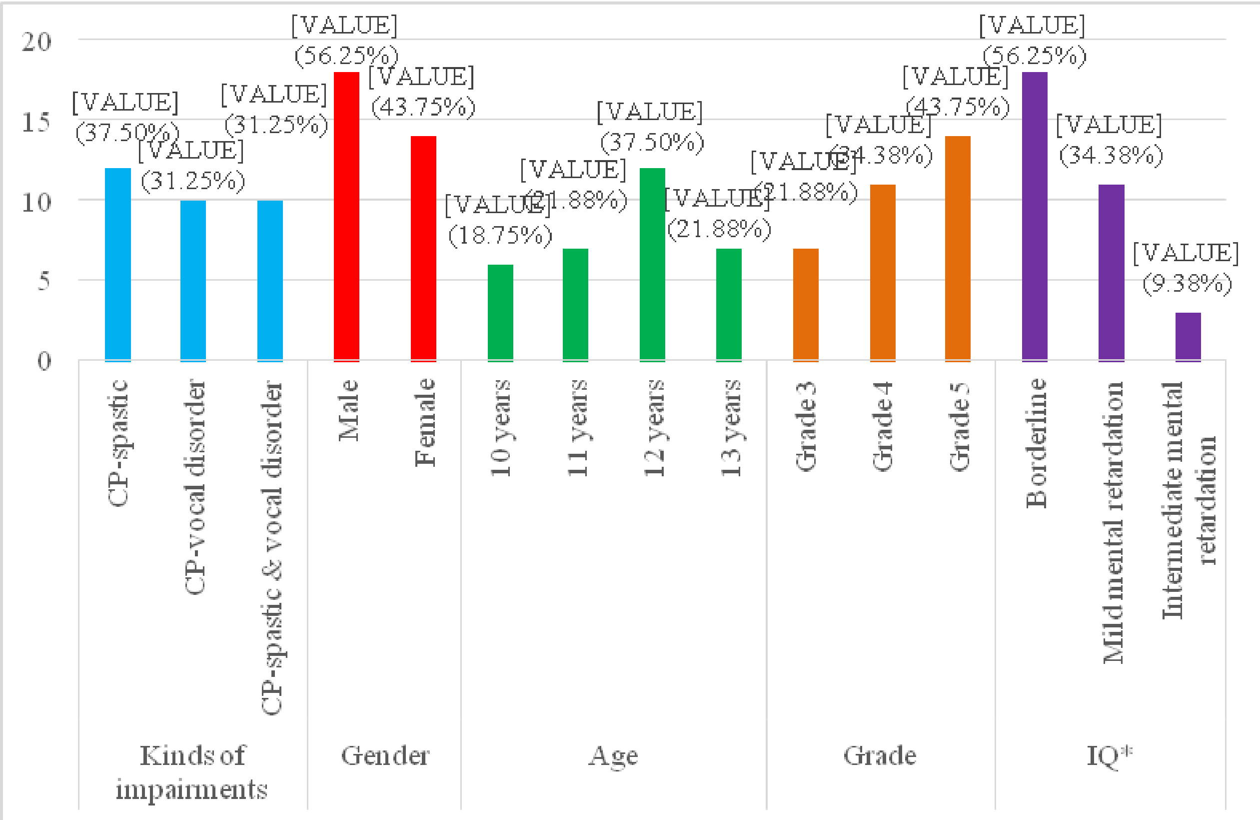
Table 6.

Profiles of the participants

Variables	Category	Frequencies	Percentages
Kinds of impairments	CP-spastic	12	37,50%
	CP-vocal disorder	10	31,25%
	CP-spastic & vocal disorder	10	31,25%
Gender	Male	18	56,25%
	Female	14	43,75%
Age	10 years	6	18,75%
	11 years	7	21,88%
	12 years	12	37,50%
	13 years	7	21,88%
Grade	Grade 3	7	21,88%
	Grade 4	11	34,38%
	Grade 5	14	43,75%
IQ	Borderline	18	56,25%
	Mild mental retardation	11	34,38%
	Intermediate mental retardation	3	9,38%

Figure 6.

Profiles of the participants



Based on Table 6, which presents the profiles of 32 participants, the sample consists of children with cerebral palsy who display considerable diversity in their characteristics. CP-spastic is the most common impairment type (37.50%), followed by CP–vocal disorder and the combined CP-spastic with vocal disorder, each accounting for 31.25%. The participants are predominantly male (56.25%) and range in age from 10 to 13, with 12-year-olds forming the largest subgroup (37.50%). Most are enrolled in Grade 5 (43.75%). Regarding intelligence levels, over half of the participants (56.25%) fall within the borderline category, while the intermediate mental retardation category represents the smallest proportion (9.38%). Overall, this distribution reflects a varied sample suitable for examining differences in narrative writing abilities across groups.

Score on Literal Reading

In the second stage of analysis, the students' literal reading scores were examined. Pre- and post-test results were categorized to reflect levels of word-recognition ability and literal reading comprehension. The initial focus was on evaluating participants' word-recognition performance across both testing phases. These results are presented in Table 7.

Table 7.

Descriptive Statistics for Word Recognition (WR)

Group	N	Min.	Max.	Range	Mean	SD
Variable: Word Recognition Quiz						
Pre-Test	32	1	8	7	3.84	1.92
Treatment (Story 1)	32	1	6	5	3.28	1.33
Treatment (Story 2)	32	2	7	5	4.06	1.34
Treatment (Story 3)	32	1	8	7	4.41	1.78
Treatment (Story 4)	32	0	8	8	5.16	1.96
Post-Test	32	1	8	7	5.59	1.77

Table 7 provides descriptive statistics for word-recognition (WR) performance across the study phases—pre-test, four treatment sessions (Stories 1–4), and post-test—each involving 32 participants. Pre-test scores ranged from 1 to 8 (M = 3.84, SD = 1.92), indicating moderate variability. The treatment phases demonstrated steady improvement. Story 1 and Story 2, which used 5-word items, produced narrower score ranges (1–6 and 2–7) with mean scores of 3.28 (SD = 1.33) and 4.06 (SD = 1.34). Story 3 and Story 4, which employed more challenging 8-word items, showed further growth with means of 4.41 (SD = 1.78) and 5.16 (SD = 1.96), and Story 4 exhibited the widest range (0–8). The post-test yielded the highest mean score of 5.59 (SD = 1.77) and a range of 1–8. The consistent increase in mean scores—from 3.84 at pre-test to 5.59 at post-test—alongside broader score distributions in later phases, reflects substantial improvement in word recognition over time. Although standard deviations remained fairly stable (1.33–1.96), indicating consistent individual variability, the overall upward trend suggests that the mobile application–mediated learning intervention positively enhanced the literacy skills of students with CP. Refer to Table 8.

Table 8.

Descriptive Statistics for Literal Comprehension

Group	N	Min.	Max.	Range	Mean	SD
Variable: Literal Comprehension (LC) Quiz						
Pre-Test	32	0	7	7	2.88	1.88
Treatment (Story 1)	32	0	5	5	2.25	1.32
Treatment (Story 2)	32	1	6	5	3.19	1.31
Treatment (Story 3)	32	1	7	6	3.69	1.62
Treatment (Story 4)	32	1	8	7	4.66	1.78
Post-Test	32	0	8	8	5.00	1.93

Table 8 presents descriptive statistics for literal comprehension across the pre-test, four treatment phases (Stories 1–4), and the post-test, with all phases including 32 participants. Pre-test scores ranged from 0 to 7 (M = 2.88, SD = 1.88), reflecting moderate initial variability in comprehension abilities. During the treatment phase, Story 1 showed a slight decline in performance (M = 2.25, SD = 1.32), but subsequent stories demonstrated a steady upward progression. Mean scores increased to 3.19 (SD = 1.31) in Story 2, 3.69 (SD = 1.62) in Story 3, and 4.66 (SD = 1.78) in Story 4. The post-test produced the highest mean (M = 5.00, SD = 1.93) and the widest score range (0–8). This reflects an overall gain of 2.12 points from pre-test to post-test, indicating meaningful growth in literal comprehension. Although standard deviations remained relatively consistent (1.31–1.93), signaling sustained individual differences, the clear upward trend suggests that the mobile application–mediated learning intervention contributed to improved literal comprehension among students with cerebral palsy.

Evidence shows that word recognition improved notably from pretest to post-test, demonstrating the effectiveness of repeated exposure. Through read-aloud activities across themes, students received consistent practice with pronunciation. In Storytelling 1, students were introduced to sounds and meanings within a context established by the researcher, prompting them to search for interpretations and construct a fuller understanding of the narrative. By Storytelling 2, 3, and 4, students displayed increasing confidence in predicting and interpreting meaning independently as their exposure accumulated. Findings suggest that successful interactions relied on clear pronunciation, effective storytelling performance, accurate word identification, and strong connections between words and their contextual meanings. The application's clear audio delivery further enhanced students' comprehension of contextual meaning. As a result, frequent read-aloud practice strengthened vocabulary and improved students' ability to use phonetic cues for word identification.

Table 9 reports descriptive statistics for overall achievement scores, calculated as the combined average of word-recognition and literal-comprehension results. Across all 32 participants, the data show a clear improvement from pre-test to post-test, with mean scores rising from 3.36 (SD = 1.89) to 5.30 (SD = 1.94), yielding a mean gain of +1.94 points. The score range widened slightly from 7.00 points (0.50–7.50) in the pre-test to 7.50 points (0.50–8.00) in the post-test, indicating greater variability in performance following the intervention. Median scores increased from 3.25 to 5.50, and the mode shifted from 2.50 to 3.50, reflecting a consistent upward movement across central tendency measures. These findings indicate meaningful growth in integrated literacy achievement after the mobile application–mediated learning intervention.

Table 9.

Descriptive Statistics for Overall Achievement

Group	N	Min	Max	Range	Mean	SD	Median	Mode
Pre-Test Achievement	32	0.50	7.50	7.00	3.36	1.89	3.25	2.50
Post-Test Achievement	32	0.50	8.00	7.50	5.30	1.94	5.50	3.50
Achievement Gain	32	0.00	3.00	3.00	+1.94	0.81	2.00	2.00

Table 10.

Achievement Score Distribution by Performance Level

Pre-Test Achievement Categories:

Performance Level	Score Range	N	%
Very Low	0.0 - 1.9	5	15.6%
Low	2.0 - 3.9	15	46.9%
Moderate	4.0 - 5.9	8	25.0%
High	6.0 - 7.5	4	12.5%

Post-Test Achievement Categories:

Performance Level	Score Range	N	%
Very Low	0.0 - 1.9	1	3.1%
Low	2.0 - 3.9	6	18.8%
Moderate	4.0 - 5.9	13	40.6%
High	6.0 - 8.0	12	37.5%

Table 10 shows the distribution of participants across performance categories for pre-test and post-test achievement scores, revealing a clear upward shift in literacy proficiency following the intervention. In the pre-test, nearly half of the participants (46.9%) were in the low-performance category (scores 2.0–3.9), and only 12.5% demonstrated high performance (scores 6.0–7.5). After the intervention, this distribution changed substantially: the proportion of low performers decreased to 18.8%, while the percentage of high performers tripled to 37.5%. The moderate-performance category also grew from 25.0% to 40.6%, and the very low category declined sharply from 15.6% to 3.1%. These shifts indicate that the intervention successfully moved most participants from lower to higher achievement levels, demonstrating significant improvement in overall literacy performance.

Table 11.

Achievement Improvement Analysis

Metric	Value	Interpretation
Mean Gain	+1.94 points	Substantial improvement
% Improvement	57.7%	From 3.36 to 5.30
Effect Size (r)	0.86	Large effect (calculated from Wilcoxon)
Participants with Gain >0	28/32 (87.5%)	Majority improved
Participants with Gain ≥2	19/32 (59.4%)	Significant improvement
Maximum Gain	+3.00 points	HG, SE, LP
Minimum Gain	0.00 points	CT, AR

Table 11 summarizes key metrics of achievement improvement, demonstrating a substantial and meaningful effect of the intervention. The average gain of +1.94 points indicates strong overall progress, while the 57.7% percentage improvement highlights the relative magnitude of growth from pre- to post-test. The large effect size (r = 0.86) further confirms the practical significance of the intervention. Most participants (87.5%, or 28 out of 32) showed measurable improvement, and more than half (59.4%, or 19 participants) achieved substantial gains of 2 points or more. Although individual progress varied—with maximum gains reaching +3.00 points and two participants showing no improvement—the overall pattern demonstrates that the intervention was broadly effective in enhancing integrated literacy achievement.

Table 12.

Achievement by Impairment Type

Impairment Type	N	Pre-Test Mean	Post-Test Mean	Mean Gain	% Improvement
CP-spastic	12	3.71	5.63	+1.92	51.8%
CP-vocal disorder	10	3.15	5.10	+1.95	61.9%
CP-spastic & vocal disorder	10	3.10	5.05	+1.95	62.9%
Total	32	3.36	5.30	+1.94	57.7%

Table 12 provides an analysis of achievement scores by impairment type, showing consistent improvement across all three CP subgroups. Participants with CP–spastic impairments began with a slightly higher pre-test mean (3.71) and reached a post-test mean of 5.63, yielding a mean gain of +1.92 points (51.8% improvement). The CP–vocal disorder group and the combined CP–spastic & vocal disorder group started with similar pre-test means (3.15 and 3.10) and achieved comparable post-test means (5.10 and 5.05). Their mean gains of +1.95 points correspond to improvements of 61.9% and 62.9%, respectively. These results show that all impairment subtypes benefited substantially from the intervention, with nearly identical absolute gains, indicating that the mobile application–mediated learning approach was similarly effective across different CP profiles.

Table 13.
Achievement by IQ Level

IQ Category	N	Pre-Test Mean	Post-Test Mean	Mean Gain	% Improvement
Borderline	18	3.89	5.83	+1.94	49.9%
Mild mental retardation	11	2.91	4.77	+1.86	63.9%
Intermediate mental retardation	3	1.67	3.67	+2.00	120.0%
Total	32	3.36	5.30	+1.94	57.7%

Table 13 presents achievement scores by participants' IQ levels, showing substantial improvement across all cognitive-functioning groups. Students in the Borderline IQ category began with the highest pre-test mean (3.89) and achieved the highest post-test mean (5.83), resulting in a mean gain of +1.94 points (49.9% improvement). The Mild mental retardation group showed a mean gain of +1.86 points, increasing from 2.91 to 4.77, which corresponds to a 63.9% improvement. Remarkably, the three participants in the Intermediate mental retardation category—who had the lowest initial performance (pre-test mean = 1.67) —demonstrated the largest relative gain of +2.00 points (120.0% improvement), reaching a post-test mean of 3.67. These results suggest that the intervention benefited students across all cognitive levels, with those starting at the lowest baseline showing particularly strong relative progress.

Hypothesis Testing

Normality Test

The Shapiro–Wilk test is a widely utilized statistical method for assessing the normality of data distributions and is particularly well suited for small sample sizes (n < 50) (Avram & Mărușteri, 2022). The test determines whether a dataset significantly deviates from a normal distribution and is readily available in most statistical software packages (Carper et al., 2023). Its strong sensitivity to departures from normality—especially in the distribution tails—makes it a preferred option among researchers (Sasmita et al., 2023). The test is versatile and applicable to various data types, further enhancing its value across scientific disciplines (Şatır et al., 2024). Overall, the Shapiro–Wilk test not only supports the validation of parametric assumptions but also plays a crucial role in ensuring accurate interpretation of statistical findings across diverse research contexts (Dallmann et al., 2023).

Based on the Shapiro–Wilk normality test results in Table 14, the distribution of scores for both pre-test and post-test measures displays a mixed pattern with respect to normality assumptions. The pre-test scores for both Word Recognition (WR) and Literal Comprehension (LC) violate normality, as indicated by significant p-values (WR: $p = .040$; LC: $p = .027$), both below the $\alpha = .05$ threshold. In contrast, the post-test results show different outcomes: the WR post-test scores do not significantly deviate from normality ($p = .060$), and the LC post-test scores clearly meet the normality assumption ($p = .207$). This shift suggests that the intervention may have contributed to a more normalized distribution of post-test performance, particularly for LC. Given that the pre-test scores and the difference scores do not satisfy the assumption of normality, the use of non-parametric statistical procedures—such as the Wilcoxon Signed-Rank Test—is appropriate for analyzing pre- and post-test comparisons.

Table 14.

Normality Test

Kinds of Test	Statistic	df	Sig.
Pretest WR	0.930	32	0.040
Pretest LC	0.924	32	0.027
Posttest WR	0.937	32	0.060
Posttest LC	0.956	32	0.207

Wilcoxon Signed-Rank Test

The Wilcoxon signed-rank test is a widely used nonparametric statistical method for comparing two related samples, particularly useful when normality assumptions are violated (Hoang et al., 2021). It assesses whether the median difference between paired observations significantly differs from zero, offering a robust alternative to the parametric paired t-test (Esposito et al., 2021). This test has been applied across a range of disciplines—including image processing and clinical decision-support systems—to confirm meaningful improvements in model performance and diagnostic accuracy (Hwang et al., 2022). Its principal advantage is its capacity to analyze ordinal data or interval data that do not follow a normal distribution, without requiring the strict assumptions inherent in parametric tests (Hoang et al., 2021). As a result, the Wilcoxon signed-rank test strengthens the reliability of findings derived from smaller samples and supports rigorous statistical analysis across diverse research contexts (Dinh et al., 2021).

The Wilcoxon Signed-Rank Test results in Table 15 show statistically significant improvements in both literacy domains following the mobile application–mediated learning intervention. Word Recognition (WR) showed a significant increase from pre-test to post-test (Z = -3.146, p = 0.002), while LC showed an even stronger significant improvement (Z = -3.298, p = 0.001). The negative Z-values reflect the consistent direction of change, indicating that post-test scores were systematically higher than pre-test scores for both measures. Although the table header incorrectly references the "Mann–Whitney U" test—which applies to independent samples—the reported Wilcoxon W values (808.000 for WR and 796.500 for LC) and the paired-sample Z-scores confirm that the correct test was performed. Overall, these results provide compelling evidence that the intervention significantly improved both word-recognition and literal-comprehension skills in children with cerebral palsy.

Table 15.

Wilcoxon Signed-Rank Test

Kinds of Test	Mann-Whitney U	Wilcoxon W	Z	Sig
WR	280.000	808.000	-3.146	0.002
LC	268.500	796.500	-3.298	0.001

Kruskal-Wallis Test

The Kruskal–Wallis test is a robust nonparametric method used to evaluate differences among three or more independent groups, particularly when the normality assumptions required for parametric tests are not met (Cheruiyot, 2020). By ranking the data rather than relying on raw values, the test provides a flexible means of analyzing ordinal or non-normally distributed continuous data (Cheruiyot, 2020). It is frequently applied in ecological research—for example, to compare microbial communities across treatment conditions to determine whether significant compositional differences exist (Ghathian et al., 2025). In fields such as psychology and medicine, the Kruskal–Wallis test is similarly valuable for examining variations in responses across demographic groups or intervention settings without requiring equal variances (Czech & Wielechowski, 2023). Its ability to handle skewed distributions and heterogeneous datasets makes it an essential tool for researchers working with complex or non-normal data (Ferencz et al., 2019). Table 16 presents the results of the Kruskal–Wallis test used in this study.

Table 16.

Kruskal-Wallis Test

Variable	Grouping Variable	H statistic	df	Sig.
WR Improvement	Impairment Type	0.812	2	0.913
LC Improvement	Impairment Type	0.314	2	0.855
WR Improvement	Grade Level	0.719	2	0.698
LC Improvement	Grade Level	0.320	2	0.852
WR Improvement	IQ Level	0.443	2	0.801
LC Improvement	IQ Level	0.717	2	0.699

Table 16 reports the Kruskal–Wallis H test results assessing whether improvements in WR and LC varied significantly across different participant subgroups. The findings show no statistically significant differences in improvement scores based on impairment type (WR: $H = 0.812$, $p = .913$; LC: $H = 0.314$, $p = .855$), grade level (WR: $H = 0.719$, $p = .698$; LC: $H = 0.320$, $p = .852$), or IQ level (WR: $H = 0.443$, $p = .801$; LC: $H = 0.717$, $p = .699$). All p-values are well above the .05 threshold, indicating no meaningful subgroup differences. These results suggest that the mobile application–mediated learning intervention was uniformly effective across students with cerebral palsy, regardless of their impairment type, grade level, or cognitive functioning.

DISCUSSION AND CONCLUSION

RQ 1: How does mobile application mediated learning figure students diagnosed with cerebral palsy literacy?

The mobile application–mediated learning intervention significantly enhanced the literacy skills of students diagnosed with cerebral palsy. Quantitative results show notable gains across foundational and applied literacy domains: word recognition improved by 45.6% (from $M = 3.84$ to $M = 5.59$), literal comprehension increased by 73.6% (from $M = 2.88$ to $M = 5.00$), and overall integrated achievement rose by 57.7% (from $M = 3.36$ to $M = 5.30$). Wilcoxon Signed-Rank Test results confirm these improvements as statistically significant for both word recognition (Z = -3.146, p = .002) and literal comprehension (Z = -3.298, p = .001), accompanied by large effect sizes (r = 0.56 and r = 0.58). The intervention was effective across subgroups, with 87.5% of participants improving and 59.4% achieving gains of two points or more. These findings demonstrate that the mobile application provides structured, engaging, and accessible learning experiences that meaningfully support literacy development for students with CP.

Recent research on mobile application–mediated learning interventions shows that these technologies can substantially improve literacy skills among children with CP. Studies report gains in key domains such as word recognition and comprehension, with progress evident across diverse participant subgroups. Tailored interventions also actively engage both children and parents, helping to create a supportive learning environment (Svensson et al., 2024). Integrating mobile applications into therapy provides personalized, interactive experiences that accommodate the varied cognitive and physical abilities of children with CP (McLeod et al., 2023). Emerging evidence further indicates positive effects on functional capabilities, supporting broader adoption of technology-driven approaches within educational and therapeutic settings (Demont et al., 2022). Importantly, the emphasis on individualized strategies aligns with existing frameworks that promote functional improvement through active participation, reinforcing the effectiveness of mobile application–mediated methods in advancing literacy development for this population (Goyal et al., 2022).

RQ 2: How does mobile application mediated learning increase difference students diagnosed with cerebral palsy literacy based on word recognition and oral reading literacy?

The mobile application–mediated learning intervention shows equitable effectiveness in improving literacy skills across diverse subgroups of students with cerebral palsy. Kruskal–Wallis analyses revealed no significant differences in improvement based on impairment type (WR: H = 0.812, p = .913; LC: H = 0.314, p = .855), grade level (WR: H = 0.719, p = .698; LC: H = 0.320, p = .852), or IQ level (WR: H = 0.443, p = .801; LC: H = 0.717, p = .699). These non-significant results indicate that the intervention benefited students uniformly, regardless of CP subtype, educational placement, or cognitive functioning. Although descriptive data show that all subgroups achieved meaningful gains (absolute improvements of 1.86–2.00 points), the absence of statistically significant between-group differences suggests that the intervention did not preferentially advantage any single subgroup. This pattern of equitable effectiveness highlights the intervention's promise as an inclusive educational tool capable of addressing the heterogeneous needs of the CP population without creating disparities in achievement.

Recent research underscores the potential of mobile application–mediated learning interventions to enhance literacy skills among children with CP. However, while some studies report positive outcomes, the evidence is not uniformly consistent across all participant demographics (Alakrash & Razak, 2021; Gray et al., 2025). Many digital applications are designed to accommodate diverse learning styles and needs, enabling some children with CP to benefit from literacy-supportive features. Yet, the degree of effectiveness across different subgroups varies, and findings remain mixed, indicating that the broader efficacy of such interventions continues to be an important area for further investigation (Alakrash & Razak, 2021).

Moreover, although mobile applications are often described as usable and accessible tools that can effectively engage students and promote inclusive learning environments, the extent to which such engagement translates into equitable literacy gains across different impairment profiles and cognitive levels must be interpreted cautiously (Staccini & Lau, 2022). Emerging evidence suggests that technology may help broaden access to learning opportunities, yet stronger validation is needed before firm conclusions can be drawn (Skalidis et al., 2025). It remains essential that interventions be designed to address the specific challenges experienced by children with CP, and while holistic, technology-supported approaches show promise, disparities in effectiveness may still persist across subgroups (Lin, 2025).

The aim of this study was to examine word recognition and literal comprehension in students with CP and to evaluate the effectiveness of a mobile application–mediated storytelling intervention. A pre-test/post-test design was implemented with 32 participants categorized into three IQ groups: Borderline (IQ 71–84), Mild mental retardation (IQ 50–70), and Intermediate mental retardation (IQ 35–55). Results showed that all IQ groups exhibited significant literacy gains following the intervention. Wilcoxon Signed-Rank Tests confirmed statistically significant improvements in both word recognition ($Z = -3.146$, $p = .002$) and literal comprehension ($Z = -3.298$, $p = .001$). Additionally, Kruskal–Wallis tests found no significant differences in improvement across IQ levels (WR: $H = 0.443$, $p = .801$; LC: $H = 0.717$, $p = .699$), indicating that the intervention was equally effective regardless of cognitive ability. These findings demonstrate that the mobile application–mediated storytelling approach is effective in enhancing literacy among students with CP, with benefits extending across diverse cognitive profiles.

Craig et al. (2021), Critten (2003), Sankar and Mundkur (2005) similarly found that word recognition is reflected in a learner's ability to extract words, articulate them clearly, and connect them to their meanings within a text. Findings from the present study align with Asbel et al. (2010), Craig et al. (2021), Critten (2013), and Mello (2021), showing that literal comprehension among students with CP is strongly shaped by the teacher's ability to link textual meanings to the students' lived experiences and contextual knowledge. Because children with CP often face limitations in acquiring new cognitive skills, they rely heavily on teachers, instructional media, and accessible learning resources to support their progress. The study further indicates that students benefit substantially from the *bacakanbuku* audiobook, as the vocabulary level, thematic content, and contextual presentation align well with their cognitive capacities (Ehri & Snowling, 2004; Patell et al., 2020; Sadowska et al., 2020; Tzuriel, 2013). Notably, word recognition, vocabulary growth, and literal comprehension were not significantly influenced by IQ level or degree of intellectual disability.

Our research indicates that phonological awareness is widely recognized as a primary predictor of early reading development. Phonological awareness refers to the ability to identify and reflect on phonological features independent of word meaning (Smith, 2005) and includes a range of skills, most notably phonemic awareness—the conscious recognition of phonemes as sound units associated with alphabetic literacy (Perfetti et al., 1987). Although debates persist regarding the broader construct of phonological processing (Anthony & Lonigan, 2004), substantial evidence affirms that phonemic awareness instruction is crucial for effective intervention among students with early reading delays, including those with significant speech impairments (Blischak et al., 2004). Such instruction reinforces word pronunciation and provides learners with repeated opportunities to imitate, recall, and independently practice sound patterns at a pace appropriate to their abilities. Research by Clendon et al. (2021), Martined et al. (2021), and Micheletti et al. (2024) further supports the need for rehearsal and repeated word exposure among students with cerebral palsy before they can effectively grasp meaning.

Research consistently shows that word recognition, oral reading fluency, and listening comprehension are central components of reading proficiency (Butterfuss et al., 2020). Numerous studies have demonstrated a strong empirical link between word recognition and reading comprehension in elementary-aged children (Karageorgos et al., 2020; Müller et al., 2015). Cadime et al. (2017), for example, reported correlations ranging from .36 to .55 among Portuguese students in grades two through four, indicating that weak word recognition skills are associated with difficulties in reading comprehension. This relationship is clarified by Pallathadka et al.'s (2022) model, which suggests that early readers, who have not yet developed automatic word recognition, must devote substantial cognitive effort to decoding. When word recognition becomes more efficient, cognitive resources can be redirected toward constructing meaning. Consequently, poor word recognition often leads to challenges in understanding written text. Although essential, word identification alone is insufficient for full comprehension. Prior work also indicates that repeated practice and targeted exposure can improve cognitive functioning and support learning among students with intellectual delays (Craig et al., 2021; Critten, 2013; Umek et al., 2005; Tzuriel et al., 2010).

Aligned with the findings of Asbell et al. (2010), Craig et al. (2021), and Patell et al. (2020), this study highlights that word recognition in students with CP centers on understanding literal information drawn from the narrative presented to them. During the pretest, teachers provided scaffolding to guide students' responses to orally administered literal comprehension questions while the story was read aloud, allowing an initial assessment of their understanding. The intervention phase required students to read the narrative using the mobile application and follow its embedded instructions. These conclusions are consistent with those of Ribeiro et al. (2015). Moreover, empirical work by Pallathadka et al. (2022) and Ribeiro et al. (2015) demonstrates meaningful correlations between oral reading fluency and literacy performance among students with disabilities, further supporting the present findings.

The study provides compelling evidence that the mobile application–mediated learning intervention effectively improved children's word recognition skills and literal comprehension of stories. These findings demonstrate that children with CP and intellectual barriers can develop meaningful literacy skills when provided with appropriate instructional support. The intervention targeted foundational aspects of reading, focusing specifically on word recognition and literal understanding, and employed progressively graded materials beginning with simpler 5-line stories and advancing to more complex 8-line narratives. This structured progression aligns with established literacy development frameworks that differentiate between word-level skills (such as spelling and word reading) and text-level abilities (including reading comprehension and written composition), thereby offering a coherent pathway for skill acquisition (Breadmore et al., 2019, p. 12). Literacy development is often viewed as a continuous process that begins prior to school age and advances toward proficient reading (Brown, 2014; Kern & Friedman, 2008), a perspective broad enough to guide effective literacy support for children with disabilities.

While literacy development is achievable for individuals with impairments, it is important to acknowledge that they require additional support, and their progress may not be as rapid or efficient as that of peers without disabilities. Numerous studies have identified barriers that hinder children with impairments from attaining full developmental potential, even when literacy growth can be conceptualized along a continuum. Personal and sometimes innate factors often contribute to slower progress among these learners (Clendon et al., 2021; Nurwahidah et al., 2021; Williams et al., 2014). Targeted intervention, therefore, becomes essential in providing them with genuine opportunities to succeed. Evidence consistently recommends that adults or skilled readers play an active role in supporting these children, as such guided intervention enables them to build and extend their literacy skills more effectively (Asbell et al., 2010; Critten, 2013; Dessemontet et al., 2019; Khair et al., 2023).

The findings indicate that the application-based intervention led to substantial improvements in both word recognition and literal reading comprehension. Gains in word recognition emerged as early as the second session and continued to increase through the fourth treatment (Mello, 2021; Tzuriel et al., 2013), while the addition of Storyline 4 produced marked growth in comprehension. Overall, the program demonstrates strong potential to improve the reading skills of children with cerebral palsy and intellectual disabilities. This study extends prior research (Ehri, 2005; Lian et al., 2023; Sysoev et al., 2022) that focused on foundational reading skills such as phonics, letter identification, visual perception, and color discrimination. The present intervention moves beyond these basics by offering more advanced features, including sequences of sentences paired with visuals to support word recognition and promote higher-level understanding of sentence meaning. Although similar applications have been developed for children with autism (Khair et al., 2023), *bacakanbuku* offers an advantage through its scanning process, which prepares users before they read the full narrative. Word recognition activities provide a critical foundation for comprehension, and reading aloud further supports learners with impairments by helping them form accurate prosodic representations of text (Micheletti et al., 2024; Patell et al., 2020).

Based on the overall research findings, it can be concluded that the mobile application–

mediated learning intervention significantly and effectively enhances the literacy skills of students with cerebral palsy, as demonstrated by substantial improvements in word recognition, literal comprehension, and integrated achievement, supported by strong statistical evidence. Moreover, the intervention proved equitably and inclusively effective, with no significant differences in outcomes across subgroups defined by impairment type, grade level, or IQ level. Thus, this approach offers a fair, accessible, and scalable educational solution for supporting the literacy development of students within the diverse cerebral palsy population.

Overall, mobile application–mediated learning interventions designed to support school-age children's literacy development have proven highly valuable; however, prior studies have not demonstrated their effectiveness specifically for children with cerebral palsy who also experience intellectual barriers that complicate school learning. This study helps fill that gap by offering new insights that can advance both theory and practice in literacy development and special education. The findings underscore the importance of supporting children in achieving strong reading comprehension through structured literacy interventions that target both word recognition and literal understanding (Asbell et al., 2010; Critten, 2013; Patell et al., 2020; Tzuriel et al., 2013).

To conclude, this study provides clear evidence that the mobile application used in the intervention effectively improved word recognition and literal reading comprehension among students with cerebral palsy. Empirical analysis offers strong support for the application's effectiveness as a literacy intervention tool. However, a limitation was identified in that the storytelling-based reading activities focused only on literal comprehension and did not assess higher-level skills such as inferential or critical reading. The study's novelty lies in its use of a mobile application specifically designed for students with cerebral palsy. Future research is recommended to extend this innovation by developing mobile applications that address all three levels of reading—literal, inferential, and critical. Additional studies using experimental designs or research-and-development approaches for mobile-based instructional design are also encouraged.

Declaration

The authors declare that there is no conflict of interest in writing this article.

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APPENDIX

Table 5.

Profiles of the participants

No.	Initials	Kinds of impairments	Gender	Age	Grade	IQ
1	AR	CP-spastic	M	10	3	Borderline
2	LS	CP-spastic	F	10	3	Borderline
3	AO	CP-vocal disorder	M	13	3	Intermediate mental retardation
4	JT	CP-spastic & vocal disorder	F	11	4	Mild mental retardation
5	MO	CP-spastic & vocal disorder	M	11	4	Borderline
6	DI	CP-vocal disorder	F	12	4	Mild mental retardation
7	AD	CP-vocal disorder	M	12	4	Mild mental retardation
8	DA	CP-spastic	M	12	5	Borderline
9	RB	CP-spastic	M	12	5	Borderline
10	AM	CP-spastic & vocal disorder	M	13	5	Borderline
11	TH	CP-spastic & vocal disorder	M	13	5	Borderline
12	RN	CP-spastic	F	10	3	Borderline
13	FS	CP-vocal disorder	M	11	3	Mild mental retardation
14	YT	CP-spastic & vocal disorder	F	12	4	Mild mental retardation
15	EW	CP-spastic	M	10	3	Borderline

16	KS	CP-vocal disorder	F	13	5	Mild mental retardation
17	JP	CP-spastic & vocal disorder	M	11	4	Borderline
18	ND	CP-spastic	F	12	5	Borderline
19	RA	CP-vocal disorder	M	12	5	Mild mental retardation
20	AL	CP-spastic & vocal disorder	F	11	4	Intermediate mental retardation
21	MI	CP-spastic	M	12	5	Borderline
22	SR	CP-vocal disorder	F	10	3	Borderline
23	BT	CP-spastic & vocal disorder	M	12	4	Mild mental retardation
24	DW	CP-spastic	M	13	5	Borderline
25	FA	CP-vocal disorder	F	11	4	Mild mental retardation
26	HA	CP-spastic & vocal disorder	M	12	5	Borderline
27	CE	CP-spastic	F	10	5	Intermediate mental retardation
28	ZR	CP-vocal disorder	M	13	5	Mild mental retardation
29	VN	CP-spastic & vocal disorder	F	11	4	Borderline
30	OM	CP-spastic	M	12	5	Borderline
31	PI	CP-vocal disorder	F	12	4	Mild mental retardation
32	KA	CP-spastic	F	13	5	Borderline

*IQ was retrieved from school document. It was measured using the Stanford Binet method. And it was very restrictive so that only converted qualitative data could be released by the school.