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Children's Reading Engagement and Social Reading Experiences: Exploring the Influence of Augmented Reality (AR) Books

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Abstract

The quality of children's reading experiences plays a significant role in their opportunity to thrive, and these reading experiences can be shaped by different text types (Krcmar & Cingel, 2014). Over the last decade, the nature of reading has been evolving, and Augmented Reality (AR) represents a step change in bringing together the physical book with digital enhancements (Panchenko et al., 2020; Polyzou et al., 2023). Augmented Reality (AR) books represent a hybrid reading experience, where print books are augmented with digital features (e.g., animations, sounds, comprehension questions). This offers opportunities for new research questions focusing on children's reading experiences and how different reading mediums could shape and support their reading practices. This research adopted a mixed-methods exploratory sequential design to i) provide in-depth insights into children's reading engagement with AR books, focusing on behavioural, cognitive, affective, and social dimensions and ii) explore the social reading experiences (shared reading and book-talk) afforded by AR books for children with reading difficulties.

Previous research highlights that the quality of children's reading experiences and outcomes is associated with their reading engagement (McGeown & Conradi-Smith, 2023); however, research to date has only examined children's reading engagement within the context of print books or digital texts. Therefore, Study 1 examined children's perspectives and experiences of AR books, within the context of reading engagement. In total, 38 demographically diverse children (aged 8–10, 21 boys, 17 English as an Additional Language, 14 ethnicities, and nine with teacher-reported reading difficulties) from the UK participated. After reading an AR book, children participated in interviews to learn about their reading engagement. Deductive (themes) and inductive (subthemes) approaches to thematic analysis were used (Braun & Clarke, 2006),

examining children's AR reading experiences within the context of their behavioural, cognitive, affective and social engagement (Lee et al., 2021a). The majority of children found AR books easy to use, and provided examples of how AR books supported their behavioural engagement (e.g., desire to read more/extend reading practices), altered their cognitive engagement (e.g., reading strategies, visual representation/use of imagination, comprehension monitoring), influenced their affective engagement: (e.g., diverse positive feelings), and social engagement (e.g., prompted interaction and discussion), providing examples suggesting similarities and differences with print books. In addition, class teachers from the classes participating in this project took part in interviews (n = 2), and their perceptions of the usability of AR books in the classroom are discussed (e.g., time restrictions and availability), as these issues could complicate the implementation of AR books within classrooms.

Shared reading and book talk are common activities used to engage primary school readers, yet can be anxiety-provoking for those with reading difficulties. Study 2 examined whether, and how, AR books could foster more positive social reading experiences for children with reading difficulties by comparing children's book-talk and reading experiences with an Augmented Reality (AR) and non-AR (matched in content and format, except for the number of pages) book. In total, 32 children (aged 8–10, 17 girls, 3 English as an Additional Language, 7 ethnicities, and all with reading difficulties) from the UK participated. Children participated in dyads in two shared book reading sessions (AR/non-AR book, counterbalanced), with book-talk after each session, followed by a general discussion to learn of their perceptions of the similarities and differences in their AR/non-AR reading experiences. It was found that AR books were associated with significantly higher levels of book talk following the reading session (both in number of words spoken and sentence length), while many similarities and differences were found in children's experiences

with the AR and non-AR books. For example, shared reading in both conditions could support reading progress (e.g., positive peer support) and foster positive social reading experiences (e.g., enjoying reading together and feeling connected); however, differences were also found in relation to the AR book shared reading (e.g., ease of use).

The findings of this thesis have contributed to the very limited research literature on AR books and reading experiences. Given the increase in the use of technology among children, this research reported how this new form of technology can potentially support and extend children's reading practices and experiences. For AR books to be used optimally within the classroom, it is essential to raise teachers' awareness of AR books, and how they influence children's reading engagement, so that teachers can make informed decisions about their use. Moreover, previous research has demonstrated the importance of talking about text with peers (Gambrell, 2011), and its positive influence on readers' social engagement (Lee et al., 2021a). Enabling positive social reading experiences for children who have difficulties with reading is essential, and AR books offer promise in this regard. This research provides novel and educationally important insights which can inform the reading practices of children with reading difficulties, as it is the first research to explore the potential impact of AR books on the book-talk and reading experiences of children with reading difficulties. Finally, AR does offer a new direction for book publishing (Gudinavičius & Markelevičiūtė, 2020; Lai et al., 2015) and the findings of this research could develop our understanding of how best to integrate AR into books to facilitate positive engaging and enriching reading experiences for children.

Lay summary

This research explored how children's reading experiences can be shaped by a new form of technology Augmented Reality (AR). Augmented Reality (AR) books are print books with special features (e.g., 3D animations, sounds, and/or graphics related to the book), which can be accessed via digital devices (e.g., iPads or smartphones). Specifically, this research explored whether and how Augmented Reality (AR) books influence children's involvement in reading; how they behave, how they feel, how they think, and how they interact with each other. Children's involvement in reading represents reading engagement, and this research investigated four aspects of reading engagement: behavioural (reading's behaviours, e.g., children's reading speed), cognitive (mental effort children put into reading, e.g., strategies children use to support their understanding of text), affective (feelings children experience while they read, e.g., enjoyment), and social engagement (children's interaction with other in reading activities, e.g., discussing the book).

This research consists of two studies: Study 1 explores children's perspectives of how AR books influence their reading engagement. In total, 38 children with different reading enjoyment levels and different reading skills levels participated in AR book's reading sessions, reading the book with a peer from the same classroom (32 children) or by themselves (6 children) as they preferred, and were interviewed to reflect on their reading experiences. The majority of children found AR books easy to use, and children provided examples of how AR books reshape their behavioural engagement (e.g., changing reading behaviours: reading direction), affect their cognitive engagement (e.g., altering their imagination process), influence their affective engagement: (e.g., experiencing a range of feelings e.g., it's enjoyable, fun, impressive, and weird), and social engagement (e.g., prompting interaction and discussion), providing examples

suggesting similarities and differences with print books. In addition, two classroom teachers were interviewed to share their perceptions of the usability of implementing AR books within their classrooms. Teachers reported issues that could complicate using the AR books in classrooms and highlighted that they would use the AR books with small groups and in one-on-one settings.

Study 2 explored how AR books influence children's reading experiences, particularly children with reading difficulties, with a focus on the social aspect of their reading engagement. In total, 32 children were instructed to read in dyads: two children reading together, and these dyads were selected by the class teacher (16 groups). Each group joined two reading sessions, one with an AR book and one with non-AR books (10 min), and children discussed the book together after each session based on two questions: 1) Talk with your classmate about what you liked most about the story, and what you did not like. 2) What can you remember most about the story? Discussions were audio recorded, and the quantity of children's talk about the book was analysed. Following this, children joined a general discussion to learn about their shared reading experiences. Study 2 found that AR books significantly increased the quantity of children's book talk (the number of words spoken by children and the length of their sentences), and many similarities (e.g., feeling connected) and differences (e.g., ease of use) were found in children's experiences with the AR and non-AR books.

This research provides novel in-depth insights into children's reading engagement through presenting children's perspectives and experiences of AR books, which provides a foundation for researchers, educators, and AR book designers/developers interested in better supporting children's reading experiences and outcomes with AR books.

Declaration

I declare that the thesis has been composed by myself and that the work has not be submitted for any other degree or professional qualification. I confirm that the work submitted is my own. I confirm that appropriate credit has been given within this thesis where reference has been made to the work of others.

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To Sarah, touching things gently with such a sweetheart, planting little trees and fluffy hearts all around.

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To family, and our rainy talks, between a shiny “hello” and a soft “bye”.

To friends, and our crispy chats, between short stays and long walks.

To Serdar and Emma, gathering, letting the words stand.

To the words, coming all around, letting the thesis start.

and in between, to little Kawla, and the snowflakes in her heart.

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Chapter 1

Introduction

Reading represents an essential skill that affects children's everyday activities, academic achievements, and self-exploration to thrive in the world (Alexander, 2005; Breadmore et al., 2019; Castles et al., 2018). However, the National Literacy Trust's Annual Literacy Survey (2024) reported that children and young people's (8-18 years) reading enjoyment levels decreased in 2024, representing the lowest record since 2005, when the survey started. In 2024, only 34.6% of children agreed that they enjoyed reading in their free time (Clark et al., 2024). In addition, the levels of reading enjoyment decline as children get older - 66.5% of children aged 5-8 enjoyed reading, while the percentage drops to 51.9% for children aged 8-11 and declines further past the age of 11 as follows: aged 11 to 14 (30.7%), aged 14 to 16 (29.7%), with an increase at age 16 to 18 (40.0%) (Clark et al., 2024). Further, the results from this survey highlighted a positive association between children's reading enjoyment and reading frequency in their free time - 48.2% of children who enjoyed reading read daily, while only 5.9% of children who did not enjoy reading read daily (Clark et al., 2024). In contrast, the rate of young students who use electronic devices has been increasing. Recently, students spend more time with their electronic devices to watch, play, or even read (Danaei et al., 2020; L. Wang et al., 2019; Xu et al., 2021). Children are increasingly showing a stronger preference for on-screen reading (Halamish & Elbaz, 2020). However, the most recent of the National Literacy Trust's Annual Literacy Survey's to directly compare paper and screen (2019) reported that the dominant medium of children's reading, at that time, was paper (Clark & Teravainen-Goff, 2019).

Reading skills are argued to be underpinned by two cognitive abilities and processes, specifically, decoding and linguistic comprehension (Gough & Tunmer, 1986), and children's

literacy development, including reading, is affected by factors that emerge from the child's environment (e.g., home literacy environment) and child-based factors (i.e., motivation) (Breadmore et al., 2019). Within classrooms, readers vary as they bring different knowledge, skills, and experiences related to reading (Tunmer & Hoover, 2019). However, Tunmer and Hoover (2019) argued that learning to read is not only related to the cognitive foundations, but also psychological factors such as motivation and engagement. Indeed, reading engagement is a crucial factor that affects children's reading literacy (Cao et al., 2024; Lee et al., 2021a), and it was found that engagement positively affects academic achievement (Fredricks et al., 2004).

Engagement has been discussed in previous research, either in relation to school and learning, e.g., engagement theory (Fredricks et al., 2004), or with the focus specifically on reading, e.g., reading engagement model (Guthrie & Wigfield, 2000). In general, engagement is a multidimensional construct which reflects how children behave, feel, and think while being involved in activities (e.g., reading) (Fredricks et al., 2004; Unrau & Quirk, 2014). Research has found that less engaged readers show lower reading achievement compared to engaged readers (Guthrie, 2004). Previous research differentiated between active (e.g., sitting still) and interactive (e.g., participating in reading discussion) engagement and highlighted that early literacy skills can be predicted by interactive not active, engagement (Son et al., 2023).

More recently, a systematic review of reading engagement research, carried out by Lee et al (2021) highlighted four dimensions of reading engagement, including behavioural, cognitive, affective and social dimensions, unlike previous studies that considered reading engagement as a form of two (i.e., affective and behavioural) or three (i.e., affective, behavioural and cognitive) components (Barber & Klauda, 2020; Cao et al., 2024; Clinton-Lisell et al., 2024; Fredricks et al., 2004; Unrau & Quirk, 2014).

Reading books has been considered an essential source to develop students' literacy skills (Arnold et al., 1994; Danaei et al., 2020; Neuman, 1999; Takacs et al., 2015). A meta-analysis of 29 studies (published 1951-1993) was conducted to assess the relationship between reading books and children's literacy outcomes (Bus, 1995). The result confirmed that storybook reading positively affects children's language growth and reading skills, which is considered a predictor of reading success (Bus, 1995). More recently, Mol and Bus (2011) meta-analysed 99 studies (published 2004-2008) to explore the association between reading growth and print exposure. Their findings indicated that independent free time reading benefits readers, even those who are struggling with reading. Previous research reported that children's vocabulary between grades three and eight thrives as a result of reading texts (Robbins & Ehri, 1994; Sénéchal, 1997), and recognition of word meaning significantly increases when words come in a story context (Robbins & Ehri, 1994). Providing children with high-quality storybooks, therefore, would promote children's literacy skills, including reading (Neuman, 1999). Indeed, reading practices/processes become more complex with increasing age (Castles et al., 2018), and readers are usually exposed to narrative texts during primary grade and increasingly read more technical and expository texts with age (Mol & Bus, 2011).

Over the last two decades, reading mediums have evolved, and children's books have experienced a variety of enhancements aiming to promote reader learning and engagement. Halamish and Elbaz (2020) reported that children in elementary school show a better understanding when they read texts presented on paper compared to texts on screen. However, a meta-analysis of 39 studies (published 2002-2019) highlighted that even though digital books negatively impact children's (aged one to eight years) reading comprehension, their enhancements that target the story content surpass the outcomes of paper books (Furenes et al., 2021). Indeed,

while the transition to screen-based devices has provoked questions and varied concerns about the impact of technology on reading compared to paper book reading (Schwabe et al., 2023), an emerging technology (i.e., Augmented Reality) has challenged the physical/digital dichotomy.

Augmented Reality (AR) technology is increasingly being integrated into educational settings to support students' learning (Kerawalla et al., 2006; Phadung et al., 2017), and Augmented Reality (AR) books represent one of its recent implementations (Panchenko et al., 2020). AR books offer unique reading experiences by integrating physical and digital media (K.-H. Cheng, 2019; Danaei et al., 2020; L. Wang et al., 2019), and recent research has reported adults' perceptions and experiences of this technology (e.g., Cheng, 2016, 2019). Indeed, Augmented Reality (AR) storybooks represent a suitable alternative reading medium for young readers since they combine both paper storybook and digital technology, where readers can interact with the physical book via their electronic devices. More specifically, AR technology enables paper books to be enhanced through the addition of digital features such as sounds, 3D animations, and interactive questions (Danaei et al., 2020; L. Wang et al., 2019; Yilmaz et al., 2017). AR books therefore invite more physically interactive reading experiences as students explore and combine paper and virtual content (Danaei et al., 2020; L. Wang et al., 2019).

Reading engagement has been explored within the context of different text types (e.g., paper or digital books: see Clinton-Lisell et al., 2024 for a review), and has been conceptualised in different ways. However, there is no research that has explored the four dimensions of reading engagement simultaneously within the context of AR books. Thus, this research aimed to examine children's reading experiences and perspectives with AR books, using reading engagement as a conceptual lens, and drawing upon four distinct dimensions of engagement, as identified in a recent systematic review of reading engagement research (Lee et al., 2021a).

This thesis is structured by starting with the current chapter (introduction) and moving to Chapter 2 (literature review), which provides an overview of the theoretical frameworks for studying children's reading engagement within the context of Augmented Reality (AR) books, and shares research relevant to the key aspects of children's reading (e.g., reading development, reading engagement, and reading mediums). In the methodology chapter (Chapter 3), the philosophical assumptions behind this research, the methodological approach, and data collection methods are highlighted, including the recruiting sample procedure, data analysis process, ethical considerations and open research practices. The fourth chapter presents Study 1, which provides in-depth insights into children's reading engagement with AR books, which was published in *Frontiers in Psychology* on 14 August 2024. In addition, teachers' insights (Study 1) concerning the usability of implementing AR books within classrooms will be discussed in Chapter 5, as the implementation of AR books demands unique usability considerations. Study 2 is presented in Chapter 6, which was submitted to *Reading Psychology* on 04 December 2024 and published on 17 June 2025. As this research aims to include children's voices and raise young readers' knowledge of AR books, an article written for young readers is shared (Chapter 7). This article is provisionally accepted (12 May 2025) and published on July 11 2025 by *Frontiers for Young Minds*. Finally, in Chapter 8 (Thesis discussion), additional study findings (e.g., Study 1 observations) are discussed, and the findings of both studies (Chapters 4, 5 and 6) are integrated and discussed in terms of how they relate to previous theory and research. In addition, implications for educational practice and AR book development, limitations, and future research directions are considered.

Chapter 2

Literature Review

Understanding text meaning represents the ultimate goal of the reading process (Altun, 2018). Therefore, in this chapter children's reading development research is shared, but with a specific focus on reading comprehension. In addition, this chapter provides a historical and contemporary view of different reading difficulties and how reading difficulties are associated with social reading anxiety. Moreover, this chapter highlights the importance of reading engagement to promote the quality of children's reading experiences, discussing its four dimensions (i.e., behaviour, cognitive, affective, and social), as these dimensions, which were proposed following a recent systematic review by Lee et al.(2021), were adopted as a framework for this research. Furthermore, this chapter explores how children's books have evolved and articulates the value of illustrations in children's books. This chapter, additionally, explains how reading mediums (e.g., paper and digital books) can shape children's reading experiences and reading engagement and how a new form of books, Augmented Reality (AR) books, may lead to different consequences for children's reading engagement, including children with reading difficulties. Finally, the usability of implementing AR books in educational settings is discussed.

2.1. Reading Development

In this section, children's reading development is discussed, with a focus on reading comprehension, reading difficulties, and reading anxiety.

The ability to read is an essential skill that affects young students' academic achievements and everyday activities (Breadmore et al., 2019; Castles et al., 2018; Danaei et al., 2020). Indeed, reading opens doors for self-exploration and self-enrichment to thrive in this world (Alexander, 2005). However, the process of how this skill is developed has been the topic of debate, and has

been explored by different fields and different disciplinary perspectives (e.g., neuroscience, psychology, and education) (Al Dahhan et al., 2016). Different views of reading development have been proposed; while some views particularly focus on the early stage of reading development and the acquisition of the basic skills underpinning word reading (e.g., phonological awareness), other views perceive reading as "a long-term developmental process" (Alexander, 2005, p. 414).

Reading is more than decoding as children are expected to comprehend what they have decoded (Alexander, 2005; Nation & Snowling, 2004). As proposed by Plaut et al.'s (1996) model, reading is an interaction between both phonological and semantic pathways (Nation & Snowling, 2004). Young readers construct the text's meaning more easily if they no longer struggle with word identification (Kuhn & Stahl, 2003). According to Chall's (1996) stages of reading development model, young readers are expected to automatize their decoding ability to move from learning to read toward reading to learn (Kuhn & Stahl, 2003), which is in line with the instance theory of automatization (LaBerge & Samuels, 1974) that highlights reading automaticity as a path toward an advanced reading process (Bar-Zvi Shaked et al., 2020; LaBerge & Samuels, 1974). In addition, the cognitive and affective aspects of reading effect readers' experiences (Breadmore et al., 2019; Kulikowich & Hepfer, 2017).

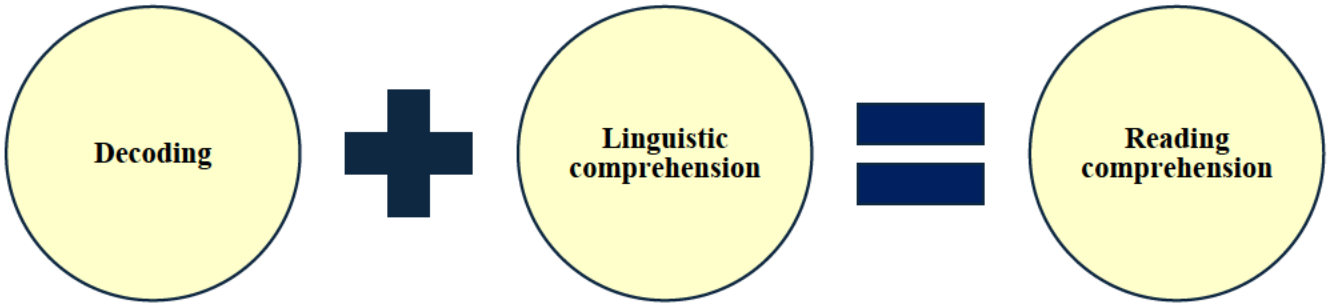
2.1.1. Reading comprehension

The concept of reading comprehension is shaped by different reading models such as the situational model (Van Dijk & Kintsch, 1983) which described meaning as a form of combining the text with background knowledge (Breadmore et al., 2019), and the construction-integration model (Kintsch, 1988), which focused on the cognitive processes that support comprehension (e.g., working memory) (Stafura & Perfetti, 2017). Historically, reading comprehension has been defined as "the ability to extract and construct linguistically based meaning, both literal and

inferred, from written text" (Tunmer & Hoover, 2019, p. 77). The simple view of reading (SVR) differentiates between reading comprehension and linguistic comprehension (Hoover & Gough, 1990), as reading comprehension is a combination of both linguistic comprehension and decoding (see Figure 1). Linguistic comprehension is defined as children's ability to derive the meaning from words in spoken form, while reading comprehension, on the other hand, refers to children's ability to derive the meaning from words in print form (Gough & Tunmer, 1986). In their longitudinal study of 716 children, Babayiğit et al. (2021) found that linguistic comprehension at age five uniquely contributes to children's reading comprehension at ages ten and fourteen (Babayiğit et al., 2021) highlighting the long-term role of linguistic comprehension in reading comprehension skills and reading achievement.

Figure 1

The Simple View of Reading (reading) (Gough & Tunmer, 1986)



2.1.2. Reading Difficulties

2.1.2.1 Historical and contemporary perspectives of reading difficulties. Reading difficulties such as dyslexia and specific reading comprehension impairment are relatively common among students (Duff & Clarke, 2011). The prevalence of reading difficulties varies considerably depending on school-level data, and it has been suggested that approximately fifteen percent of children struggle with reading (Francis et al., 2022; McArthur & Castles, 2017), with difficulties in either word reading and/or comprehension. Readers with poor reading skills are highly heterogeneous (McArthur & Castles, 2017), and different terminology has been used to refer to children who face difficulties in reading. For example, children with reading disability (Casey et al., 1992), less skilled readers (Montali & Lewandowski, 1996), struggling readers (Triplett, 2007), children with reading difficulties (McArthur & Castles, 2017), poor readers (Francis et al., 2021; Sleeman et al., 2024), and people with dyslexia as a subgroup of poor readers (Knight & Crick, 2021). In 1986, Gough and Tunmer proposed a simple model of reading concerning reading and reading difficulties. In this, reading was said to be predicted by decoding and linguistic comprehension, and reading difficulties stemmed from an inability to decode, comprehend, or both, which resulted in three types of reading difficulties, including dyslexia (i.e., poor decoding), hyperlexia (i.e., poor comprehension), and reading disability (i.e., poor decoding and poor comprehension) (Gough & Tunmer, 1986) (see Figure 2). While some reading development models focus only on either the decoding or comprehension process, the simple view of reading (SVR) acknowledges the combination of both (Breadmore et al., 2019), as these two complex components are separable, but interlinked, and children may show strengths in one component and weaknesses in another (Breadmore et al., 2019).

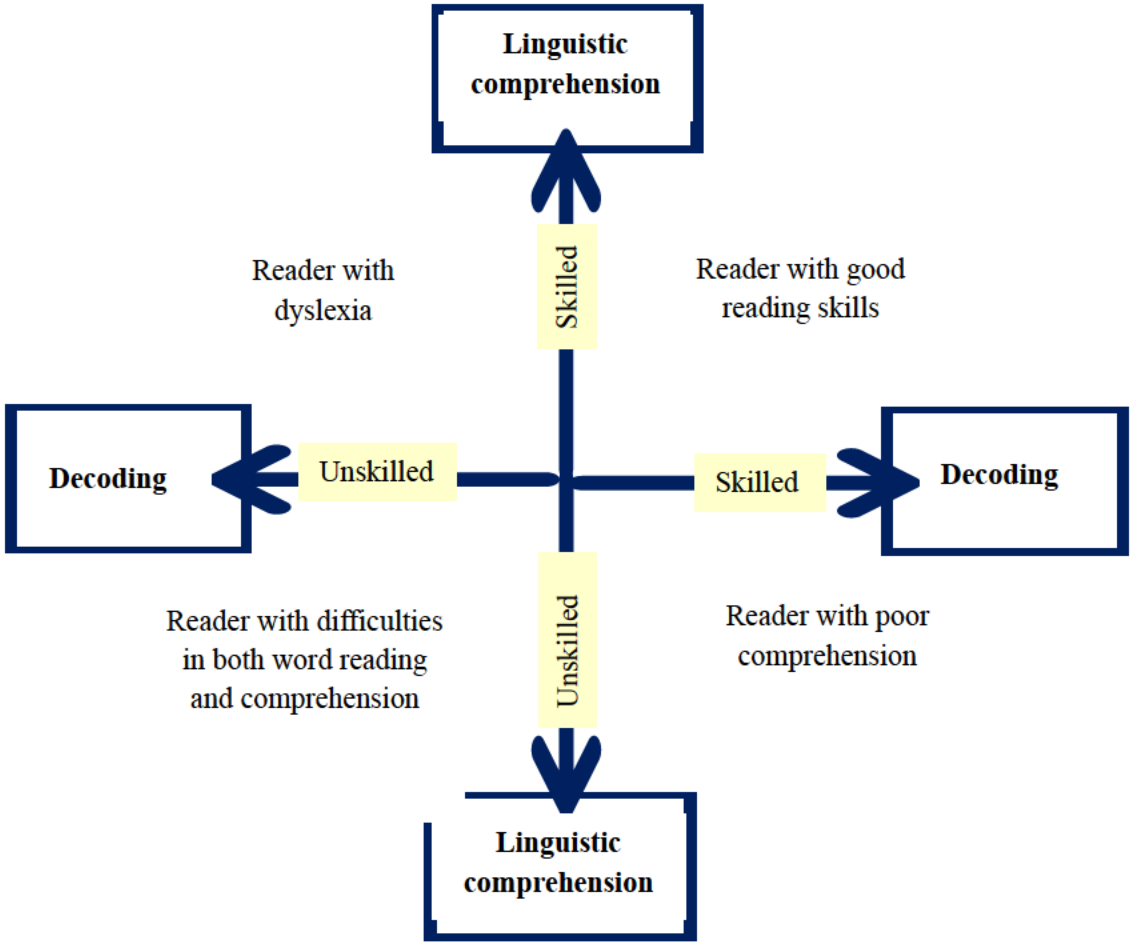
In general, there is a positive correlation between decoding and linguistic comprehension among the general population of readers (Gough & Tunmer, 1986). Dyslexia and poor comprehension, however, stem from an exception to this correlation as readers with dyslexia are only relatively skilled in comprehension, while readers with poor comprehension show the opposite (i.e., skilled in decoding only) (Gough & Tunmer, 1986). Readers with poor comprehension skills have difficulties understanding what they have decoded, "despite being able to read text accurately, fluently, and at age-appropriate levels" (Nation et al., 2010, p. 1031). Dyslexia and poor comprehension represent two types of reading difficulty, while the third one is the common (garden variety) reading disability, which is characterised by both decoding and comprehension difficulties (Gough & Tunmer, 1986) (see Figure 2).

Catts (2018) argued that presenting comprehension next to decoding in the simple view of reading (SVR) may lead to simplifying the complexity of comprehension and measuring it as a single entity. Reading comprehension, however, is a multidimensional cognitive construct influenced by text and the reader, so it varies even within one individual based on what and why readers read (Catts, 2018). In addition, some research suggested an extension to the simple view of reading (SVR) by highlighting the role of vocabulary as an independent factor that predicts reading comprehension (e.g., Braze et al., 2007). However, the findings of Braze et al. (2016) study, which was generated based on data from 286 young adults, supported the SVR's framework by confirming that vocabulary could be included as a component within linguistic comprehension instead of being an independent contributor (Braze et al., 2016). Moreover, even though the simple view of reading (SVR) acknowledged the combination of decoding and comprehension, it did not consider the complexity of comprehension as it involves cognitive skills and numerous processes (e.g., working memory) (Clarke, Henderson, et al., 2010). For example, in their longitudinal study,

Cain et al. (2004) highlighted the relationship between reading comprehension and working memory among children aged 8, 9, and 11 years and how significant variance in reading comprehension can be explained by working memory. Finally, the simple view of reading (SVR) did not capture other aspects related to reading beyond decoding and comprehension, such as motivation and engagement (Duke & Cartwright, 2021).

Figure 2

The Simple View of Reading (reading difficulties) (Gough & Tunmer, 1986)



There is a lack of consensus regarding diagnosing reading difficulties, (Al Otaiba et al., 2023). For example, many terms have been used interchangeably with dyslexia, such as reading difficulties (Gibbs & Elliott, 2020), and research suggests there is no evidence of a clear difference between students who identified as dyslexic and those with literacy difficulties (Knight & Crick, 2021). However, Carroll et al. (2025) reported a considerable consensus across expert panels regarding the definition of dyslexia (e.g., reading fluency is a key marker among different ages). The expert panels consisted of individuals with dyslexia, specialist teachers, educational psychologists, and academics (Carroll et al., 2025)**.**

Identifying readers with poor comprehension is arguably not simple, as reading words fluently can hide children's difficulty comprehending the meaning (Breadmore et al., 2019). Previous research reported that approximately 8% to 15% of primary school students fall into this category (i.e., readers with poor comprehension) (Clarke, Snowling, et al., 2010; Nation & Snowling, 1997). Nation and Snowling (1998) highlighted that it is hard to discover readers with poor comprehension skills at such a young age since reading comprehension develops gradually over the years (Nation & Snowling, 1998). For example, Nation et al. (2010) conducted a longitudinal study investigating which language skills students with poor comprehension would insufficiently experience in their early childhood. The study selected students at age five and continued assessing them over four years. The findings indicated that students with poor comprehension in their mid-childhood had not experienced a "slow start with reading accuracy or fluency" in their early childhood (Nation et al., 2010, p. 1036), highlighting that decoding or reading accuracy skills were not the cause of their comprehension difficulties. Given that comprehending the texts is the ultimate goal of reading (Altun, 2018; Breadmore et al., 2019), poor comprehension is a critical issue (Duff & Clarke, 2011).

2.1.2.2 Reading difficulties and anxiety. Reading difficulties can affect children's academic, social, and emotional experiences and outcomes (Alexander, 2005; Claessen et al., 2020; Fishstrom et al., 2024; Francis et al., 2022; McArthur, 2022; McArthur & Castles, 2017). To date, the majority of research focusing on children with reading difficulties has focused on cognitive difficulties and remediating difficulties associated with phonological decoding, language, etc (e.g., Al Otaiba et al., 2023; Duff & Clarke, 2011; Hall et al., 2023). However, fewer studies have focused on the affective or emotional aspects associated with reading difficulties (Katzir et al., 2018), with some exceptions. For example, (Casey et al., 1992; Claessen et al., 2020; McArthur & Castles, 2017). Indeed, compared to typical readers, children with reading difficulties typically have higher levels of anxiety (McArthur & Castles, 2017; Novita et al., 2019; Wilmot et al., 2023) as difficulties with reading is associated with both reading and social anxiety, which can have consequences for reading fluency and comprehension (Fishstrom et al., 2024). For example, due to fear of embarrassment, some children may have concerns about reading aloud (Francis et al., 2022).

To date, many scales have been developed to measure anxiety. For example, in their systematic review and meta-analysis of 34 studies to investigate the association between poor reading and anxiety, Francis et al. (2019) reported that the three common measures of anxiety used were: the State-Trait Anxiety Inventory (STAI), the Multidimensional Anxiety Scale for Children (MASC), and the Child Behaviour Checklist (CBCL), yet a few scales were developed to measure reading anxiety in particular. As a result, Francis et al. (2020) developed a self-report questionnaire for children, *the Reading Anxiety Test for Children – Self Report (RAT-C)* (Francis et al., 2020), which consists of three subscales: Generalised Reading Anxiety, Social Reading Anxiety, and

Physical Symptoms, which can be implemented in educational settings to identify children who have elevated reading anxiety.

2.3. Reading Engagement

Engagement is a multidimensional construct that reflects how learners behave, feel, and think while they are involved in tasks and activities such as reading (Fredricks et al., 2004; Unrau & Quirk, 2014), and it is suggested that approximately forty percent of students internationally demonstrate low levels of engagement in reading (Barber & Klauda, 2020). Compared to less engaged readers, engaged readers show higher reading achievement (Guthrie, 2004). In their study, Son et al. (2023) differentiated between active and interactive engagement, indicating that children's early literacy skills can be predicted by their interactive, not active, engagement. Interactive engagement reflects dynamic engagement where children interact with their teacher and peers verbally, socially, and cognitively during reading (e.g., participating in reading discussion) (Son et al., 2023). Active engagement, on the other hand, occurs "when children show non-interactive but overt engagement behaviours by participating in and enjoying reading" (e.g., sitting still) (Son et al., 2023, p. 48).

Literacy researchers considered reading engagement a crucial factor that positively affects students' literacy development (Lee et al., 2021a). For example, the reading engagement model, proposed by Guthrie and Wigfield (2000), emphasised the crucial role of reading engagement on students' reading achievement (Guthrie & Wigfield, 2000). According to the reading engagement model, reading engagement is a cluster of motivation (e.g., intrinsic motivations) and strategies used (e.g., comprehension monitoring and questioning), as they function together to drive reading engagement (Guthrie et al., 2001; Guthrie & Cox, 2001). In addition, this model highlighted the role of social interaction and indicated that reading engagement occurs when children are socially

interactive with others (e.g., exchanging ideas of the text with peers) (Guthrie & Wigfield, 2000; Wigfield et al., 2014). Different indicators can be collected to gauge reading engagement such as reporting the number of pages the student read daily (Guthrie et al., 2001), and self-reported strategy use (Guthrie & Cox, 2001).

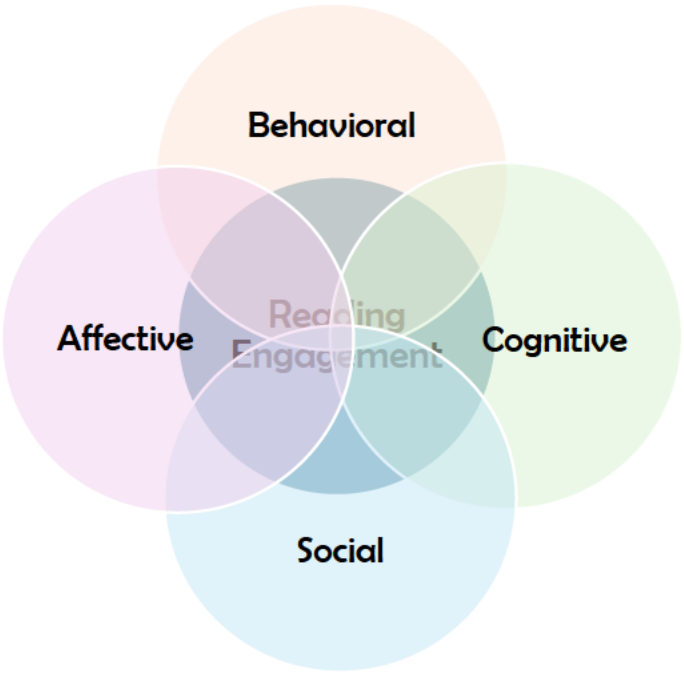
To differentiate between reading motivation and reading engagement and explain the relationship between them in reading, reading motivation has been defined as "the drive to read resulting from an individual's beliefs about, attitudes toward, and goals for reading" (Conradi et al., 2014, p. 154). Reading motivation precedes reading engagement in that motivated readers read more (Schiefele et al., 2012) and exert more cognitive effort while reading (Logan et al., 2011; Taboada et al., 2009). Motivation is, therefore, the impetus, while engagement is the result of that (Unrau & Quirk, 2014). For instance, in their research, Unrau and Quirk (2014) provided an example of a reader who stopped reading and put the book down due to feeling bored. According to Unrau and Quirk (2014), the action of putting the book down is an indicator of behavioural reading engagement, while the reason behind this action is associated with reading motivation (Unrau & Quirk, 2014). However, some considered engagement a "motivational construct" (Unrau & Quirk, 2014, p. 261).

Reading engagement has been defined as "behavioural displays of effort, time, and persistence in attaining desired outcomes" (Klauda & Guthrie, 2015, P. 240), but as readers' actions and interactions, which are associated with reading, are not always observable, Unrau and Quirk (2014) proposed defining reading engagement in terms of both observable and unobservable actions related to reading activities (Lee et al., 2021a; Unrau & Quirk, 2014). Indeed, to date, there is a lack of conceptual and operational clarity in research into children's reading engagement (Unrau & Quirk, 2014; Lee et al., 2021). For example, the dimensional construct of reading

engagement has been changed from two (affective and behavioural) to three (affective, behavioural, and cognitive) dimensions based on researchers' changing knowledge of reading engagement. A recent systematic review of reading engagement research (Lee et al., 2021a) proposed four dimensions of engagement: behavioural, cognitive, affective, and social (see also McGeown and Conradi-Smith, 2024) (see Figure 3). Previous research has drawn upon specific dimensions of engagement to explore the relationship between readers' reading experiences and reading outcomes, for example, cognitive engagement (e.g., Miyamoto et al., 2019). These four dimensions, however, do not appear from a review of the literature to have been studied in parallel.

Figure 3

Reading engagement framework



2.3.1. Behavioural engagement

Behavioural engagement has been defined as reading behaviours, for example, how frequently and for how long children read, the way they read, and the text types they read (McGeown & Conradi-Smith, 2024). Research has shown that more time spent reading, specifically (fiction) book reading, leads to better reading and language skills (Nation et al., 2022; Torppa et al., 2020; Van Bergen et al., 2021). Different tools, such as self-report questionnaires, teacher ratings (Unrau & Quirk, 2014), and teachers' observations (Lee et al., 2021a) have been used to capture students' behavioural reading engagement. However, the implementation of different tools may lead to different results. For example, a class teacher reported that reading her student's responses on the *Reading Engagement Scale* revealed how her student, whom she was considered a disengaged reader based on her observation, was an avid reader but with different text types (i.e., fantasy and graphic novels) (McGeown & Conradi-Smith, 2024). Indeed, children hold a valid view of themselves as they are involved with their experiences all the time compared to adults' involvement in children's experiences (Sturgess et al., 2002).

2.3.2. Cognitive engagement

Cognitive engagement has been defined as the level of children's cognitive effort and the application of goal-directed cognitive strategies (e.g., re-reading, decoding, drawing upon background knowledge) that children implement to support their comprehension while reading (Lee et al., 2021; McGeown & Conradi-Smith, 2024; Unrau & Quirk, 2014). Indeed, the relationship between children's reading motivation and skill was mediated by the metacognitive knowledge of strategy use (Miyamoto et al., 2019). Cognitive engagement can be assessed in different ways, for example through self-reported cognitive engagement or measurement of the implementation of cognitive strategies when reading (Guthrie & Cox, 2001; Unrau & Quirk,

2014). Further, given that cognitive processes cannot be observed (Lutz et al., 2006), children can also demonstrate cognitive engagement through verbalizations about the book content (Clinton-Lisell et al., 2024) and the accuracy in responding to teachers' questions about the text (Lutz et al., 2006).

2.3.3. Affective engagement

Affective engagement has been defined as the depth and breadth of diverse feelings and emotions experienced by young readers while reading, such as enjoyment, anticipation, interest, excitement, sadness, etc. (Lee et al., 2021; McGeown & Conradi-Smith, 2024; Unrau & Quirk, 2014). It has been reported that enjoyable and positive reading experiences affect children's choices to read more in the future (Clark et al., 2023; Currie & McGeown, 2024; McGeown & Wilkinson, 2021). Affective engagement can be indicated by capturing readers' body language and facial expressions while discussing a book (Barber & Klauda, 2020) and readers' expressive tone (Lutz et al., 2006). Further, as affective engagement cannot always be observable, self-reports are commonly used with children, through surveys, interviews or focus groups, to understand the feelings of affective engagement (Unrau & Quirk, 2014).

2.3.4. Social engagement

Social engagement has been defined as children's participation in different reading activities with others, including reading together, sharing ideas about reading, swapping, and discussing books they have read (Lee et al., 2021; Lutz et al., 2006; McGeown & Conradi-Smith, 2024). Both agentic and non-agentic interactions could be included in the social reading activities (Lee et al., 2021), and engaging reading experiences can be fostered if these activities are positively perceived and experienced (Cremin, 2014; McGeown & Wilkinson, 2021). Different forms of social reading activities can be implemented, such as reading aloud, reading together, book-talk,

or sharing recommendations with others, and these activities can take place with peers, friends, family, teachers, etc. (Cremin et al., 2024; Gambrell, 2011; McGeown & Conradi-Smith, 2024). Previous research reported that reading engagement is strongly affected by children's relationships with their peers (Cremin, 2014), and recently, there has been growing interest in children's social interaction and technology (Kawas et al., 2020). For example, 41% of research published between 2011 and 2019 by the Interaction Design and Children journal (IDC) highlighted the value of technology in supporting children's social interaction with their parents or peers (Kawas et al., 2020).

Social reading activities: shared reading and book-talk. Social reading activities can support young readers in different ways. For example, shared book reading can positively influence children's language development, phonological awareness skills (Dowdall et al., 2020; Noble et al., 2019; Pillinger & Vardy, 2022), story retelling (Olszewski et al., 2018), and reading engagement (Clinton-Lisell et al., 2024). In their systematic review, Pillinger and Vardy (2022) highlighted the role of dialogic reading in extending the benefits of shared reading as children are actively involved in shared reading rather than being a listener. In addition, research demonstrated that talking about texts with peers offers opportunities for children to feel connected (Cremin et al., 2024), learn from each other (McGeown & Conradi-Smith, 2024), and build positive reader identities (Cremin et al., 2024). Further, technology may play an additional role in extending children's talk about text. For example, in their content analysis of IDC papers, Kawas et al. (2020) highlighted the role of technology in offering opportunities to support children's ability to form narratives.

Different text formats have been used in studying shared book reading, including print books (e.g., Dowdall et al., 2020; Krcmar & Cingel, 2014; Yuill & Martin, 2016), digital books

(e.g., Chen, 2024; Parish-Morris et al., 2013; Strouse et al., 2023), and more recently, Augmented Reality **(**AR) books (Cheng & Tsai, 2016; Cheng & Tsai, 2014). Through these studies, it was found that reading mediums can alter shared reading experiences (Krcmar & Cingel, 2014), children's language (Ewin et al., 2021), and the richness of book conversation (Strouse et al., 2023). For example, previous research investigated how different reading mediums influence the quantity and the quality of book conversation during adult-child shared reading (e.g., Ewin et al., 2021; Krcmar & Cingel, 2014; Parish-Morris et al., 2013), and concern has been raised toward the quality of book conversation when readers shared a digital book as readers' talks tend to be related to the device in addition to the content (Ewin et al., 2021; Krcmar & Cingel, 2014; Parish-Morris et al., 2013). Strouse et al. (2023), however, claimed that the quality of book-talk (content-related) is not necessarily decreased when readers share digital books if these books are carefully designed (e.g., include only story-relevant hotspots).

Previous research has only investigated adult-child shared book reading, either where the child shares a book with a parent or a teacher, and child-child dyad reading (e.g., Brown et al., 2018; Downs et al., 2020; Lloyd Eldredge & William Quinn, 1988), which was commonly to be implemented in the form of peer tutoring, where two children with two different reading levels read together (Topping et al., 2015). Indeed, given the positive influence of child-child dyad reading on children's reading comprehension (Flores et al., 2024; Van Keer, 2004) and reading fluency (Duran et al., 2019), and the relationship between reading difficulties and anxiety (McArthur & Castles, 2017; Novita et al., 2019; Wilmot et al., 2023), reading alongside a peer with reading difficulties using a different reading medium (e.g., AR book) has the potential to create a more relaxing social reading environment for children with reading difficulties.

In the following section, different reading mediums of children's books will be discussed, including print, digital, and AR books, highlighting the value of static and dynamic illustrations. Reading mediums are discussed in relation to reading experience in general and then specifically in relation to reading engagement.

2.4. Reading mediums

2.4.1. Print and Digital books

In recent years there has been growing interest in children's literacy learning, including learning within the context of literacy and technology (Kawas et al., 2020). For example, compared to the previous decade (2002-2010), the number of research published between 2011 and 2019 by the Interaction Design and Children journal (IDC) that focused on the role of technology in supporting children's cognitive development has increased from 7% to 16% (Kawas et al., 2020). On the other hand, in reading research, there has been growing interest in exploring the medium effects (e.g., reading on screen) and how reading mediums influence child readers' reading experiences (see Furenes et al., 2021; McDermott & Gormley, 2016; Ortlieb et al., 2014; Putro & Lee, 2017). Indeed, print books have experienced a variety of enhancements with the aim of promoting reader learning and engagement. For instance, search and find activities, tactile features such as pop-ups and flaps, comprehension questions, and the interactive features of digital books (Rouse & Holloway-Attaway, 2020; Shinskey, 2021; Vanderschantz et al., 2019; Xu et al., 2021). At one point, it was expected that print books would be replaced by the existence of digital books (Ha et al., 2011). Print books, however, are still used more widely, possibly due to their physical features, including flexibility, tangibility, robustness, transportability, and possession (De Ioannes Becker & Hornecker, 2021; Ha et al., 2011; Grasset et al., 2008).

There have been inconsistent results when comparing the influence of paper and digital books on children's reading experiences. For example, some studies have suggested that adding additional features to digital books would distract children from reading, which has negative consequences on their comprehension (Altun, 2018). For example, Altun (2018) found that compared to print books, digital storybooks were not more effective in terms of supporting readers' comprehension as the representation of the additional features in the digital book may distract readers from following the storyline due to the limited capacity of the working memory to process information, which was highlighted by Cognitive load theory (Sweller, 1994). In their meta-analysis, Furenes et al., (2021) examined 39 studies to investigate the inconsistent results related to the influence of reading mediums (digital books vs. paper books) on children's reading comprehension. They reported that specific enhancements in digital books (e.g., adding additional explanations of story content) could minimize the negative effect of digital books on children's comprehension (Furenes et al., 2021). Indeed, different findings of the impact of digital books on children's reading experience can be explained by the differential effects of different designed features – where some features may distract and hence have a negative impact, whilst others may support. For example, previous research reported that including elements such as hotspots and games may lead to poor comprehension (Altun, 2018; Bus et al., 2015; Takacs et al., 2015), while adding certain well-designed elements (e.g., animated pictures and sound) could support children's comprehension and literacy development (Altun, 2018; Bus et al., 2015; López-Escribano et al., 2021; Takacs et al., 2015).

Static and dynamic illustrations in children's books. Illustrations in children's books facilitate reading (Brookshire et al., 2002), promote their literacy (Brookshire et al., 2002), stimulate children's senses (Sun et al., 2025)**,** and affect their book selection (Brookshire et al.,

2002). In addition, previous research suggests that high-quality illustrations in children's picture books can increase vocabulary usage, narrative ability, and narrative retelling (Davis et al., 2024). In their study, Brookshire et al. (2002) compared 71 first and third-grade children's reading comprehension under three conditions: reading a book with illustrations only, a book with text only, and a book with both illustrations and text. The result revealed that children showed a higher level of comprehension when they read a book that combined both the text and the illustrations simultaneously (Brookshire et al., 2002)**.** However, Brookshire et al. (2002) argued that illustrations are expected to support reading, so they should not be eccentric or novel to avoid defeating the purpose of children's picture books (i.e., reading) (Brookshire et al., 2002).

The relationship between illustrations and text is a key element of designing children's books, which was highlighted by a recent systematic review (Sun et al., 2025), as the interaction between the text and the illustrations affects children's ability to process and understand texts (Brookshire et al., 2002; Sun et al., 2025). To explain how individuals learn from words and pictures, Mayer and colleagues (2002) developed Multimedia learning theory which highlighted that Multimedia learning occurs "when people build mental representation from words (such as spoken text or print text) and pictures (such as illustrations, photos, animations, and video" (Mayer, 2005, p. 3). For example, in 1992, Mayer and Anderson found that effective learning from pictures and words happened when they were presented at the same time or space (Mayer & Anderson, 1992). In addition, the interaction between text and illustrations can serve different purposes, such as providing similar information (the concurrence function) or delivering reciprocal information (the complementarity function) (Unsworth, 2006; Zhou & Yadav, 2017). In contrast to using illustrations as an additional cue (picture-independent text), reading "picture-dependent" text where children cannot read the text without referring back to the picture could distract them from

reading, particularly those readers with below-average reading skills or children who just started to read (Brookshire et al., 2002).

Pictures can be designed and presented in different ways, which have different consequences on students' learning. For example, the emotional design adopted enhancements such as human-like features and distinct colours (Mayer & Estrella, 2014). In their study, Mayer and Estrella (2014) found that students who used enhanced graphics in a multimedia lesson, developed based on emotional design, performed better in the learning test than those who used black-and-white drawings. However, Mayer and Estrella (2014) highlighted that these enhancements should be relevant to the content to minimise the harmful effects of seductive details (i.e., interesting but irrelevant information) (Sundararajan & Adesope, 2020), which represents one of the principles outlined by multimedia learning theory to develop more effective learning environments (Mayer, 2005). In their review of 411 peer-reviewed articles (published between 1996 and 2016), Li et al. (2019) reported that coherence (elimination of seductive details), contiguity (visual and verbal information presented contiguously, both temporally and spatially) and redundancy (exclusion of extraneous information) were the most common principles of multimedia learning theory discussed and implemented for developing more effective learning environments (Li et al., 2019).

In digital books, illustrations can take different forms (e.g., static and dynamic) (Takacs et al., 2015), and it was found that multimedia effects in digital books (e.g., multimedia motion pictures) could facilitate children's mental imagery skills (i.e., mental representation of the story), resulting in positive consequences on children's comprehension (Altun, 2018; Boerma et al., 2016). As multimedia effects in digital books (e.g., motion pictures) can have different effects on children's reading experiences depending on how they are designed and integrated with the text,

this raises important questions for new technologies that offer new types of digital features (e.g., AR technology). With the additional enhancement of illustrations offered by AR technology (e.g., 3D animation), Augmented Reality (AR) books have the potential to extend children's reading experiences and reading engagement in different ways.

2.4.2. Augmented Reality (AR) books

Augmented Reality **(**AR) books are physical books that are augmented with digital features (e.g., animation, sound, interactive activity), which are currently activated through electronic devices (e.g., phone, tablet computer, iPad) directed towards the physical book (see Figure 4) (Besa, 2021; Cheng & Tsai, 2014; Panchenko et al., 2020; Polyzou et al., 2023; Shinskey, 2021; Vanderschantz et al., 2019). Unlike digital books, AR augments paper books with an additional digital layer of features afforded by a digital device. AR books, therefore, are separate from the work on physical (i.e., paper) or digital books, offering new opportunities and questions about the impact of this technology on children's reading experiences and engagement. For example, more physically interactive reading experiences and an interactive space for students can be offered due to combining paper and digital content (Wang, 2022), and the rotating of the device to explore 3D models from various angles (Yang et al., 2025).

There is a large body of research developing on the value of Augmented Reality (AR) technology in educational settings, including AR games, AR-based learning material, and AR books (Akçayır & Akçayır, 2017; Bujak et al., 2013; Cuendet et al., 2013; Fernández-Batanero et al., 2022; Wu et al., 2013; J. Wu et al., 2024), and it has been claimed that AR technology has a positive influence on students' reading concentration (Wang et al., 2019), learning effectiveness (Chang et al., 2023) and transmission of knowledge (Fernandes & Leite, 2023), in addition to

supporting reading attitudes and motivation (e.g., Othman et al., 2021; Roumba & Nicolaidou, 2022; Yilmaz et al., 2017).

In their study, Tobar-Muñoz et al. (2017) explored the impact of AR game-based learning on students' performance in reading comprehension and motivation. In their comparative study, the authors randomly divided students (aged 8-12 years) into two groups. The first group read the book and engaged with AR features in the AR game, while the second group only read the book. The findings indicated that students in the experimental group showed greater motivation and interest compared to the control group. The result, however, did not show any differences in terms of reading comprehension. On the other hand, Chien et al. (2019) investigated the influence of AR-based learning material on comprehension and learning achievement while delivering a plant observation activity among third-grade students. The findings of their quasi-experimental study indicated that students who observed the plants through AR showed a significant increase in their comprehension. The data of students with learning difficulties, however, were eliminated by the authors before analysing data.

Within the context of AR books, few studies have investigated the influence of AR books on elementary school students' reading experiences. Table 1 represents seven studies published between 2012 and 2025, where three criteria were adopted for inclusion: Reading medium (AR book), participants (elementary/primary school) and setting of research (school or library, not home), using "*Scopus*" database, "*Google Scholar*" research engine, and "read", "AR book", "Augmented reality book", "child", "primary", and "elementary" as search terms. For example, Danaei et al. (2020) compared students' reading comprehension among two groups (aged 7 to 9); the first group used AR storybooks, while the second group read print storybooks with the same content. The findings revealed that students who used AR storybooks experienced a significant

improvement in reading comprehension due to the additional features that AR storybooks offered. However, children's reading skills were not evaluated before conducting the experiment, as this study adopted a post-test design. In addition, in their experiment, only 2D animations were included in the AR book, and the involvement of 3D animations may lead to additional insights. Moreover, it was noticed that the influence of AR features on children's reading comprehension was often evaluated by recalling (Tobar-Muñoz et al., 2017), re-telling, and comprehension questions (Danaei et al., 2020). Considering a different approach, such as representing children's voices on how AR books would support their reading understanding and reading experiences may extend previous research findings. For example, in their quasi-experimental study, Wu et al. (2024) noted that primary school students experienced lower cognitive load and showed flow experience, which is defined as a " positive psychological state with challenges, internal rewards and pleasure", when they interacted with Augmented Reality *(*AR) mathematical picture books, compared to students who either used mathematical picture books only or mathematical texts only (Wu et al. 2024, p. 24633). Based on the interview data, students found the AR books helpful in extending their understanding, particularly due to the presence of three-dimensional images (Wu et al. 2024). Indeed, as reported in previous research on paper and digital books, the influence of AR technology on children's reading experiences could vary depending on how AR features are designed and integrated (i.e., adding value to paper books by underlining the meaning rather than distracting the reader from the content) (Grasset et al., 2008).

Figure 4

Augmented reality book accessed via a tablet computer


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Table 1

A summary of papers examining the influence of AR books on elementary school students' reading experiences and/or outcomes.

Publication year and setting	Authors	Title	Book genre	N and age (all primary school)	Research design	Outcome variable(s)	Measures	Key findings	AR access via
2025 School	Yang, G., Yan, Y., Guo, S., & Wei, X.	The Impact of Embedding Interactive Tasks in Augmented Reality Storybooks on Children's Reading Engagement and Reading Comprehension.	Storybook.	40 children aged 8-10 years.	A mixed-methods approach.	Reading engagement, story retelling, and story understanding.	The Reading Engagement Assessment Protocol, Morrow's 10-point scale evaluations for retelling, and semi-structured interview	Children in the experimental group showed significantly higher levels of reading engagement, story retelling, and reading comprehension.	Tablet computer
2024 School	Liu, S., Sui, Y., You, Z., Shi, J., Wang, Z., & Zhong, C.	Reading better with AR or print picture books? A quasi-experiment on primary school students' reading comprehension, story retelling, and reading motivation.	Storybook.	80 second-grade students.	A quasi-experimental study.	Reading comprehension, story retelling, and reading motivation.	Reading comprehension tests, story retelling tests, and reading motivation scale)	Children in the experimental group showed significantly higher levels of reading motivation, comprehension, and story retelling.	iPad
2024 School	Wu, J., Jiang, H., Long, L., & Zhang, X.	Effects of AR mathematical picture books on primary school students' geometric thinking, cognitive load, and flow experience.	Nonfiction book: (mathematical).	83 fourth-grade students.	A quasi-experimental design.	Geometric thinking level, cognitive load, and flow experience.	Geometric thinking assessment test, a flow experience scale, a cognitive load scale, and an interview.	Students' geometric thinking levels significantly improved with AR features. Students experienced lower cognitive load and showed flow experience.	Tablet computer
2022 School	Roumba, E., & Nicolaidou, I	Augmented Reality Books: Motivation, Attitudes, and Behaviors of Young Readers.	Nonfiction books: (world's monuments, the Sun and other planets).	40 fourth and fifth-grade students.	Pre-test post-test case Study.	Changes in motivation to learn, attitudes, and behaviors	Questionnaire measuring motivation, attitudes, behaviors, and observation.	Children's motivation to learn significantly increased, and children's attitudes and behaviors toward AR book reading were positive,	Smartphone
2020 Library	Danaei, D., Jamali, H. R., Mansourian, Y., & Rastegarpour, H.	Comparing reading comprehension between children reading augmented reality and print storybooks.	Storybook.	34 children aged 7 to 9 years.	A quasi-experimental methodology; post-test only.	Reading comprehension.	Observation, and Morrow's (1985) 10-point scale for retelling, implicit and explicit questions for recalling, and interview.	Improvement in reading comprehension as students did better in retelling and answering comprehension questions.	Tablet

Year of publication and setting	Authors	Title	Book genre	N and age (primary school)	Research design	Outcome variables	Measures	Key findings	Access via
2018 Library and school	ChanLin, L. J.	Bridging Children's Reading with an Augmented Reality Story Library	Storybook	Observation: 20 children Questionnaire: 137 elementary school students aged above 10 years.	Not specified	Children's reaction to AR reading.	Observations and questionnaire: reading enjoyment and the use of the AR interface.	Children were positive about AR reading as they enjoyed AR reading and expressed a desire to read more AR stories.	Tablet
2012 School	Eiksund, O.	Children's Interaction with Augmented Reality Storybooks	Storybook (prototype)	21 children, aged 8 and 9 years	An interaction design approaches.	Children's interaction with the AR storybook.	Observation and questionnaire.	Children expressed positive emotions while they interacted with the AR book. Although children easily interacted with the AR book, they found the hand-held PC screen heavy, especially if they held it for a long time.	Hand-held PC screen.

Criteria for inclusion: All studies had to include the following criteria to be included: Reading medium (AR book), participants (elementary/primary school) and setting of research (school or library, not home).

Reporting of age is inconsistent (age/grade), as information is reported based on published information in the articles.

Digital devices are reported based on published information in the articles.

2.5. Reading engagement and different book types

2.5.1. Reading engagement with print and digital books

Compared to print books, readers can engage with digital books in many different ways, and diverse navigation profiles may lead to varied reading experiences and outcomes. In the context of digital books, prior research showed changes in children's navigation while reading. For example, several studies have shown that compared to reading print books, reading digital books, either children read by themselves (e.g., Zhou & Yadav, 2017) or shared reading with an adult (e.g., Moody et al., 2010), fosters a higher level of children's reading engagement, including behavioural (e.g., attention, reading time) (Clinton-Lisell et al., 2024), and emotional (e.g., facial expressions such as a smile) engagement (Moody et al., 2010).

In another study, Zhou and Yadav (2017) randomly assigned 72 children (aged 4-5 years) to one of four conditions, including reading a print story only, reading a print story with questions, reading a multimedia story (i.e., a digital version of the story runs through a touch screen device), and reading a multimedia story with questions. Participants in each condition were asked to read the story twice over two weeks to generate observable outcomes. Zhou and Yadav (2017) implemented an observation protocol with a 3-point Likert scale while analysing reading session videos to assess children's reading engagement. The findings revealed that children's physical and emotional reading engagement was positively affected by reading a multimedia story compared with a print storybook. However, there was no significant difference in terms of verbal engagement (Zhou & Yadav, 2017). Similarly, in their study, Moody et al. (2010) used a within-subjects experimental design and assigned children (aged 3-6 years) to three reading conditions: adult-led digital storybook condition, child-led digital storybook condition, and adult-led print storybook condition to explore the influence of different reading mediums on children's engagement (e.g.,

persistence and enthusiasm) and communication. Moody et al. (2010) noted that children who participated in an adult-led digital storybook session had a higher persistence level than those who participated in an adult-led paper storybook session. However, it was claimed that reading digital books may negatively affect children's reading engagement, such as being associated with a tendency to skim texts (Lim & Toh, 2020), consuming more time, and prompting communication about the device (Richter & Courage, 2017).

2.5.2. Reading engagement with Augmented Reality Books

With the recent emergence of AR books, qualitative research is necessary to better understand children's perspectives and experiences of AR books and how it relates to their reading engagement. Thorough examination of existing literature, no qualitative study has been conducted to determine the influence of AR storybooks on the four dimensions of children's reading engagement in parallel. That said, some studies have investigated the positive influence of AR books on children's behavioural (e.g., interaction) and verbal (e.g., negotiation) engagement while they read by themselves or during sharing reading with their parents (e.g., Järvenpää, 2022; Othman et al., 2021). Recently, in their study, Yang et al. (2025) assessed 40 children's (aged 8-10 years) physical, verbal, and emotional engagement through the Reading Engagement Assessment Protocol using a three-point Likert scale. Each category of reading engagement includes several behavioural indicators (e.g., attention allocation). In addition, children joined semi-structured interviews for cross-validation. The findings revealed that children who read the AR book with interactive tasks showed significant improvement in their reading engagement, including the three aspects of reading engagement (i.e., physical, verbal, and emotional engagement) compared to children who read the AR book without interactive tasks embedded into the AR book (Yang et al., 2025). Yang et al. (2025) highlighted the role of the interactive task in

shifting children's engagement toward the content of the AR book instead of being only engaged with the AR features. Indeed, research has shown how the influence of AR books on children's reading experiences is complex, nuanced, and highly variable, notably due to the influence of book design (e.g., embedding interactive questions) (Yang et al., 2025), and individual differences between children, which emphasizes the need for in-depth examination that qualitative research is well-positioned to do.

One of the key challenges of evaluating the influence of new technology is that it depends on how the technology is used in real-world settings – where the focus of this thesis is classroom contexts. In the following section, the usability of implementing AR books in educational settings is discussed.

2.6. Usability of implementing AR books in educational settings.

Usability is a key factor in facilitating the implementation of AR technology in classrooms (Akçayır & Akçayır, 2017). Usability includes many aspects, such as safety, efficiency, effectiveness, and ease of use (Cheng, 2019; Cheng & Tsai, 2013). In their systematic review, Akçayır and Akçayır (2017) reported that usability issues are the most common challenges in implementing AR technology in educational settings, and these issues need to be addressed to prevent their negative effect on students' experience (e.g., consuming students' time) (Akçayır & Akçayır, 2017; Yilmaz et al., 2017). Indeed, positive experience with AR books in school settings is important, as user satisfaction was highlighted by Avila-Garzon et al. (2021) as a key element that measures the usability of AR applications in an educational context within their review of twenty-five years of augmented reality in education.

Given that AR technology demands quite intensive interaction (e.g., rotating of the device to explore 3D models from various angles) (Cheng & Tsai, 2013; Yang et al., 2025), it is important

to develop usable (i.e., ease of use) and flexible systems, which may have positive consequences for student engagement with the AR experience (Cheng, 2019; Cheng & Tsai, 2013; Daşdemir, 2022). In addition, it is crucial to consider students' active participation while implementing AR technology in classrooms (Fernández-Batanero et al., 2022), as autonomy plays an essential role in children's learning, prompts children's interest, and activates learning processes (Grolnick & Ryan, 1987). For example, in their study, Kerawalla et al. (2006) found that students (aged 10 years) who used AR technology to learn astronomy were less engaged compared to students who used traditional resources. Cheng and Tsai (2016) argued that less engagement may emerge from the absence of autonomy since most of the AR operation, which was carried out by Kerawalla et al. (2006), was demonstrated by the teacher rather than the children. Finally, additional barriers such as the lack of resources, technical support, time, and resistance to change could complicate the implementation of AR books in educational settings (Panchenko et al., 2020).

2.7. Chapter Summary and Rationale

Children's reading enjoyment and engagement are at an all-time low (Clark et al., 2023), and it is suggested that approximately fifteen per cent of children struggle with reading (Francis et al., 2022; McArthur & Castles, 2017). Yet digital literacy practices are becoming increasingly present in children's lives (Picton et al., 2022), and AR books offer a way to blend print and digital forms of reading. There is an essential need for research to understand whether, and how, AR books can be utilised in ways to enhance children's reading experience and outcomes. Indeed, children show active involvement in the reading process when their voices in relation to reading are heard (Ng, 2018). Given that children are the ultimate users of AR books, children's thoughts and insights are crucial to inform educators, designers and authors to optimally improve children's reading experiences and outcomes.

The framework of reading engagement (Lee et al., 2021a), which highlighted the importance of the four dimensions of reading engagement (behavioural, cognitive, affective, and social), offers a comprehensive approach to investigating and extending understanding of children's experiences with AR books, given the technology's potential to shape, extend or alter children's reading engagement in ways which have not been previously investigated in print or digital books.

In the context of digital books, previous research demonstrates the positive effects of digital books on children's behaviour and affective reading engagement (e.g., Clinton-Lisell et al., 2024; Moody et al., 2010; Zhou & Yadav, 2017). Within the context of AR books, children use a digital device to switch between the text, illustrations, and AR features (Dünser & Hornecker, 2007; Fiusa et al., 2023), which likely have consequences for children's behavioural engagement, such as inviting more interactive reading behaviours. In addition, in line with the multimedia learning theory (Mayer, 2005), AR books may influence children's cognitive load and strategies while reading (Cheng, 2016), as they are expected to integrate content from the text, illustrations, and the AR features to comprehend the story. As AR features offer an additional source of information, these features may be perceived differently by child readers, either to support or hinder their comprehension. Furthermore, new affective reading experiences could be invoked by AR books' features, given their novelty for most children, and as these books have different natures when compared to paper books. Finally, given the integration of physical and digital interactivity offered by AR books, AR books may shape children's social interactions and create different opportunities for children to explore and discuss AR books together. Indeed, previous research has shown how digital features can have different influences on children's reading experiences. Thus, there is a

need for a deep, critical exploration of how children's reading engagement is influenced by AR-specific features based on children's perspectives.

This research aimed to explore how primary-aged children (aged 8-10) with different reading skill levels perceived the features of AR books as supportive, or not, of their reading engagement (behavioural, cognitive, affective, and social) based on their reading experiences (Study 1). As this research evolved and based on the Study 1's findings, the scope was narrowed to focus particularly on children with reading difficulties to explore how AR books support their social reading engagement (shared reading and book talk) (Study 2) (see section 3.2.3), This research adopts the classification of the Simple View of Reading (Gough & Tunmer, 1986) to report details about the sample (i.e., reporting the type of reading difficulties).

In the next chapter (chapter 3), the research design will be discussed, including the research questions, the philosophical assumption behind this research, the methodological approach, methods of data collection and the rationale behind the choice of data collection tools, the recruiting sample procedure, data analysis process, ethical and methodological considerations, and open research practices. Following this, Chapter 4 will present Study 1, which was published by *Frontiers in Psychology* on 14 Aug 2024, and Study 2 will be presented in Chapter 5, which was submitted to *Reading Psychology* on 04 December 2024. Chapter 6 will present an article that aims to raise young readers knowledge of AR books. This article is provisionally accepted (12 May 2025) and under final validation (where the cartoon production process begins) by *Frontiers for Young Minds*. Finally, thesis will be discussed in Chapter 7.

Chapter 3

Methodology

This chapter represents how my philosophical position informed the design of this research, starting with the worldview, which sheds light on the philosophical assumption behind this research and informs the theoretical lens, followed by the methodological approach, and methods of data collection (Creswell & Clark, 2018). In addition, this chapter provides the rationale behind the choice of data collection tools, how these tools were developed, and how the materials (AR and non-AR books) were selected. Moreover, the recruiting sample procedure and data analysis process are reported in detail, ending this chapter by describing ethical, methodological considerations and open research practices.

In order to critically reflect on methodological considerations, below is a summary of each study's objectives and research questions.

3.1. Research Aims and Questions

Overarching Objectives (study 1)

I. To explore children's perspectives and experiences of Augmented Reality (AR) books, within the framework of reading engagement.

II. To explore teachers' perceptions of the usability of AR books in the classroom.

Research Questions (study 1)

1. How do children interact with AR storybooks in a classroom setting in real-time?
2. How do children perceive the features of AR storybooks as supportive of their reading engagement?
3. What are teachers' perceptions of the usability of AR books in the classroom?

Aligned with open research practices, the study was preregistered and can be accessed here: https://osf.io/9q678

Overarching Objectives (study 2)

I. To explore whether AR features influenced the quantity of book-talk between children with reading difficulties.

II. To understand the perspectives and experiences of children with reading difficulties, following reading an AR and non-AR book with a peer.

Research Questions (study 2)

1. To what extent does AR influence the quantity of book-talk between children with reading difficulties after reading?
2. For children with reading difficulties, what are their perspectives and experiences of reading with a peer, using an AR and non-AR book?

Aligned with open research practices, the study was preregistered and can be accessed here: https://osf.io/x6r4z

3.2. Research Philosophy

3.2.1. Worldview

This research is an interdisciplinary project bringing together perspectives from the fields of education, psychology, and technology. The term 'worldview' is used instead of 'paradigm' in line with (Creswell & Clark, 2018) who suggested that this term reflects shared beliefs and values of researchers without being associated with a specific discipline. Different worldviews inform different research designs based on how the researchers perceive the nature of reality (ontology) and how the researchers define the relationship between themselves and what is being researched

(epistemology) (Biesta, 2010; Creswell & Clark, 2018; Hesse-Biber et al., 2015). Quantitative approaches are associated with the postpositivist worldview, one singular reality, while qualitative methods are associated with the constructivist worldview, multiple realities (Hesse-Biber & Johnson, 2015). However, this research adopted a pragmatist worldview, which is associated with mixed methods research, where the researcher is not forced to select between these two worldviews but combines both (Creswell & Clark, 2018), preserving the nature of reality as singular (testing hypothesis: AR features influence the quantity of book-talk) and multiple (representing different perspectives). Indeed, even though this approach was received as epistemologically incoherent (Howe, 1988), such an approach is appropriate in some research settings (Tashakkori & Teddlie, 2010). In addition, the pragmatist worldview was adopted since it prioritizes the research questions and what is practical to address them (Creswell & Clark, 2018).

3.2.2. Theoretical lens

This research adopted a *reading engagement framework* (Lee et al., 2021a) within a social science theory as a guiding explanation, which shaped the direction of both studies (Creswell & Clark, 2018). Study 1 provides insights into children's perspectives and experiences of reading AR books, within the framework of reading engagement, exploring behavioural, affective, cognitive, and social aspects (Lee et al., 2021a), while Study 2 examined whether AR books can foster positive and productive social reading experiences for children with reading difficulties within the framework of reading engagement, particularly the social aspect (Lee et al., 2021a). Even though Study 1 was qualitative, the framework was adopted as a preliminary framework and modified as the data were analysed (e.g., extending the definition of behavioural engagement to include reading behaviours such as navigation strategies). Indeed, this approach, which is called the inductive interpretive approach, is used in qualitative research (Creswell & Clark, 2018). In addition, while

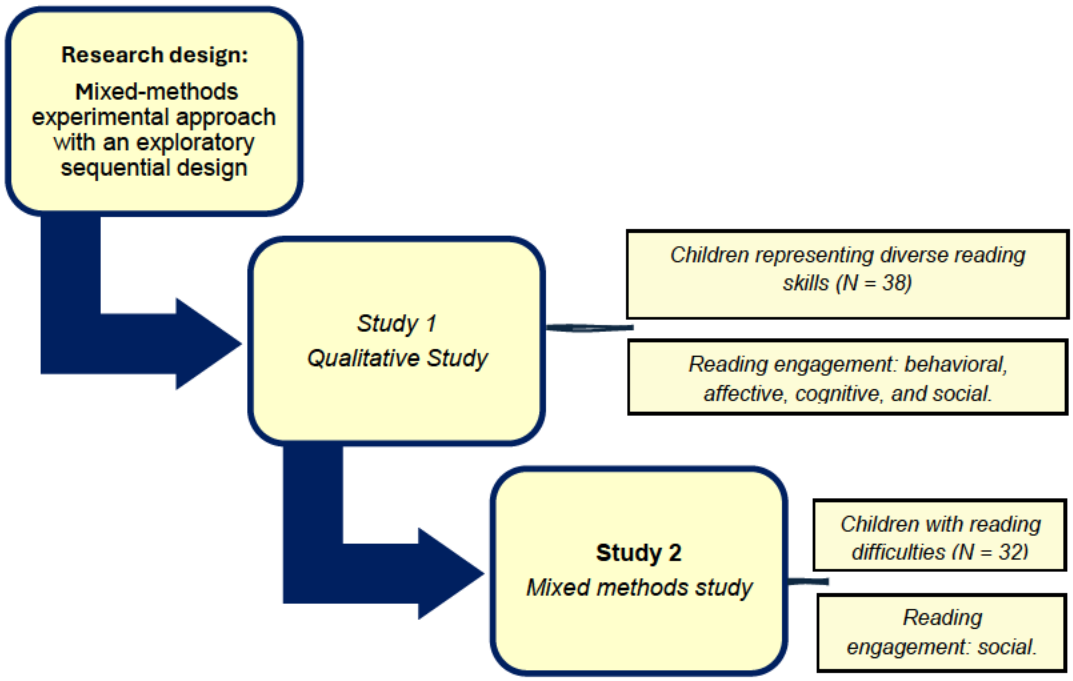
this research emphasised the uniqueness of each student, which is in line with the constructivist learning theory (Bada & Olusegun, 2015), this research stresses the role of social interaction, which is in line with Vygotsky's sociocultural theory (John-Steiner & Mahn, 1996).

3.2.3. Methodological approach

Study design. This research adopted a mixed-methods experimental design to provide in-depth insights into children's reading experiences with AR books. More specifically, this research adopted a mixed-method approach with an exploratory sequential design, which begins with prioritising the collection of qualitative data (Study 1) and then, based on the exploratory results, designing a "quantitative feature" (Creswell & Clark, 2018, p. 67). (see Figure 5). Study 2's social reading experiences, including shared reading and the book-talk, were designed based on the qualitative results of the first study (Alhamad et al., 2024). More specifically, in Study 1, children reported that AR books offered social opportunities to interact with peers and allowed them to discuss the book together. In addition, Study 1 children, particularly those with reading difficulties who more frequently chose to read the AR book alone, commented on a desire to share reading AR books with others. Moreover, even though the first study primarily focused on children's experiences of AR books, two class teachers, who were familiar with AR books, were interviewed to explore their perceptions of the usability of AR books in classrooms. Both teachers reported that AR books would support children's social reading experiences (e.g., prompting book talk among children), and were interested in implementing AR books in one-on-one or small-group settings.

Figure 5

Research design: Study 1 & Study 2: Participant and reading engagement focus

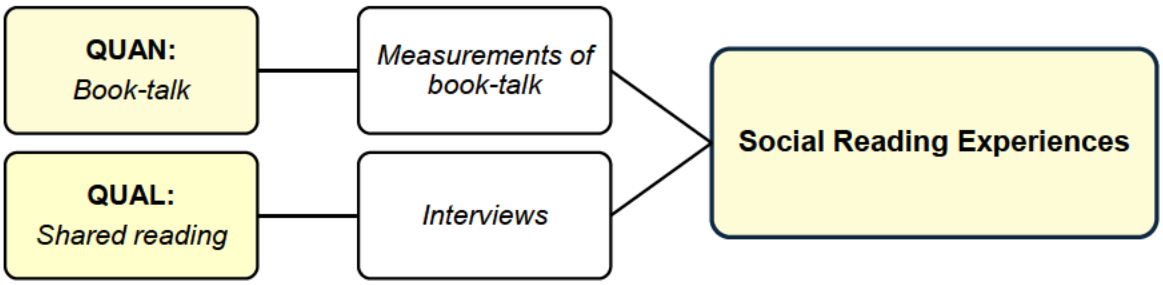


Study 1 adopted a qualitative design, using observations to determine accessibility and interviews to examine the influence of Augmented Reality (AR) books on children's self-reports of reading engagement and teachers' perceptions of the usability of AR books in the classroom. On the other hand, Study 2 adopted a mixed-method experimental design to examine whether AR books can foster positive and productive social reading experiences for children with reading difficulties. In Study 2, a convergent parallel mixed design (QUAN+QUAL) was adopted, where quantitative and qualitative data were collected simultaneously and analysed separately. Then the results of quantitative (measurements of book-talk) and qualitative (interviews) data analysis were combined (see Figure 6) (Creswell & Clark, 2018) to bring greater insights into how AR books can foster positive social reading experiences for children with reading difficulties. It did this by reporting statistics (QUAN) while giving voice to children (QUAL), in line with the constructivist perspective of learning which values students' perspectives and involvement (Ng, 2018). The

experimental design of Study 2 was applied within the *repeated measures design* (Creswell & Clark, 2018), which was selected to minimize confounding variables such as participant characteristics (Boettinger, 2021). In addition, a counterbalanced implementation design (complete counterbalancing) was adopted in the experimental study to control the influence of order effects, which would enhance the interval validity (Allen, 2017) (see Appendix A1).

Figure 6

Study 2's design: a convergent parallel mixed design



Recruiting participants: children. Non-probabilistic sampling was used to recruit participants in both studies, which included selecting children who were available and provided consent to participate (in addition to obtaining teacher and parent/guardian consent) (Andrade, 2021; Creswell & Clark, 2018). Recruiting schools was an unpredictable process and one of the challenges faced due to having limited time to collect data, so opportunity sampling was used even though it has limited external validity and its findings cannot be generalized (Palinkas et al., 2015).

However, one of the advantages of opportunity sampling is that it could have high internal validity (Palinkas et al., 2015).

Even though opportunity sampling was used to recruit children for both studies, the procedure was different. In Study 1, the school, which had a known demographically diverse school population, was directly contacted based on the existing link of the first supervisor, while the schools in Study 2 were contacted in several ways simultaneously. First, schools were emailed based on the City of Edinburgh Council's website (https://www.edinburgh.gov.uk/), which provides all contact details and information about Edinburgh's primary schools (38 schools were emailed). Meanwhile, a poster was created and shared with colleagues who had connections with schoolteachers' groups to share it informally, and with the City of Edinburgh Council to pass it formally to schools, along with the existing links of both supervisors. Prior to both, City of Edinburgh local authority approval was sought and received.

Study 1 aimed to recruit a diverse sample in terms of reading skills levels, reading enjoyment levels, and cultural background to reflect diverse perspectives on whether, and how, children might perceive AR books as supportive of their reading engagement. Although opportunity sampling was used to recruit the school, the diversity criteria was considered by recruiting a school with a diverse population. The sample was narrowed in Study 2 to focus particularly on children who report difficulties in reading to get in-depth insights into whether, and how, AR books could support their social reading engagement.

To indicate the necessary sample size for a quantitative sample, power analysis formulas for experiments are used (Creswell & Clark, 2018). Given that the second study sample is quantitative, *G*Power* was used to determine the adequate sample size of the paired samples t-test

(Mayr et al., 2007), which is compatible with Cohen's effect size measures and perceived to be useful (Erdfelder et al., 1996). While Study 2 prioritizes children with reading difficulties, the term "*children with below-average reading skill levels"* was used in the preregistration process, using *below-average* as the criteria to extend the sample (i.e., readers with poor reading skills who are not diagnosed with reading difficulties) if a sufficient number of children with reading difficulties did not participate. The term "children with reading difficulties" was used across two studies, referring to students who experience difficulties with reading in line with Al Dahhan et al. (2016), as this terminology does not carry implications regards the cause or the remediation and reading difficulties were reported based on the classification of the simple view of reading (Gough & Tunmer, 1986). Please see sections 4.5.1 and 6.6.1 for participants' details from Study 1 and Study 2. Participants' details/the background characteristics of the sample were school-held data and reported to outline a diverse representative sample. However, 'English as an Additional Language' data is not reliable/consistent, as there was a variation between schools in terms of including students under this category. Therefore, the background characteristics data need to be interpreted with consideration of this.

In terms of tablet/iPad use proficiency, the sample in both studies had already had access to tablet/iPad devices, as schools in Scotland have 1:1 device access due to the government strategy (Nisbet, 2023). However, there is a variation between schools in terms of access to tablet/iPad devices (Nisbet, 2023). In terms of prior experience using AR, the sample participated in a workshop on how to use AR within the classroom (Study 1) or small groups (Study 2).

Recruiting participants: teachers. As teachers were required to have familiarity with AR books prior to taking part in the interviews, purposeful sampling was used to recruit teachers so

only those class teachers from the classes participating in this project took part in the interviews. As a result, the sample size is small (n = 2). Indeed, purposeful sampling is used in qualitative research to provide rich data with limited resources (Palinkas et al., 2015).

3.2.4. Methods of data collection

3.2.4.1. Choice of tools and materials

Tools. Study 1 used interviews and observations to collect data and requested demographic information (gender, age, ethnicity, English as an Additional Language (EAL), and difficulties with reading, either decoding and/or comprehension). In childhood research, interviews have been used to generate in-depth- data and to provide valuable insights (Rolfe & Siraj-Blatchford, 2010). In previous AR research, interviews have been used by Yilmaz et al. (2017) to shed light on children's views and perspectives of AR books and their potential to support cognition and listening skills (Yilmaz et al., 2017), reading comprehension (Hornecker & Dünser, 2007), and attention (Polyzou et al., 2023). Further, teachers were interviewed by Othman et al. (2020) to reflect on an AR approach to support children's motivation to learn, and children's literacy learning in early childhood classrooms (Pan et al., 2021). Applying interviews, thus, would allow children to reflect on and share their experiences of reading and the AR book, to understand whether, and how, the AR books have potential to support reading engagement. In addition, observations immediately preceding interviews, with the researcher being there for both, would prevent misinterpreting the data and support the progress of the interviews. For instance, the researcher can prompt children by referring back to the use of the AR book during the interviews, which allows children to link their thoughts with their recent experiences.

Observations allow real-time use to be captured as well as spontaneous reactions, and experiences associated with AR books. Unstructured observation is often applied at the beginning

stage of the research to capture all possible behaviours (Brewer, 2008). In AR research, observations have been used to explore how children interact with AR objects (Dünser & Hornecker, 2007), AR platform (ChanLin, 2018), AR game-based learning (Tobar-Muñoz et al., 2017), and AR storybooks (Polyzou et al., 2023; Roumba & Nicolaidou, 2022), and to capture how children and their parents interact during AR book reading sessions (K.-H. Cheng & Tsai, 2014). Indeed, qualitative data can be collected by observation (Brewer, 2008). Given that structured observation with AR book reading is rare and there is little guidance for researchers to use to formally observe AR book reading, applying semi-structured observation is appropriate, albeit with pre-planned ideas of what this study intended to capture. However, the validity of the observations has been received with some concern e.g., whether the researcher reflects the true picture of what has been observed (Baker, 2006). Conducting interviews, thus, would strengthen the validity of the observation since this procedure would allow the researcher to generate data from more than one resource, which promotes the accuracy of the findings (criterion validity) (Baker, 2006).

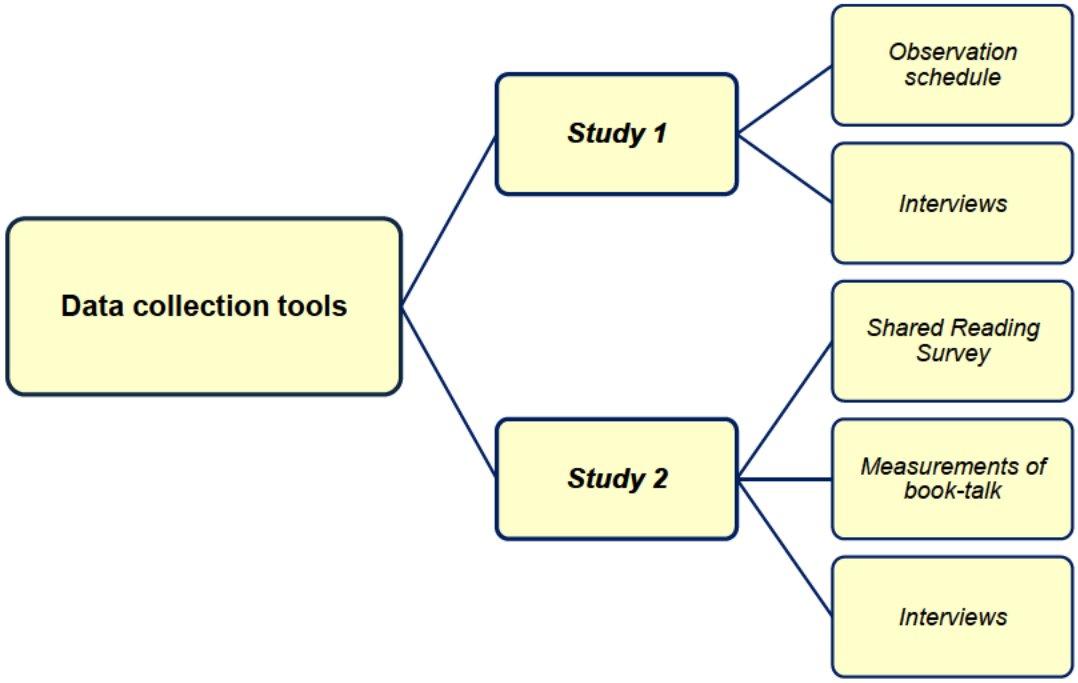
Study 2 used surveys, measurements of book-talk, and interviews to collect data. In addition to requesting demographic information (gender, age, ethnicity, English as an Additional Language (EAL), and difficulties with reading, either decoding and/or comprehension), the *Reading Anxiety Test for Children – Self Report* (RAT-C; www.motif.org.au) (D. Francis et al., 2020) was used to gather reading anxiety information about the participants. The full test consists of three subscales: Generalised Reading Anxiety, Social Reading Anxiety, and Physical Symptoms. However, the *Social Reading Anxiety Subscale* was only used for ease/speed and alignment with the research question/interests. This subscale consists of six statements (e.g., “I worry when I have to read aloud in front of my classmates”) with the following response options:

Never, Sometimes, Often, Always, Don't know. Research argues that children hold a valid view of themselves and their emotions, thus, a self-report measure can be an effective tool to use with children (Sturgess et al., 2002). In addition, measurements of book-talk were used to calculate the quantity of book-talk between children (the number of words spoken) under two conditions during book-talk sessions. The number of words has been used in previous studies as a measuring tool to investigate the quantity of book conversation during adult-child shared reading with different reading mediums (see Ewin et al., 2021).

Interviews were chosen to gather children's perspectives, prioritizing children's voices (Wilmot et al., 2023), particularly those with reading difficulties. In previous research, different tools have been used to examine children's reading experiences with AR books, where their voices have been indirectly represented, for example, interpretations from observations (e.g., ChanLin, 2018; Dünser & Hornecker, 2007; Roumba & Nicolaidou, 2022), interviews with parents (e.g., Cheng, 2019; Cheng & Tsai, 2014; De Ioannes Becker & Hornecker, 2021), or class teachers (e.g., Othman et al., 2021; Pan et al., 2021). However, other studies have interviewed children to reflect on their own thoughts and experiences (e.g., Hornecker & Dünser, 2007; Polyzou et al., 2023; Yilmaz et al., 2017). This research adopted Ranson's (2000) pedagogy of voice which values expressing children's voices and how this empowers children (Ranson, 2000) (see Figure 7 for data collection tools of both studies).

Figure 7

Data collection tools



Choice of storybooks: (AR and non-AR books). Visiting a couple of libraries and using online bookstore catalogues (see Appendix A2 for a list of books purchased and viewed), AR books were reviewed to find a book suitable for the age group of Study 1. Following discussion with the supervisors, Arbi 1 was selected due to the simplicity of AR interaction (device held over full page image), suitability of language/content for age range, genre (fiction), length (appropriate for assessment sessions), and quality of story, illustrations, and AR features. For Study 2, Arbi 1 and 2 were selected (see Figures 8 and Figures 9) due to their suitability for counterbalanced implementation design (the two books were written by the same author for the same age group within one series). However, while the first book contained 40 pages (16 pages of text on the left hand and 16 pages of full-page illustration on the right hand), the second book contained 46 pages (20 pages of text on the left hand and 20 pages of full-page illustration on the right hand) with additional pages providing general information and instructions. The average number of words

written per page was as follows: (Arbi1 = 56 words) and (Arbi 2 = 93 words). The two books were published by the CreateSpace Independent publishing platform in 2015 and 2016, and Arbi 1 App and Arbi 2 App were downloaded from the App Store to access the AR features through the iPad (A2197-10.2-inch-7TH Gen).

Figure 8

Screenshots of the storybook (Arbi 1)

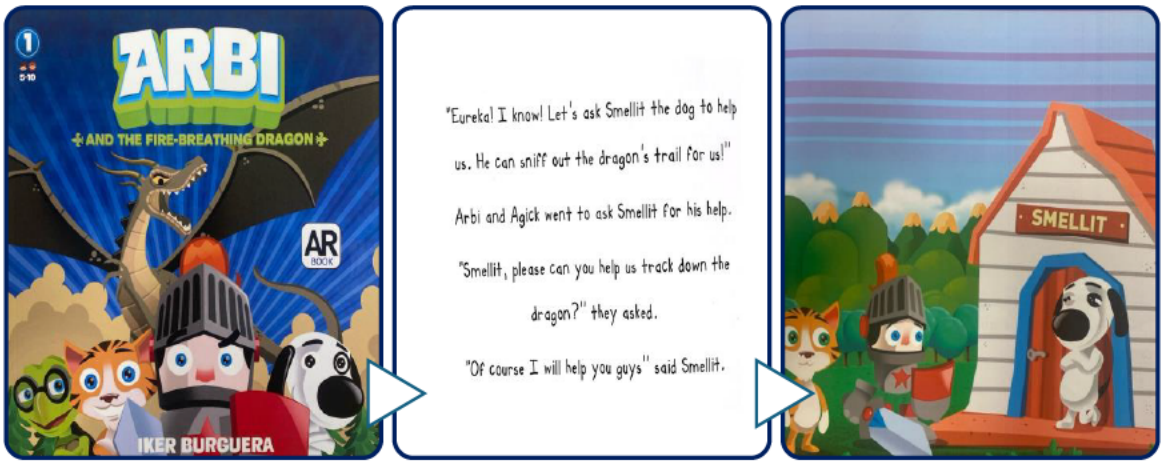


Figure 9

Screenshots of the storybook (Arbi 2)

3.2.4.2. Development and implementation of tools.

Children and Teachers' Interviews. For Study 1, four dimensions of reading engagement, based on a recent systematic review (Lee et al., 2021), were adopted to develop interview questions. Dimensions of reading engagement include behavioral, cognitive, affective, and social engagement. Behavioral engagement reflects the frequency and duration of children's reading and the nature of text types read. Cognitive engagement includes children's level of cognitive effort while reading, and the implementation of cognitive strategies to support comprehension. Affective engagement refers to the emotions and feelings experienced while reading, positive or negative. These different aspects of engagement are focused on the child as a solitary reader, whereas social engagement refers to children's participation in diverse reading activities with others (Lee et al., 2021; McGeown & Wilkinson, 2021). For this study, for example, affective engagement questions focused on what the child did and did not like about the book, and any other feelings associated with reading the AR book. For teachers' interviews, questions were developed after reviewing a

systemic review related to the usability of augmented reality in educational settings (Akçayır & Akçayır, 2017) (see Appendix A3 for students and teachers' interview questions). Although teachers' interview questions included questions related to reading engagement and reading comprehension, which emerged after reviewing a meta-analysis done by (Savva et al., 2022) and (Altun, 2018; Delgado & Salmerón, 2021; Duff & Clarke, 2011), those questions were not included in this study (see section 3.5).

For Study 2, the interview questions were developed to reflect children's thoughts on social reading experiences, including reading AR and non-AR books together, particularly with a peer, considering both the positive and negative elements (e.g., how they find reading the AR book with someone else, and the best and most challenging aspects of reading together with a classmate) (see Appendix A4). For both studies, the interview questions were created independently in an iterative process and through discussion with the supervisors. Regarding the implementation of the interviews, in Study 1, students who showed interest in reading an AR book and being interviewed with others were interviewed with their peers, while those who selected 1-1 reading sessions were interviewed individually. This was to allow personal preferences to be accommodated, gain insights into both shared and collective AR reading experiences. In Study 2, all children were interviewed with a peer, as they had just completed the AR reading session together.

Observation schedule. To develop the observation schedule (Study 1: RQ1), two children (aged eight years) were observed interacting naturally with the AR book for the first time (printed book, with iPad affording AR features), and their verbal (e.g., comments or questions) and nonverbal (e.g., reader's position while exploring the AR book) behaviours were captured by written notes, which led to developing a short checklist that reflects broad aspects of children's reading patterns: the reader's position while exploring the AR book (always sitting-always

standing-switching), how the reader goes through pages (linear way, starting with the text always-liner way, start with the picture always -forward and backward), and how the reader reads the text (silent-loudly-listening to peer), and developing a schedule to determine accessibility, either easy, manageable, or difficult based on written notes in relation to ease of use. The observation schedule includes empty cells representing each page of the storybook, which were labelled either a page with a text or with an image (see Appendix A5). Even though the checklist was applied during the observation, the findings were not reported within Study 1's paper due to the manuscript's word limit. However, the reader's position while exploring the AR book (always sitting-always standing-switching) and how the reader reads the text (silent-loudly-listening to peer) are discussed in the thesis discussion chapter (Chapter 7). Before conducting the observation, all children participated in a short workshop in their classroom, as a whole class, lasting approximately 15 minutes, to learn what AR books are and to see a demonstration of how AR books work (see Appendix A6 for the script).

Survey/ self-report. To reduce uncomfortable feelings that could be prompted by the *Social Reading Anxiety subscale's* statements, the *Shared Reading Survey* was developed, which consisted of three short surveys related to (1) children's opinions about the two books they read, (2) their views toward reading, and (3) how they feel when they share reading with others, which represents the *Social Reading Anxiety Subscale* (see Appendix A7). The short survey was completed by children with support if needed (e.g., reading the items aloud where children communicated this as a preference and explaining the meaning of some words).

Measurements of book-talk. Two open-ended questions were developed to initiate the book talk between the readers while discussing the two books together. These were 1) "Could you talk with your classmate about what you liked most about the story, and what you did not like?"

2) “What can you remember most about the story?” Open-ended questions were chosen to generate and increase conversations about the books (Kelly et al., 2024). The prompt “Was there anything else?” was used when children stopped talking together. The book-talk sessions ended when the two children said no to the prompt either verbally by saying no or non-verbally by showing a head gesture.

3.2.4.3. Data analysis.

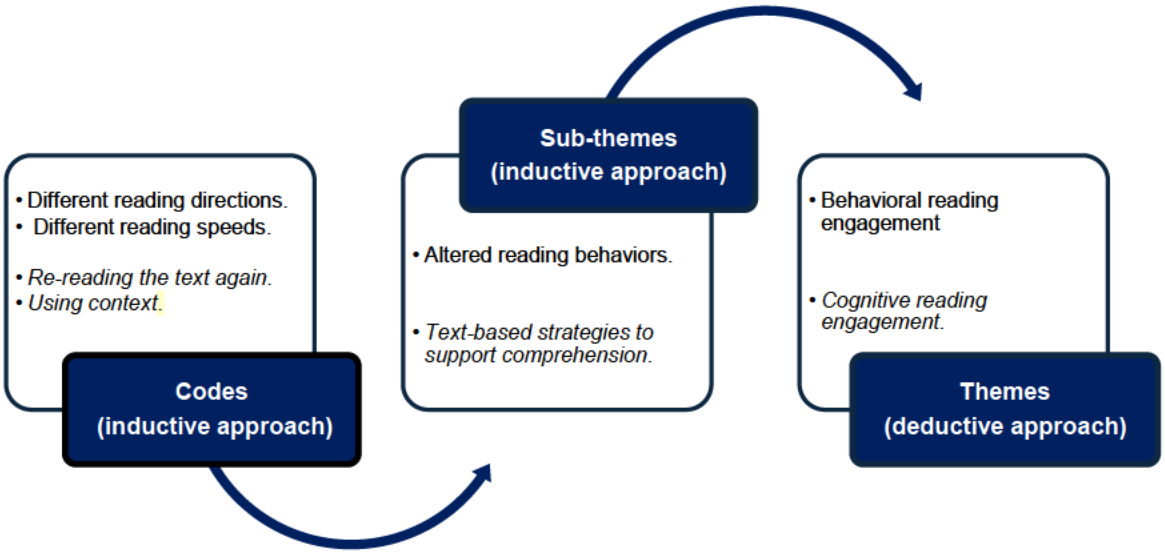
Children and Teachers' Interviews. The six phases of thematic analysis outlined by Braun & Clarke (2006) were applied to analyse the interview data, using NVivo software (Version 13 and 14) (Lumivero, 2023). Following the preregistered process, each of the first five interviews was fully analysed independently by the PhD researcher and first supervisor, and then cross-referenced before the PhD researcher carried out thematic analysis on the whole data set in NVivo. The remaining data analysis was carried out with discussion meetings with supervisors throughout. This consensus-building process was essential to improve the reliability of the codes and themes (Peacock et al., 2027).

In Study 1, the themes were identified using a combination of deductive (themes: the four dimensions of engagement: behavioural, cognitive, affective, social) and data-driven inductive (subthemes) approaches to analyse children's interviews (see Figure 10). To accomplish this, after transcribing data (Phase 1), interesting features across the entire data set were systematically coded, and relevant data was collated (e.g., different reading directions, different reading speeds, re-reading the text again, using context). At this stage, aligning with the data-driven inductive approach, empirical codes, not based on the reading engagement framework, were generated (Phase 2). Then, sub-themes from codes were developed (e.g., ‘different reading direction’ and ‘different reading speed’ were subsumed under the sub-theme ‘altered reading behaviours’; ‘re-

read the text again' and 'using context' were subsumed under the subtheme 'text-based strategies to support comprehension'), and then the subthemes were classified under four broad themes (deductive approach) (Lee et al., 2021) (Phase 3). After reviewing the themes and checking whether the themes and sub-themes worked with the coded extracts and the entire data set (Phase 4), themes were defined and named (Phase 5), and the report was produced with prevalence estimates – both the number of children and the number of references, which were provided by NVivo (Phase 6).

Figure 10

Study 1 analysis process with two examples

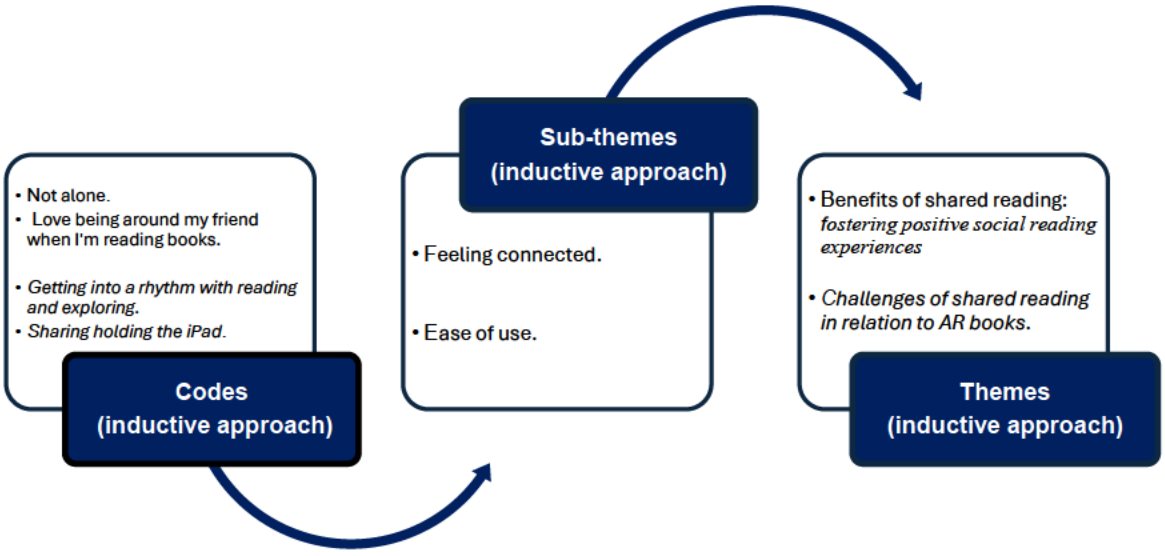


Unlike Study 1, which used a combination of deductive and data-driven inductive approaches, Study 2 only applied an inductive approach (see Figure 11). Indeed, given that the social dimension of reading engagement received less attention compared to other dimensions, and

"proved somewhat unclear" when it was addressed across previous studies (Lee et al., 2021, p. 561), no theoretical framework was used to guide the analysis process. After reading through the interview transcripts several times (Phase 1) and developing initial codes (e.g., not alone, love being around my friend when I'm reading books, getting into a rhythm with reading and exploring, sharing holding the iPad) (Phase 2), broader sub-themes and themes within the data were identified (e.g., 'not alone' and 'love being around my friend when I'm reading books' were subsumed under the sub-theme 'feeling connected' and classified under the theme: benefits of shared reading; 'getting into a rhythm with reading and exploring' and 'sharing holding the iPad' were subsumed under the subtheme 'ease of use' and classified under the theme: challenges of shared reading in relation to AR books (Phase 3). The themes were revisited and reviewed (Phase 4) before being defined (Phase 5). Finally, the report was generated, including all themes and prevalence information – sometimes based on dyads (/16) or individual students (/32) as appropriate.

Figure 11

Study 2 analysis process with two examples



Regarding teachers' interviews, an inductive approach of thematic analysis was used to identify and report themes related to teachers' perceptions of the usability of AR books in the classroom (RQ3). After transcribing interviews (Phase 1) and generating codes (e.g., quality of text, readability levels, only use with one-on-one, use with small groups) (Phase 2), sub-themes and themes were developed (e.g., 'quality of text' and 'readability levels' were subsumed under the sub-theme 'availability'; 'only use with one-on-one' and 'use with small groups' were subsumed under the subtheme 'procedure/implementation') (Phase 3). The sub-themes and themes were reviewed with discussion meetings with supervisors throughout (Phase 4) and defined (Phase 5) before producing the report (Phase 6).

Observation schedule. A coding frame (Schreier, 2012) was used to analyse the data to answer the first research question of Study 1. The six phases of data-driven category formation, outlined by Kuckartz & Rädiker (2019), were applied. First, the objective was determined, which was to reflect whether the reader demonstrated easy engagement with the AR book (Phase 1), and the type of categories was selected: deductive categories (accessibility 1. easy 2. manageable, or 3. difficult) and inductive subcategories (Phase 2). Then, after being familiarised with the data (Phase 3), the notes were processed sequentially, and codes and subcategories were developed with discussion meetings with supervisors throughout (Phase 4). The formed codes were grouped (e.g., 'covering the camera with a finger and 'holding the iPad closely to images' were grouped under 'activating images via iPad'; 'pressing the sign-out button', and 'skipping pressing the question button' were grouped under 'responding to the interactive questions') (Phase 5). Two subcategories were developed, (1) challenges, including (A) managing alternation between the book and the iPad, (B) activating images via iPad, and (C) responding to the interactive questions,

and (2) the frequency of receiving help, including (A) not receiving help, (B) receiving help one to two times, and (C) receiving help more than two times (Phase 6). Based on how often the reader received help with any of these challenges when interacting with the AR book, accessibility was determined as either easy, manageable, or difficult (see Figure 12).

Figure 12

Analysis process (observation)

Categories (deductive)	**Reader's interaction with the AR book (accessibility)**
1- Easy	**A** + (A, B, C)
2- Manageable	**B** + (A, B, C)
3- Difficult	**C** + (A, B, C)

Subcategory (inductive)	**Challenges**
(A) Managing alternation between the book and the iPad.	
(B) Activating images via iPad.	
(C) Responding to the interactive questions.	

Subcategory (inductive)	**Frequency of receiving help**
(**A**) Not receiving help	
(**B**) Receiving help one to two times	
(**C**) Receiving help more than two times	

Survey/ self-report (the Reading Anxiety Test for Children – Self Report). Individual responses were summed using RAT-C scoring guidance (Francis et al., 2020) to generate a *Social Reading Anxiety* score. Based on the NORMS TABLE RAT-C (Francis et al., 2020), 13 students included in this study had elevated Social Reading Anxiety. This was included in background information about the participants.

Measurements of book-talk. All book-talk sessions were audio-recorded and transcribed in full. The *ATOS Analyzer Tool* (www.renaissance.com) was used to calculate the word count,

average word length, and average sentence length in both the AR and non-AR conditions. A *paired samples t-test* was carried out through SPSS Statistics (Version 29.0) to compare AR and non-AR conditions (see Appendix A8). However, as the output of the *paired samples t-test* "does not include an estimate of the size of the effect" (Harrison et al., 2021, p. 140), Cohen's *d*, thus, was calculated manually, following the formula outlined by Harrison et al (2021, p. 140).

3.3. Ethical considerations

This research followed the BPS Codes of Ethics and Conduct (British Psychological Society, 2021) and the BPS Codes of Human Research Ethics (Oates et al., 2021), which guided the decision-making while conducting the two studies. Aligning with the respect for privacy principle, privacy and confidentiality were considered throughout. For example, personal information was requested to describe the sample (see Appendix A9), and therefore an ID code for each child was used to represent the participants, and schools and locations were anonymised (only the country was reported) to ensure that the participants were not identifiable if the research was published. In addition, to minimise the potential risk and eliminate the discomfort and stress children may experience when they fill out the *Social Reading Anxiety Subscale,* minor modifications were made to the introduction (see Appendix A7) emphasising that there were no right or wrong answers and the child's answers would not be shared with teachers or anyone else. In addition, children were not requested to write their names down on the survey.

Following research access via the local authority/council approval and ethical approval from the University of Edinburgh (see Appendix B.1 and B.2), headteacher, parent/guardian, and child consent were required and obtained prior to participation (see Appendix C for copies of consent forms for Study 1 and Study 2). Indeed, based on the BPS Code of Human Research Ethics

(Oates et al., 2021), consent was sought from participants after sufficient information about the project was given in an accessible form. The project information was written at different readability levels for the participants (i.e., headteachers, parents, and children), and attached to the consent forms. However, given that this project was conducted in school settings where following adult directions is commonly expected, children's decision to participate may have been influenced by this (Oates et al., 2021). Therefore, a verbal check with the student prior to the research interaction was carried out. Moreover, participants were given the option to withdraw at any time during the data-gathering phase. The date for withdrawing was set as two weeks after the data collection was planned for, and inserted into the info/consent form after dates were confirmed with schools and prior to consent forms being sent home.

Given that the ethics application process for Study 1 started when schools were getting back in-person after COVID-19, considerations of risk to minimise the potential harm were taken through developing two designs to collect data, in-person and digital approach. Indeed, schools decided whether they preferred a digital approach (i.e., interviews via Teams) or in-person data collection and this decision was left entirely to the school, who was provided with sufficient information to make an informed decision. This aligns with the BPS Code of Human Research Ethics, which confirms that developing protocols to manage risk is an essential part of the project's design. In addition, two forms, including the *Starting/ Restarting Off-campus Research and Research-related activities: Researcher Checklist (C19)* and *Travel Risk Assessment: TRA1-CV19 Travel during Covid-19 version,* were submitted to the ethics committee, which addressed how potential risks will be managed if the study was conducted in-person. For example, carrying out lateral flow tests daily when in school, and ensuring that children were grouped as they were in class (e.g., from the same classroom).

3.4. Methodological considerations

Building a relationship

Following the principles stated by the BPS Codes of Ethics (British Psychological Society, 2021), working in partnership with research participants is part of the social responsibility researchers should consider. Indeed, establishing a rapport with participants is important in conducting studies to facilitate communication, particularly with children. Indeed, the interview was an integral part of this research, and it was found that the relationship between the interviewer and interviewee is important to produce good research (Riese, 2007). Having a good rapport with the participants, which was approached through short visits to their classrooms, small talk, and short walks from/to classrooms, and showing interest in hearing their voices was essential to allow children to feel comfortable sharing their thoughts and feel that their opinions were valued.

Children's characteristics

Children's reading skills may affect their ability to express themselves. For example, to respond to a survey, children with reading difficulties may experience difficulties understanding the survey's statements, which in turn have consequences for their responses. Thus, it is crucial to test the readability level of statements and to offer additional supports (e.g., reading the statements aloud for children with difficulties in decoding, and explaining the meaning for children who have difficulties in reading comprehension). For example, in this research, the *Reading Anxiety Test for Children – Self Report* (RAT-C; www.motif.org.au) was used to gather reading anxiety information about the participants, which was particularly developed by Francis et al (2020) for children with reading difficulties. In addition, survey statements were read aloud to children who preferred this option, and some words were explained to children who asked about the meaning. For example, (embarrassing) was one of the terms children asked about.

Recording tools

The distinction between children's voices while transcribing data was one of the challenges in conducting this research, as most children in Study 1 participated within small groups of two, and the researcher aimed to represent children's voices and provide background data regarding each child. To facilitate the distinction process when transcribing Study 2 data, as data collected from dyads, the researcher searched for different recorder tools approved by the university that would provide this feature (i.e., distinguish between voices). The researcher tried a set of Comica CVM-WM200 (A) recorders, which were linked to two separate microphones. However, when data was transferred from the recorder to the device, two voices were integrated into one unit. Thus, the same recorder used in Study 1 was implemented in Study 2 as it was easy to operate, but with a different approach that made the distinction process more practical, such as writing notes to describe the child's voice during a small-talk with participants before starting the sessions.

3.5. Open Research

Open research practices increase trust in research findings (van Dijk et al., 2021), which is increased through openness, reproducibility, and transparency (B. G. Cook et al., 2018). Applying open research practices can boost integrity in research (Gehlbach & Robinson, 2018) and lead to more reliable research aiming to enhance educational outcomes (B. G. Cook et al., 2018; van Dijk et al., 2021). Two elements of open research practices were adopted in this study: preregistration and open materials (B. G. Cook et al., 2018; van Dijk et al., 2021). Indeed, preregistration improves the reproducibility and credibility of research results (Nosek et al., 2019), and it is applied by describing the study before it is conducted through sharing research hypotheses, sampling approach, data collection methods, and data analysis plans (van Dijk et al., 2021). Given that

preregistering qualitative studies is possible (van Dijk et al., 2021), both studies were preregistered. The pre-registration of both studies was hosted by OSF (www.osf.io), which supports a wide range of research designs.

Credibility depends on the transparency of the research process (Klein et al., 2018), and transparency represents "the ultimate goal of preregistration", (van Dijk et al., 2021, p. 147). Indeed, increasing transparency would increase the replicability of research (Nosek & Errington, 2020), which is not only important in quantitative but also in qualitative research (Aguinis & Solarino, 2019), particularly in the field of learning difficulties to recognise under which condition and with whom an intervention would work (van Dijk et al., 2021). Indeed, sharing research materials used in the study is necessary to reproduce research (Klein et al., 2018). Therefore, providing user-friendly tools (Klein et al., 2018) that were described comprehensively would not only facilitate the replication process but also offer an opportunity for individuals who work with students with learning difficulties to access and use the materials (van Dijk et al., 2021).

Given that both studies were preregistered, it was worth mentioning that changes were made in the preregistered plan as the research evolved. Indeed, preregistration represents one of the SEER principles that considers comparing what was proposed with what was conducted (van Dijk et al., 2021). Therefore, researchers are expected to report deviations between these two stages (Nosek et al., 2019) by referring back to the original plan (van Dijk et al., 2021). The preregistered plan of Study 1 considered how both child readers *and teachers* perceive the features of AR books as supportive of reading engagement *and reading comprehension*. However, following data collection, RQ2 was narrowed to focus solely on reading engagement and reflect only children's perspectives. This decision was made due to the low number of teacher participants (n = 2), and

the very large quantity of reading engagement data and therefore a decision to focus on this. This decision was made as reading engagement is underexplored in relation to AR books, compared to reading comprehension (e.g., Chien et al., 2019; Danaei et al., 2020; Yilmaz et al., 2017). In addition, the interview questions focused primarily on reading engagement, therefore, this data was richer.

Regarding the preregistered plan of Study 2, the influence of AR on the quantity of the book-talk was only captured after reading the book due to the limited discussion during reading the books and the tendency toward reading aloud among most children. Finally, unstructured observation was applied in Study 2 and included as a supplementary analysis (see Appendix D.1) since it provided valuable insights, but did not answer any of the research questions. The data could be used to develop a structured observation schedule for the next studies which aim to capture the interaction between children during shared AR book reading.

To conclude, this chapter has investigated the design of this research, which adopted mixed methods, and developed two studies to answer the research questions. The next chapter will focus on Study 1, which provides in-depth insights into children's reading engagement with AR books, focusing on behavioural, cognitive, affective, and social dimensions. This study was published in *Frontiers in Psychology* on 14 August 2024.

Chapter 4

Study 1: Children's insights

Augmented reality books: in-depth insights into children's reading engagement

In this chapter, Study 1, which provides in-depth insights into children's reading engagement with AR books, is presented as published by *Frontiers in Psychology* on 14 August 2024, with one minor revision: in this paper, the researcher referred to the print books as traditional, which was commonly used in previous literature. However, as technology is evolving, it seems practical, particularly for future readers, to replace the term "traditional print" with "print" book to describe the book without providing any assumption or judgment.

Note: This chapter adopted US English spelling.

Augmented reality books: in-depth insights into children's reading engagement

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Abstract

Children's reading engagement is associated with the quality of their reading experiences and outcomes; however, research to date has only examined children's reading engagement within the context of print books or digital texts. Augmented Reality represents a hybrid reading experience, where print books are augmented with digital features (e.g., animations, sounds, comprehension questions). This is the first study to examine children's perspectives and experiences of AR books, within the context of reading engagement. In total, 38 demographically diverse children (aged 8–10, 21 male, 17 English as an Additional Language, 14 ethnicities, nine with teacherreported reading difficulties) from the UK participated. After reading an AR book, children participated in interviews about their reading engagement. Deductive (themes) and inductive (subthemes) approaches to thematic analysis were used, examining children's AR reading experiences within the context of their behavioral, cognitive, affective and social engagement. The majority of children found AR books easy to use, and provided examples of how AR books supported their behavioral engagement (e.g., desire to read more/extend reading practices), altered their cognitive engagement (e.g., reading strategies, visual representation/use of imagination, comprehension monitoring), influenced their affective engagement: (e.g., diverse positive feelings), and social engagement (e.g., prompted interaction and discussion), providing

examples suggesting similarities and differences with print books. This paper provides novel in-depth insights into children's perspectives and experiences of AR books, and provides a foundation for researchers, educators, and AR book designers interested in better supporting children's reading experiences and outcomes with AR books.

KEYWORDS reading, engagement, augmented reality, books, children

4.1. Introduction

Over the last two decades, children's reading practices have shifted from the almost exclusive use of paper-based texts to an increasing use of digital devices, as children spend more time engaging in diverse literacy activities (Wang et al., 2019; Halamish and Elbaz, 2020; Furenes et al., 2021; Polyzou et al., 2023). Although little researched, Augmented Reality (AR) is an emerging technology which offers child readers a novel reading experience (Wang et al., 2019; Danaei et al., 2020) as it combines both print and digital forms. Whilst educational claims surrounding new technologies need to be approached cautiously, combining print and digital media does raise interesting questions about the nature of children's reading experiences, as well as important pedagogical and design opportunities for those wishing to support children's reading. To date, research has explored the potential value of AR in educational settings (e.g., Akçayır & Akçayır, 2017; Bujak et al., 2013; Chen et al., 2017; Cuendet et al., 2013; Fernández-Batanero et al., 2022; Wu et al., 2013), for example within AR games (Tobar-Muñoz et al., 2017), AR-based learning materials (Chien et al., 2019), AR applications (Shaaban & Mohamed, 2024) and AR books (Liu et al., 2023). However, no research has been conducted to explore how AR books shape children's reading engagement, from their perspectives. This paper therefore aims to contribute novel insights into children's perspectives and experiences of using AR books, examining if, and how, AR books influence their reading engagement.

4.2. Augmented reality books

Augmented Reality (AR) technology is increasingly being integrated into educational settings to support students' learning (e.g., Kerawalla et al., 2006; Phadung et al., 2017), and augmented reality books represent one of its recent implementations (Panchenko et al., 2020). While there are various and evolving instantiations of Augmented Reality, the term generally refers to the superimposition of digital information on the physical world, typically via a screen device (see Figure 13). In the context of AR books, this enables print books to be enhanced through the addition of AR features such as sounds, 3D animations, and interactive questions (Yilmaz et al., 2017; Wang et al., 2019; Danaei et al., 2020). AR books therefore invite more physically interactive reading experiences as students explore and combine paper and virtual content (Wang et al., 2019; Danaei et al., 2020). The enhancement of paper books is not new, for example, search and find activities, tactile features such as pop-ups and flaps, and comprehension questions within children's books are all common features (Vanderschantz et al., 2019). AR however allows a digital extension of this, for example, to include sounds, animations, graphics (Vanderschantz et al., 2019; Besa, 2021; Shinskey, 2021) and feedback on comprehension questions. As a result of these technical affordances, it has been claimed that AR technology can positively affect students' reading attitudes and motivation (e.g., Yilmaz et al., 2017; Othman et al., 2021; Roumba and Nicolaidou, 2022), in addition to supporting reading concentration (Wang et al., 2019), comprehension (Dünser and Hornecker, 2007; Danaei et al., 2020), story retelling (Liu et al., 2023), learning effectiveness (Chang et al., 2023) and transmission of knowledge (Fernandes & Leite, 2023). Given the relatively recent emergence of AR and the complexity of factors shaping if and how children interact with AR books, qualitative research is necessary to better understand children's perspectives and experiences of AR books and how it relates to their reading

engagement. Compared to print books, readers can engage with AR books in different ways. For example, research with digital books highlights different navigation profiles by both child and young adult readers (Javorsky & Trainin, 2014; Turner et al., 2020). In addition, Zhou and Yadav (2017) found that young children's behavioural and affective reading engagement were positively affected by reading multimedia stories compared with print storybooks. Similarly, Moody et al. (2010) noted that children who participated in an adult-led e-storybook session had a higher persistence level than those who participated in an adult-led print storybook session. Different navigation profiles, or ways in which readers engage with AR books, can therefore have consequences for their reading experiences and/or outcomes. Yet there is an absence of research exploring children's perspectives and experiences of AR books and how they perceive it to support, or impair, their reading engagement.

Figure 13

Augmented reality book.

4.3. Reading engagement

Until recently, research into children's reading engagement has been hindered by a lack of conceptual and operational clarity (Unrau & Quirk, 2014; Lee et al., 2021). Indeed, researchers understanding of reading engagement has evolved considerably over the last decade, from a two (affective and behavioral) to three (affective, behavioral and cognitive) (Fredricks et al., 2004; Unrau and Quirk, 2014; Barber and Klauda, 2020; Cao et al., 2024; Clinton-Lisell et al., 2024) dimensional construct. In different studies, reading engagement has been conceptualized in different ways, and has been explored within the context of different reading practices (e.g., independent or shared reading) and/or with different text types (e.g., print or digital books: see Clinton-Lisell et al., 2024 for a review). In a recent systematic review of reading engagement research (Lee et al., 2021) four dimensions of engagement were identified: behavioral, cognitive, affective and social (see also McGeown and Smith, 2024) (see Figure 14). While previous research has drawn upon these different dimensions of engagement to understand the relationship between children's reading experiences and outcomes (e.g., Clinton-Lisell et al., 2024; Miyamoto et al., 2019; Torppa et al., 2020), these four dimensions have not yet been studied in parallel. Behavioral engagement reflects children's reading behaviors, for example, the frequency and duration of children's reading, the way in which they read, and the nature of the text types read. Research demonstrates that more time spent reading, specifically book reading, and specifically fiction book reading, leads to better reading and language skills (Torppa et al., 2020; Van Bergen et al., 2021; Nation et al., 2022).

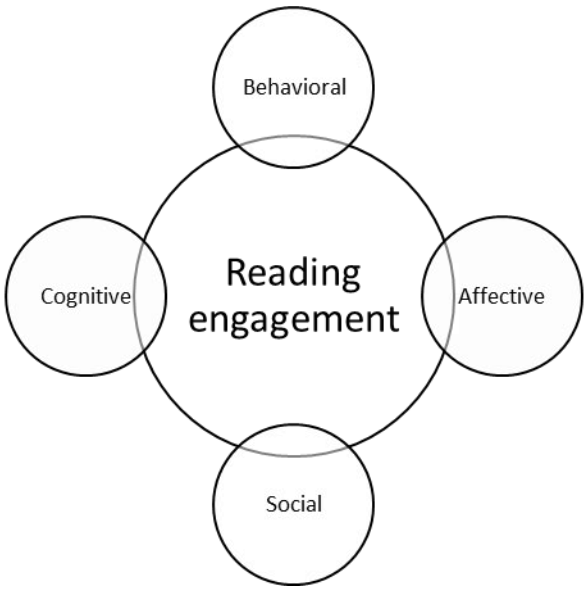
Cognitive engagement reflects children's level of cognitive effort while reading, and the application of goal-directed cognitive strategies (e.g., re-reading, decoding, drawing upon background knowledge) to support their comprehension. Indeed, research demonstrates that

metacognitive knowledge of strategy use has been found to mediate the relationship between children's reading motivation and skill (Miyamoto et al., 2019). Affective engagement reflects the breadth and depth of diverse emotions and feelings experienced by children while reading, for example enjoyment, interest, anticipation, excitement, sadness, etc. Research demonstrates that positive reading experiences are essential for children to choose to read more in future, but that even stories which elicit negative emotions, e.g., sadness, can be reported by children as enjoyable (McGeown and Wilkinson, 2021; Clark et al., 2023; Currie and McGeown, 2024). Finally, social engagement refers to children's participation in reading activities with others, as they read together, share, swap, and discuss books they have read. Social reading activities includes both agentic and non-agentic interactions (Lee et al., 2021), and when positively perceived and experienced, can foster enjoyable and engaging reading experiences (Cremin, 2014; McGeown and Wilkinson, 2021). This framework of reading engagement offers a comprehensive approach to study and understand children's experiences with AR books, given the technology's potential to alter or extend children's reading engagement in ways which have not been previously studied in print books, nor with digital texts. For example, AR books are likely to have consequences for children's behavioral engagement, inviting more interactive reading behaviors, as children use a digital device to switch between the text, illustrations and AR features, and engage with the AR digital content (Dünser & Hornecker, 2007a; Fiusa et al., 2023). AR books are also likely to influence children's cognitive strategies while reading (Cheng, 2016), as they are required to integrate content from the text, illustrations and the AR features to comprehend the story, with AR features offering an additional source of information to support (or hinder) comprehension. It is further possible that AR books invoke new affective reading experiences, given their distinctly different nature when compared to print books, and also the probability that they are novel for most children.

Finally, AR books may also shape social interactions, where the integration of physical and digital interactivity creates new opportunities for children to explore and discuss AR books together (Matcha & Awang Rambli, 2012).

Figure 14

Reading engagement framework. Adapted with permission from McGeown and Smith (2024), original framework proposed by Lee et al. (2021).



4.4. Research rationale and aim

Children's reading enjoyment and engagement are at an all-time low (Clark et al., 2023), yet digital literacy practices are becoming increasingly present in children's lives (Picton et al., 2022). AR books offer a way to blend print and digital forms of reading, yet there is an absence of research exploring children's perspectives and experiences with AR books. As the ultimate users of AR books, children's thoughts and insights are essential to inform educators, designers and authors to optimally improve children's reading experiences and outcomes, in addition to identifying new

questions for future research. This study aims to explore children's perspectives and experiences of Augmented Reality (AR) books, within the framework of reading engagement, and seeks to address two research questions as follows:

1 How do children read/interact with an AR story book in a classroom setting in real-time?

2 To what extent, and how, do children perceive the features of an AR story book as supportive of their reading engagement?

4.5. Materials and methods

4.5.1. Participants

A demographically diverse sample of 38 (21 boys, 17 girls) children (aged 8–10) the UK participated in this study. Participating children represented 14 different nationalities, with 17 speaking English as an Additional Language (EAL). In addition, nine had teacher-reported reading difficulties (seven in comprehension and two in decoding) and one student had a genetic learning disability. Self-reported levels of reading enjoyment were requested and 16 children reported high, 16 medium/intermediate, and 6 low levels of reading enjoyment. Following ethical approval from Moray House School of Education and Sport, University of Edinburgh, headteacher, parent/ guardian and child consent was obtained prior to participation.

4.5.2. Procedure

Prior to the study, all children participated in a short workshop in their classroom, lasting approximately 15 minutes, to learn what AR books are and to see a demonstration of how AR books work. Children then participated in an AR book reading session which took place in a quiet space in the school library and lasted approximately 30 minutes, with approximately 15 minutes reading the AR book and 15 minutes answering interview questions. Students were observed

interacting naturally with the AR book (printed book, with iPad affording AR features), with the support of the researcher if required. Written (anonymized) notes were made in relation to usability/accessibility, which was defined as whether the reader demonstrated easy engagement with the AR book based on observable behaviors, including managing alternation between the book and the iPad, activating images via iPad, and responding to the interactive questions. Accessibility was determined based on how many times the reader received help from the researcher to manage the alternation, the images' activation, and the interactive questions. Children were given the option to read the AR book alone or in a dyad (dyad pairs were chosen by teacher), with the researcher present in all sessions. Following this, the interview questions explored the four dimensions of reading engagement described earlier (behavioral, cognitive, affective and social). In total, twenty-two sessions were conducted (6 alone, 16 dyads). All interviews were audio recorded. Aligned with open research practices, the study was preregistered and can be accessed here: https://osf.io/9q678.

4.5.3. The AR storybook

Using online bookstore catalogs, AR books were reviewed to find a book suitable for the age group of the study. Following agreement of the research team, Arbi 1 (Burguera, 2015) (https://www.arbibook. com) was selected due to the simplicity of AR interaction (device held over full-page image), suitability of language/content for age range, genre (fiction), length (appropriate for assessment sessions), and quality of story, illustrations, and AR features. The book was written by Iker Burguera and published in 2015 by CreateSpace Independent publishing platform. The Arbi 1 App was downloaded from the App Store to access the AR features through the iPad. The theme of the Arbi 1 story is around friendship, where friends with different abilities work together to protect their village from a dragon. The book contained 40 pages (16 pages of text on left hand

and 16 pages of full-page illustration on right hand), with additional pages providing general information and instructions.

4.5.4. Data analysis

All interviews were audio recorded and themes were identified using a combination of deductive (four dimensions of engagement: behavioral cognitive, affective, social) and data-driven inductive (subthemes) approaches, using the six phases of thematic analysis outlined by Braun and Clarke, (2006). Specifically, the first author transcribed all interviews (Phase 1) before the first and third author independently read five transcripts in full, generating initial codes to identify key features of the data in a comprehensive way (Phase 2). These codes were then sorted into themes and subthemes and data relevant to each was gathered (Phase 3). The first and third author then discussed the codes and preliminary themes and subthemes in depth (Phase 4). This process (Phase 1–4) was then repeated for the entire dataset by the first author, with ongoing discussion with the second and third author throughout. Once completed, the themes were reviewed and refined by all authors in an iterative process to ensure that they accurately represented the data, and that the full complexity of the data was realized (Phases 5). This stage resulted in some amendments to subtheme names to be more accurate and specific to the data (e.g., ‘reading behaviors’ to ‘altered reading behaviors’) before being written up for publication, with quotes to exemplify each (Phase 6). This approach ensured the full complexity of the data was realized, while also using the four engagement dimensions as a guiding framework. Data was managed through NVivo, which allowed prevalence information related to each subtheme to be calculated. As this study included a diverse sample, codes were created to provide background information about the participants: codes alongside quotes provide the student’s age, gender, English as an Additional Language

status, reading enjoyment level, and whether the student had difficulties in reading. Table 2 explains how to read these codes.

Table 2

Participant codes

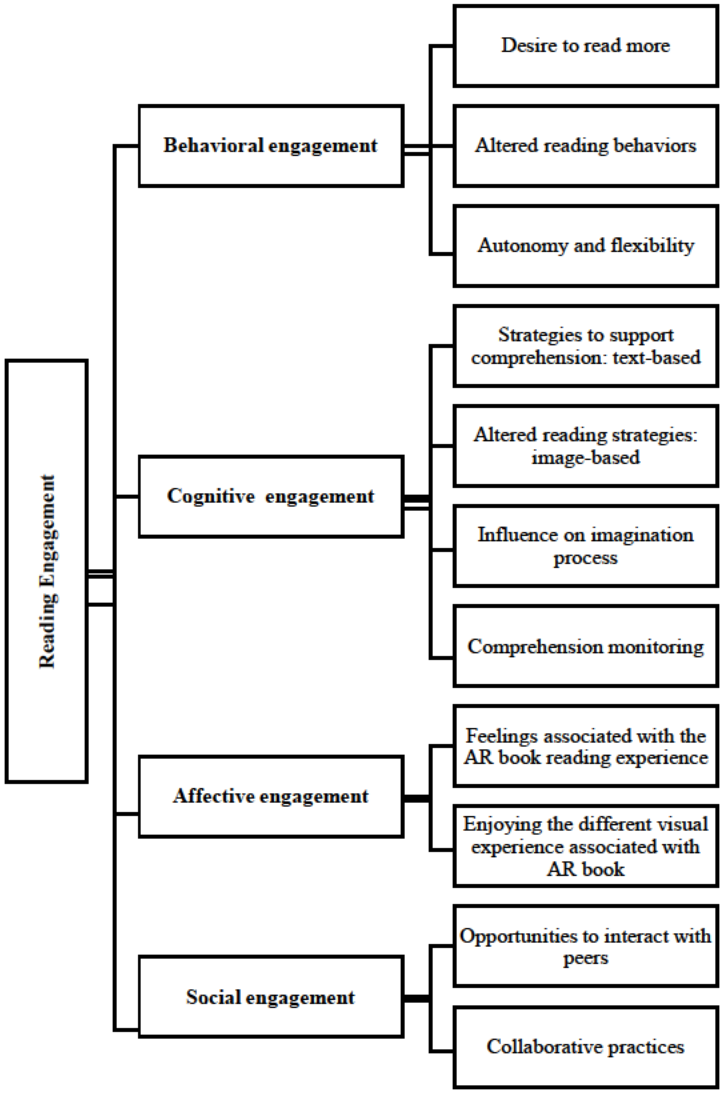
Participant information	Code
1.Age	8, 9, 10
2.Gender	M = male
	F = female
3.English as an Additional Language (EAL)	Y = Yes
	N = No
4. Self-reported level of reading enjoyment	L = Low
	I = Intermediate
	H = High
5.Teacher reported reading difficulties	RD
Examples	
Female, aged 9, with EAL, low reading enjoyment, reading difficulty	9FYLRD
Male, aged 8, not EAL, intermediate reading enjoyment, no reading difficulties.	8MNI

4.6. Results

Based on observation, 37/38 children engaged relatively easily with the AR book. Most children (23/37) did not receive any help from the researcher, and some readers (14/37) were provided with help only once (e.g., directed the reader to press the button when the lock appeared to interact with the questions or to log in when the reader sighted out from the app by mistake). However, only one child (1/38) received help from the researcher more than twice (e.g., directed the reader to point the camera at the images to be activated). The results from the interviews are presented in relation to each dimension of reading engagement and can be found in Figure 15, with names of themes and subthemes. Reference is made to relevant literature within the results, where appropriate.

Figure 15

Subthemes in relation to the four dimensions of reading engagement.



4.6.1. Behavioral engagement

Desire to read more. Behavioral engagement reflects children's reading behaviors (Lee et al., 2021), for example, the frequency and duration of children's reading and how they read. Within a demographically diverse sample, high levels of behavioral engagement were reported, with indications of a desire to read more AR books (prevalence: 20/38): '*If there is another book like this, I would read it. I would want to read it*' 8MYHRD; '*If you got another one, I will go to the library and read it*' 10MYIRD; '*I am going to be excited to read another one'* 8FNI. Furthermore, a couple (2/38) noted that they would like to re-read the same AR book again: '*Can we take this to home and read it again?*' 8MYLRD. In general, very high levels of behavioral engagement (Lee et al., 2021) were found, including a desire for volitional reading of the AR book/AR books beyond the reading session.

Altered reading behaviors**.** Children reported recognizing similarities and differences in how the AR book influenced their reading behaviors. While children's interaction was comparable to that found with print books, altered reading behaviors included changes in reading direction, greater exploration of the images, changed handling of the book, an increase in speed of reading the text to allow more time to explore the dynamic images, and comments relating to new types of interaction with the book. Some students reported that they followed a different reading pattern (12/38): '*I was reading but not the same. So, like a little bit different but not completely different'* 9MYIRD; '*I think there's some changes done when I'm reading a normal book*' 8FNI. These differences included reading direction: '*It is different because I normally look at the picture first, then read text, but I read the text first, then looked at the picture, that's the opposite*' 9FNL; '*I always I always read the text first, but today I read the picture first*' 9FNH, greater exploration of the images: '*I think it's slightly different because, in a normal book, I might just skip pictures, but*

in this book, I would look at the pictures and spent a little bit longer' 8FNH; '*Because the pictures have a kind of equal value to writing meaning that I do not just skip some pages because they are pictures*' 8MNH, and changed handling of the book: '*when you are reading a normal book, you just like have to put both hands on it, but when you are reading with the iPad and the page switch, you have to hold it like that and then keep this*' 9FNH. In addition, a few children (4/38) remarked that their experience of reading the AR book differed in speed to their typical reading practices: '*I read a bit more quickly and like that, I could see the pictures and yeah and watch what was next*' 8MYHRD; '*I read the text a bit faster and get the iPad and I point it to the pictures*' 8MYIRD. This aligns with previous research which demonstrates that different types of media can have differential influences on readers' engagement (Moody et al., 2010) and Turner et al. (2020) indicated that digital reading has more potential to be associated with skimming and scanning. One child, however, mentioned that: 'you want to read this book a lot more carefully' 8MNH, reflecting a deeper reading practice (Turner et al., 2020). Some students (10/38), however, reported a similar reading pattern: '*You can just read it like normal book, you know, so I think it's quite similar*' 8MNI; '*You still have to turn the page before press something on the iPad. So, you are not really looking at the iPad but looking at the book through the iPad'* 8MNH.

Autonomy and flexibility. Furthermore, some children (6/38) reported new types of interaction with the book: '*You're actually interacting with it'* 8MNI; '*You can actually zoom in and zoom out'* 8FYL; '*You can move the iPad further and you can see close up' 8FNI; 'It challenges you because you have to answer the questions to see the picture'* 8MYH; '*It's like testing you. If you are giving a glance or if you read'* 9FNL.

4.6.2. Cognitive engagement

Strategies to support comprehension: text-based**.** Cognitive engagement reflects the level of cognitive effort readers apply while reading and the implementation of strategies to support their comprehension (Lee et al., 2021). With regard to cognitive engagement, children shared a number of text-based strategies to support their comprehension which are similar to those applied with print books, such as re-reading, decoding, thinking, using context and word substitution. The image-based approaches however were different, with primary reference to dynamic rather than static images to support comprehension. In terms of text-based strategies, many (33/38) shared strategies they usually apply when they encounter difficult parts of text that could, or were, used with the AR book including re-reading (17/33): '*Reread the sentence and the words around it'* 8MNL; '*Well, I normally try and read it again'* 8MNH; '*Just go back to read it again to understand'* 8FYI, decoding or reading aloud (6/33): '*Sound out the word'* 8FNI; '*Trying to say out loud, see if I know it'* 9FNL, thinking time (5/33): '*Well, I stop in the middle of the text to think*' 8FYH; '*Stop and think about it instead of going on*' 8FNL, using context (3/33): '*I would read the rest of the sentence or the first step of the sentence and kind of use that to figure out what they are trying to write*' 8FYLRD; '*Just try and think of what the word means using the other words around it*' 8MNH, or replacing the word (2/33): '*If it's like the words that I cannot figure out, the words are kind of confusing, I kind of replace the word that does not really fit in*' 8FYLRD; '*If I do not understand that I try and compare it to a similar word that I've heard before*' 9FNL.

Altered reading strategies: image-based. In terms of how AR book specifically influenced children's reading strategies, some children referred to the dynamic images as a way to support their comprehension (21/38): '*Pictures always help. Maybe if you are like, not understanding what's happening in the book or something and then you just have a look at picture that can help,*

especially the picture kind of moving' 8MNI; '*It's more understanding because the AR pictures make more sense than the real pictures on the boo*k' 8FNI; '*I would not say I would not understand it if I did not have a gadget, but I might understand it a bit more because it is 3D so I can actually see what's going on and how it actually happens*' 9FNL. Most children (16/21) described dynamic images as images that 'come to life'. Although print books have pictures, and digital books have animated images, the dynamic images of AR books represent one of the unique affordances that were highly valued, and frequently mentioned, by the children. Some children (4/38), however, considered the dynamic images an extra feature that could be excluded: '*It's kind of like reading the same text twice*' 8MNH; '*I do understand the text. So, I do not really need the picture' 8H; 'The text is the one that's explaining most of it*' 8FNI.

Influence on imagination process**.** Others reported that the AR book altered their imagination process (8/38). In some, the AR books facilitated their imagination (6/38): '*But this book a lot easier to imagine in your head because it has the movement and sounds*' 8FYLRD; '*When I read a paper book, I imagine it, but this showed how it really would be like, so it helped me to understand the story more as what is going on*' 8FYH. Indeed, creating mental representations while reading is important for comprehension (Boerma et al., 2016) and both animations (Takacs et al., 2015; Altun, 2018) and AR technology (Cheng, 2016) could facilitate this process. Interestingly, while more children reported that dynamic images would facilitate their imagination, others thought it would be inhibitory (2/38): '*I like to imagine the pictures in my head, even if the book has pictures, I imagined how they move, but this book showed me how the author really, really thought how the book would be*' 8FYH.

Comprehension monitoring**.** Some children (6/38) reported that the interactive questions of the AR book helped them to track their understanding while they read: '*I really like the questions*

actually because they show that you pay attention to the book' 8FNH; '*We should improve our reading so because it gives you questions and if you have not read right, properly, that would not be able to answer the questions better*' 8MYI. Indeed, previous research has demonstrated the importance of comprehension questions on children's reading (Blewitt et al., 2009; Sénéchal, 1997; Vanderschantz et al., 2019; Zhou & Yadav, 2017), and AR books, with interactive questions, may have the potential to support children's comprehension monitoring and increase cognitive engagement while reading.

4.6.3. Affective engagement

Feelings associated with the AR book reading experience. Affective engagement reflects the emotions and feelings experienced by children while reading (Lee et al., 2021). Dimensions of affective engagement were among those most discussed by children, with the majority (37/38) expressing positive emotions relating to their AR book reading experience, such as it being impressive (16/37): '*Quite impressive! I thought of 3D you need to wear glasses*' 9MNH; '*I am kind of amazed how they got a book to do that. OK. Like if you opened it without the app, it would just be, like, normal storybook, but with the app, it is not just the normal storybook*' 8MNL; cool (12/37): '*It kind of like has cool things*' 8FNI; '*when I was young, I thought it would be really cool to make like the pictures move in the book, but I did not know it was possible and then I just saw that*' 8MNH; 'S*eeing the characters move just makes it really cool instead just being frozen*' 8MNI; enjoyable (11/37): '*I actually liked when I picked the iPad up and put it in the picture actually, kind of enjoy reading that with some music*' 9FYIRD; '*Yeah. It feels like amazing mixing with happiness into like one*' 8MNIRD; fun (7/38): '*It adds fun on it. If the whole book was just looking at pictures and just the page, would not be interesting'* 8MNI; '*A bit different than normal book, different in a fun way, not different in difficult way*' 9FNL, and weird (3/37):

'*It's kind of weird because it is all in one. All these different parts together, that's a bit weird*' 8MNI. One child (1/38), however, reported that reading the AR book '*a little bit waste of time*' 9MYIRD.

Enjoying the different visual experience associated with the AR book. There were also examples of experiences reported by children which crossed the boundaries between cognitive and affective engagement, although discussed during the interview questions on affective engagement. For example, children reported different visual experiences elicited the positive feelings they reported toward the AR book reading experience, as they enjoy the real-life/realistic (16/38) features of the AR book: '*You can see it's like in real life. If it was happening like in real life*' 8MYLRD; '*It tells you how fairy tale would be like when it comes to life*' 8FYH; '*I like it because I can see the pictures come to life, and most books you cannot do that. It just one picture*' 8MYH. Moreover, some children (10/38) mentioned enjoying exploring the differences between the static and the dynamic images: '*I like when it was in page, and then when it was 3D; it was slightly different*' 9FNL; '*I like pictures that looked like this actually seen in a different way; like this picture did not have people, but in the iPad, there was people running around there*' 8MYHRD. While others (8/38) reported enjoying the more immersive visual experience offered by the AR (6/38): '*I felt very engrossed in the picture and not as a normal book I felt I am more in this book*' 8MNH; '*It's actually like you are actually in it technically*' 8FNI; '*You feel like you are there, but you are not there*' 8MNIRD. Seeing things from another physical perspective was also reported by a couple of children (2/36): '*It could let me have a different point of view of what the story about. For example, I could see from the sky instead of seeing it from the ground*' 9MYIRD; '*You can also see from different angles*' 9MYH. On the other hand, some children shared positive feelings associated with the book itself, regardless of its AR features, such as the characters (14/27): '*I like the characters*' 8FNI, or story (13/27): '*It's really cool because of how they write it, and they*

describe a lot of what's going on' 8FYI; '*It has a proper story to it because some AR books like, there's no story*' 8FYL.

4.6.4. Social engagement

When reading the AR book, 32 children chose to read the book with a friend, while 6 children chose to read the book alone; this is reflected in some of the prevalence figures in this section.

Opportunities to interact with peers. Social engagement refers to children's participation in reading activities with others (Lee et al., 2021), as they read together, share, swap, and discuss books they have read. Children reported that the AR book could potentially affect their social interactions with others and commented on a desire to share AR books with others. For example: '*Because if you are reading by yourself, it would be a bit lonely. It will not be as fun as if, you know like you have someone with you*' 8MYI; '*It's nice to share a laugh*' 8MNI. Shared AR book reading was preferred by most participating children (32/38) since it allowed them to discuss the book with their peers (10/32): '*Because there's a lot of things you could discuss about the book*' 8FYLRD; '*It's usually better for sharing than keeping to yourself'* 8FYL; '*We like to share thoughts and then we share thoughts about what's funny and why that's funny, and then we laugh about it*' 8FYL. Most of those children who showed interest in sharing reading the AR book with their peers (9/10) reported a particular interest in sharing reading the AR book with their close friends: '*When I'm with my friends we sometimes like to talk a lot about the characters*' 8FYH; '*Because we know each other a lot and we can talk to each other about it*' 8MYIRD. Some children emphasized that they would enjoy discussing the pictures specifically: '*It's a lot of fun just saying: Ohh look at this picture, and if I was just looking at it on my own, I would not find it as much as enjoyable*' 8MNI.

Collaborative practices. Other children (9/32) preferred to read the AR book with someone else to get support, in digital device and print book together (6/9): '*One holds the iPad*

and one flips the page' 9FNI; '*We take turns someone read the text, and someone looks at the pictures and then you just swap it over*' 9FNL; '*Especially if it's your first turn and you are not super used to doing it you know so definitely I would read with someone else*' 8MNI, or to answer the interactive questions as a team (3/9): '*We take turns someone read the text, and someone look at the pictures; it's teamwork to answer the questions*' 9FNL. Reading together is a practice which naturally encourages children to socially interact with others while they read (Gambrell, 2011; Guthrie et al., 2007). Some children (6/38), however, preferred reading the AR book individually for several reasons: '*I like to read by myself and turn the pages. So, I can start and move to any page*' 10MYIRD; '*I feel better working alone*' 8IRD; '*You can go on to the next picture as quickly as you like without anybody else needing to read it until you can turn to the next thing*' 9MYH. It was noted that most participants who chose to read the AR book alone reported difficulties in reading (4/6). Half of them (3/6), however, mentioned that they would want to read the AR book with someone else after taking part in a one-on-one AR book reading session: '*someone else, probably one of my friends because when I read with my friend, I usually have a lot of fun*'8MYIRD.

4.7. Discussion

In the context of declines in children's reading enjoyment and engagement (Clark et al., 2023), it is important to critically explore the impact of emerging technologies and their potential to address this challenge by supporting children's reading engagement. In this study, children's perspectives and experiences with an AR book were explored within the conceptual framework of reading engagement (behavioral, cognitive, affective, and social). This study is, to the best of our knowledge, the first to amplify children's voices, to understand how new technologies influence their reading engagement.

In relation to behavioral engagement, usability is a key concern for educators and designers alike (Fu, 2022; Wang, 2022), ensuring new digital forms of interaction do not disrupt, but rather support or enhance, children's reading experiences. Therefore, it is important to note that almost all children in this study were new to this form of technology yet found it easy to read, and interact with, the AR storybook following brief instruction, and also reported their desire to read more AR books after the session. As anticipated, children also reported altered reading behaviors/different navigation strategies to print books, some of which were similar to those also reported in studies of digital reading, for example, reading direction, image exploration, text scanning (Javorsky & Trainin, 2014; Moody et al., 2010; Turner et al., 2020), although notably many children reported similar reading behaviors to print books. Some new behaviors (e.g., text scanning/reading text at speed) are concerning, given that speed is not a good indicator of quality (Stiegler-Balfour et al., 2023). Furthermore, flow when reading, particularly fiction books, is important for enjoyment and comprehension, where AR books have potential to disrupt this [e.g., via hotspots, see Takacs et al. (2015)]. Therefore, content alignment between text, static and dynamic images is essential to support both flow and comprehension (Zhou and Yadav, 2017). Combined, this research highlights that in addition to exploring children's voices via interviews, observational research is needed to understand more about children's interactions with AR books, and how alter their reading behaviors.

With regard to cognitive engagement, the text-based strategies reported by children (e.g., re-reading, decoding, thinking, using context, word substitution) mirror those often used in print book reading (Lim & Toh, 2020; Yeom & Jun, 2020) and which are known to vary in their effectiveness (Castles et al., 2018; Petrová, 2022). The image-based strategies reported highlighted the salience of the dynamic (rather than static) images in AR books. Interestingly, these dynamic images were

found, from children's perspectives, to alter their imagination, primarily facilitating for some, but also inhibiting for others. The creation of mental representations while reading is important for comprehension (Boerma et al., 2016) and dynamic animations (Takacs et al., 2015; Altun, 2018) represented through AR technology (Cheng, 2016) appear to have, at least from some children's perspectives, some potential to facilitate this. Indeed, it is possible that readers, but particularly those with low mental imagery skills, may benefit from dynamic images to support their mental representation of the story. However, readers with low mental imagery skills are also less skilled at integrating picture and text content compared to peers with high mental imagery skills (Boerma et al., 2016); therefore, AR books also need to support this. As a result, when designing AR books, static and dynamic images, in addition to text content, needs to be carefully considered to ensure that both deliver consistent information to facilitate ease of integration (Zhou and Yadav, 2017). Finally, some children reported that the interactive questions helped them monitor their comprehension. Previous research has demonstrated the importance of comprehension questions on children's reading (Sénéchal, 1997; Blewitt et al., 2009; Zhou and Yadav, 2017; Vanderschantz et al., 2019) and it is recognized that some readers have particular challenges with comprehension monitoring, including learners with English as an Additional Language (Hessel et al., 2021) and learners with reading difficulties (Wagoner, 1983). Comprehension monitoring is a metacognitive process which is essential for readers to track and check their interpretation of a text (Hessel et al., 2019). AR books, if including comprehension questions throughout, have potential to prompt and/or support children's comprehension monitoring. However, future research is required to understand which comprehension questions are the most effective, perhaps through manipulating comprehension questions and/or exploration of children's use of different comprehension strategies.

In terms of affective engagement, positive feelings (e.g., impressive, cool, enjoyable, fun, and weird) were reported by the majority of children, mostly in the context of the dynamic digitally imposed images (e.g., realistic, 3D features, immersive visual experience). This aligns with previous research reporting a positive relationship between AR books and reading attitudes/enjoyment (Yilmaz et al., 2017; Othman et al., 2021; Roumba and Nicolaidou, 2022). Positive emotional experiences have been found to promote students' learning (Cook et al., 2020), immersion (Yilmaz et al., 2017) and literacy development (Breadmore et al., 2019). However, not all children reported positive perspectives of the AR book, and many also commented on the characters and story itself as supporting their affective engagement (regardless of the AR features), emphasizing the importance of quality narrative for authors and designers when developing AR books. Furthermore, given the impact of technological novelty on children's affective experiences, future research should continue to explore possible changes in affective engagement as AR books become more prevalent and/or familiar.

Children were generally very optimistic about the potential for AR books to create positive social reading experiences, and the majority demonstrated a desire to share their AR book reading experience with others. For example, after seeing the AR book demonstration in class, all were given the option to read the AR book alone, or with someone else, and shared AR book reading was preferred by the majority: 32 children (16 dyads), with only 6 choosing to read alone (notably the majority of these children had reading difficulties). Sharing and discussing books with peers can be an enjoyable reading activity and can fulfil readers' needs for connection with others (Cremin, 2014; Gambrell, 2011; Guthrie et al., 2007; Pelletier et al., 2022) and extend children's learning of book content (Klvacek et al., 2019). Some children emphasized that they would enjoy discussing the pictures specifically, which aligns with Ann Evans and Saint-Aubin (2005) who

indicate that during shared book reading, when children have extra time, they tend to devote their time to exploring illustrations rather than text.

To summarize, findings from this study extend previous AR reading research which has examined the influence of AR books on children's reading attitudes and motivation (e.g., Yilmaz et al., 2017; Othman et al., 2021; Roumba and Nicolaidou, 2022), both of which are precursors to engagement (Miyamoto et al., 2019; McGeown and Smith, 2024). Furthermore, as engagement improves reading skill (Miyamoto et al., 2019; Torppa et al., 2020; Van Bergen et al., 2021) it can contribute to interpretations of research examining the relationship between AR books and children's reading comprehension (Dünser and Hornecker, 2007; Danaei et al., 2020), through considering the role of engagement.

4.8. Conclusion

This paper provides novel insights into children's perspectives and experiences of using AR books, within the reading engagement framework, and highlights the importance of listening to children's voices as new technologies emerge which may alter reading practices and experiences. As with all technologies, AR books are continuing to evolve, and research is needed to inform and optimize their development and use; this paper seeks to contribute to this evolving landscape for children. Understanding the potential for AR books to initiate and support children's reading practices, engagement and learning is essential for recommendations of their value and use within schools and classrooms. To conclude, we focus on the limitations of this study, future research directions and pedagogical implications.

4.9. Limitations

There are many methodological challenges and factors influencing how findings from this study translate or represent children's AR book reading practices. One key factor that may have shaped

children's engagement is the effect of novelty (Roumba and Nicolaidou, 2022) or the "wow" factor (Perey, 2011) children experienced from engaging with this new technology. It is likely that this decreases as children become more familiar with AR books (Cheng, 2016). While this arguably does not erode the value of an alternative media for engaging children's reading practices, it is an important consideration when interpreting the results. Furthermore, this study is based on a single AR fiction book; AR books will vary considerably in their text content, the popularity/novelty of the story, illustrations, features, etc., and therefore exploring similarities and potential differences with different AR books would be important to understand the commonalities of reading engagement resulting from AR books and how these are aligned with, or differ from, print books, and/or digital texts. Finally, with a focus on reported experiences in this study, one limitation is that observational data was limited to note-taking by the interviewer during sessions. While the first research question aimed to capture how child readers interact with AR storybooks in a classroom setting in real-time, the study only reported observational data regarding usability and ease of use. Whilst note-taking helped reveal high-level interaction patterns such as turn-taking and collaborative discussion periods, more intensive observational data (enabled by multiple observers or video recording) would have provided greater insight from nuanced multimodal interaction, such as gesture, eye-gaze, or body positioning. Future work may seek to focus on such embodied interaction to reveal how augmented reality books influence collaborative engagement. Indeed, emerging research has indicated the significance of embodied (body-based) interaction in learning to read (Wall et al., 2022) and the potential implications for pedagogy and design (Manches & Mitchell, 2023).

4.10. Future research

Qualitative research generates rich data, offering an ideal approach to identify and develop new lines of enquiry, which can then be pursued with different methodological (e.g., experimental) approaches. By using the reading engagement framework, the findings from this study offer a number of avenues for future research which may investigate these dimensions of reading engagement in further detail. In addition, the acceptability and feasibility of AR books within classrooms is also important for further study. For example, poor access to the internet, devices, and technical support in addition to educator time, expertise and confidence can impede the implementation of emerging technologies in classrooms (Panchenko et al., 2020) and therefore further research is needed to understand the challenges for using AR books within school settings. Aligned with this, while this study explored children's voices, an investigation into teachers' attitudes toward AR books and the acceptability and feasibility of using AR books in classroom practice is important (see Cheng, 2016 for related research with parents), especially as adults' perspectives will likely influence children's use and experiences. Finally, at a time where children's reading attitudes and volitional reading are declining (Clark et al., 2023), understanding whether AR books have the potential to re-engage disengaged readers, or support those with reading difficulties, to read more, is important to all those wishing to encourage children's reading.

4.11. Pedagogical implications

For AR books to be used optimally within the classroom, it is essential to raise teachers' awareness of AR books, and how they influence these different dimensions of children's reading engagement, so that teachers can make informed decisions about their use. Indeed, it is important that teachers understand the ways in which this new form of technology can potentially support and extend children's reading practices and experiences in positive ways (e.g., desire to read more, discuss

with others) but also potentially impede positive reading process (e.g., reduced use of imagination). Of course, it is important to recognize that there will always be variation in children's thoughts, feelings, behaviors and learning with any book, but this study does provide insights into the prevalence of shifts in reading engagement which can result from reading AR books (see results and discussion sections for full details). Furthermore, as most children demonstrated a desire to share their AR book reading experience with others, encouraging shared AR book reading with peers within the classroom could create novel positive social reading experiences. Using shared AR book reading may be particularly beneficial for children with reading difficulties, as those with reading difficulties often chose to participate in this study individually, but then all mentioned a desire to share an AR book with others in future. Given that children with reading difficulties often report lower reading attitudes, motivation and interest (Guthrie & Davis, 2003; Vaknin-Nusbaum et al., 2018; Van Der Sande et al., 2023) and higher levels of reading anxiety (McArthur, 2022; Fishstrom et al., 2024), AR books may be one way to support their reading practices and foster positive social reading experiences with others.

Data availability statement

The original contributions presented in the study are included in the article/supplementary material, further inquiries can be directed to the corresponding author/s.

Ethics statement

The studies involving humans were approved by the School of Education and Sport Ethics Committee, The University of Edinburgh. The studies were conducted in accordance with the local legislation and institutional requirements. Written informed consent for participation in this study was provided by the participants' legal guardians/next of kin.

Author contributions

KA: Conceptualization, Data curation, Investigation, Writing – original draft, Writing – review & editing. AM: Conceptualization, Supervision, Writing – review & editing. SM: Conceptualization, Supervision, Writing – review & editing.

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Conflict of interest

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

Publisher's note

Chapter 5

Study 1: Teachers' insights

Usability of implementing AR books within classrooms.

Teachers' insights into the usability of implementing AR books within classrooms will be presented in this chapter, as AR books require unique usability considerations. One of the AR technology's advantages is that non-technical users can easily engage with this technology regardless of their limited experience (De Sousa et al., 2023). However, issues related to technical, time restrictions, availability, and procedure will be discussed in this chapter, as these issues could have implications for the implementation of AR books within classrooms.

5.1. Technical issues

Accessing AR features does not require Wi-Fi as long as the app that connects with the AR book has been downloaded, which makes accessing the AR books more accessible than many technologies that rely on internet connectivity. However, teachers may face usability issues while implementing AR books within classrooms, such as being required to download a specific app for each AR book to activate the AR features, which requires continuous efforts to download a new app each time to access a new AR book. In addition, it was noticed that school devices (i.e., iPads) have limited access due to local authority policy and are restricted regarding downloading apps, so teachers may not be allowed to download apps via school devices, which may affect the usability of implementing AR books within classrooms. Both teachers who participated in Study 1 highlighted the role of technical issues in complicating the implementation of AR books (e.g., technical support, restriction to download apps to school devices): "*the other problem we have with the devices we have; we have very limited apps related to put on them. So, for example, I*

cannot put that app on the iPad without having school go through loops. So, I have to use it on my phone". To address such issues, a new platform has recently been developed by *Ludenso's* (www.ludenso.com), which allows users to access different AR books through downloading only one app to facilitate the process of accessing AR books. Children's AR books, however, have not been included yet within the platform.

5.2. Time issues

Previous research suggested that reading digital books consumes more time compared to print books, which could be applicable on reading AR books. This could be justified by the additional features or opportunities for interactivity. For example, Richter and Courage (2017) found that the time preschool children spent completing reading digital book doubled compared to finishing a print book. Indeed, teachers have limited time within their daily teaching schedule/timetable, and both teachers who joined Study 1 highlighted the lack of time as a challenge to implementing AR books within the classroom: *"it would be adult time*"; "*and also time because there's just so much I think you need to spend a lot of time to get the most out of it. This was just factoring in time in the week and the timetable*". As reading practice can take place outside the school (Pelletier et al., 2024), a different approach could be implemented, aligning teachers' time (e.g., borrowing the AR books to read at home and joining book talks in the classroom).

5.3. Availability issues (Quality and Text readability)

AR books vary in their quality (Wang, 2022), and both teachers highlighted the challenges of finding suitable AR books that have such a high quality of illustrations, storyline, in addition to the readability levels that match children's reading ability: *"I suppose you'd have to make sure; I suppose the reading words are similar to their school reading book"; "I think that comes down to*

the quality story and the quality of the graphics that are used and the quality of the scenario"; "I think having text interesting for the children and at the right level like ability reading".

5.4. Procedure issues: specific settings (one-on-one or small group)

AR technology has been implemented in different settings. For example, the whole class (e.g., Kerawalla et al., 2006), or in small groups (e.g., Danaei et al., 2020). Both teachers reported that they were interested in implementing AR books in one-on-one: "*I think this would have to be done one to one, and I would not use this in a big group*" or small-group settings: "*I probably wouldn't use whole class. I'm going to try with small groups, maybe two or three working together*" due to different reasons, such as giving each child a chance to fully explore the book through the device: "*I think they would probably get more out of it with as if it was a bigger than that. It would be very hard to get the manual experience*", or minimising unpleasant behaviours (e.g., destruction from the content): "*I think I you'd end up with kind of level behaviour issues I think because it's fun but are they really do what you wanting them to do? are they really engaging with the story, or are they just playing? Are they really engaging with the story that's being told, or are they just engaging with the technology that's delivering it?"*.

This brief chapter discussed issues related to the usability of implementing AR books within classrooms (technical, time restrictions, availability, and procedure issues). Teachers' insights into the procedure of implementing AR books within classroom settings (i.e. small group) were adopted to develop the design of the second study (reading AR book with a peer), which will be presented in the next chapter.

Chapter 6

Study 2

Increasing Book-Talk and Extending Reading Experiences Among Children with Reading Difficulties: The Role of Augmented Reality Books

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Abstract

Shared reading and book-talk are common activities used to engage elementary school readers, yet can be anxiety provoking for those with reading difficulties. Identifying whether, and how, new technologies can foster more positive reading experiences for children with reading difficulties is therefore essential. This study compared children's book-talk and reading experiences with an Augmented Reality (AR) and non-AR (matched in content) book. In total, 32 UK children (aged 8-10) with reading difficulties participated in dyads in two shared book reading sessions (AR/non-AR book, counterbalanced), with book-talk after each session, followed by a general discussion to learn of the similarities and differences in their AR/non-AR reading experiences. AR books significantly increased the quantity of children's book talk (number of words spoken and sentence length) and many similarities and differences found in children's experiences with the AR and non-AR book. Results are discussed in full, in addition to educational implications.

Keywords: Augmented Reality: reading difficulties, dyslexia, book-talk, social reading engagement

6.1. Introduction

Reading skills underpin children's educational outcomes (Pelletier et al., 2024), and play an essential role in children's post school opportunities and participation in society (Henriksson & Laakso, 2020). Elementary schools are an essential context for children to develop their reading skills, in addition to supporting positive reading experiences (Claessen et al., 2020; McGeown & Conradi-Smith, 2024; Wyse & Bradbury, 2022). Children who struggle with reading are often less motivated to read, lack confidence in their reading skills (Guthrie & Davis, 2003), and have an increased risk of emotional and social difficulties (Casey et al., 1992; Claessen et al., 2020; McArthur & Castles, 2017). Compared to engaged readers, disengaged readers are typically less socially interactive in reading (Gambrell, 2011). Yet integrating social reading interactions between peers (e.g., reading together and talking about books) promotes children's engagement in learning (Cantrell et al., 2017) and reading (Gambrell, 2011).

6.2. Reading difficulties and anxiety

Many children have difficulties with reading, which can affect their academic, social, and emotional experiences and outcomes. The prevalence of reading difficulties varies considerably depending on school-level data and research studies focusing specifically on understanding this population. However, it is suggested that approximately fifteen per cent of children struggle with reading (Francis et al., 2022; McArthur & Castles, 2017), with difficulties in either word reading and/or comprehension (Al Otaiba et al., 2023; Duff & Clarke, 2011; Nation & Snowling, 1998). Studies of children with reading difficulties have primarily focused on cognitive difficulties, and remediating difficulties associated with phonological decoding, language, etc. (e.g., Al Otaiba et

al., 2023; Hall et al., 2023). Far fewer studies have focused on the affective or emotional dimension of reading difficulties (Katzir et al., 2018), although see (Casey et al., 1992; Claessen et al., 2020; McArthur & Castles, 2017). Indeed children with reading difficulties typically have higher levels of anxiety compared to typical readers (McArthur & Castles, 2017; Novita et al., 2019; Wilmot et al., 2023) and difficulties with reading is associated with both reading and social anxiety (McArthur, 2022). For example, some children may have concerns about reading aloud due to fear of embarrassment (Francis et al., 2022). High levels of reading anxiety in turn has consequences for reading fluency and comprehension (Fishstrom et al., 2024).

6.3. Social reading activities

Social reading activities can take different forms, for example, book-talk, reading together, reading aloud, or sharing recommendations with others, and these activities can occur with peers, teachers, friends, family, etc. (Cremin et al., 2004; Gambrell, 2011; McGeown & Conradi-Smith, 2024). Discussing texts with peers can help children to learn from each other (McGeown & Conradi-Smith, 2024), build positive reader identities, and feel more connected to each other (Cremin et al., 2024). Shared book reading is both an educational and a social practice (Parpucu & Ezmeci, 2024). To date, a number of studies have investigated the positive influence of shared book reading on children, including children's phonological awareness skills (Parpucu & Ezmeci, 2024), language development (Dowdall et al., 2020; Noble et al., 2019), story retelling (Olszewski et al., 2018), and reading engagement (Clinton-Lisell et al., 2024).

In addition to studies which have investigated adult-child shared book reading, either where the child shares a book with a teacher (e.g., Lepola et al., 2023; Piasta et al., 2012) or a parent (e.g., Chen, 2024; Cheng & Tsai, 2016; Hamilton et al., 2021; Strouse et al., 2023); there are also a number of studies exploring *child-child* shared reading (e.g., Brown et al., 2018; Downs et al.,

2020; 2023; Lloyd & William 1988). This research examining child-child dyad reading suggests this practice has a positive influence on children's reading comprehension (Flores et al., 2024; Van Keer, 2004) and reading fluency (Duran et al., 2019). However, dyad reading is often used as a form of peer tutoring (Downs & Mohr, 2024), where a mixed ability approach (Topping et al., 2015) is used, with a lower and higher-level reader reading together (Downs & Mohr, 2024). Given the relationship between reading difficulties and anxiety (McArthur & Castles, 2017; Novita et al., 2019; Wilmot et al., 2023), positive shared reading experiences for children with reading difficulties may arise from reading alongside a peer with similar difficulties in reading. Such an approach has potential to create a more relaxing reading environment.

6.4. Reading mediums: Augmented Reality (AR) and non-AR books

Shared reading experiences are altered by reading mediums (Krcmar & Cingel, 2014). Different text types and formats have been used to support and study shared book reading, including print books (e.g., Dowdall et al., 2020; Krcmar & Cingel, 2014; Yuill & Martin, 2016), digital books (e.g., Chen, 2024; Parish-Morris et al., 2013; Strouse et al., 2023), and more recently, Augmented Reality **(**AR) books (Alhamad et al., 2024; Cheng & Tsai, 2016; Cheng & Tsai, 2014). Augmented Reality **(**AR) books blend physical and digital features as they are physical books through which digital features (e.g., animation, sound, interactive activity) can be enabled via electronic devices (e.g.,phone; tablet computer) directed towards the physical book (K.-H. Cheng & Tsai, 2014; Panchenko et al., 2020; Polyzou et al., 2023). In shared reading, children's language can be shaped by device use (Ewin et al., 2021), and different reading mediums have different influences on the richness of book conversation (Strouse et al., 2023). Indeed, language quantity (e.g., the number of words), and language quality (e.g., sentence complexity), either children are exposed to or produce, are the foundation of their literacy skills (Romeo et al., 2018; Strouse et

al., 2023). A few research studies have investigated the quantity and the quality of book conversation during adult-child shared reading with different reading mediums (e.g., Ewin et al., 2021; Krcmar & Cingel, 2014; Parish-Morris et al., 2013). Compared to print books, these studies raise a concern regarding the quality of book conversation when readers shared a digital book, for example, readers' talk is commonly also related to the device in addition to the content (Ewin et al., 2021; Krcmar & Cingel, 2014; Parish-Morris et al., 2013). However, Strouse et al (2023) argued that digital books do not necessarily decrease the quality of book-talk (content-related) if books are carefully designed, for example, by including only story-relevant hotspots (Strouse et al., 2023), and relevant enhancements such as illustrative information (Clinton-Lisell et al., 2024). In addition, previous research suggests that high-quality illustrations in children's picture books can increase vocabulary usage, narrative ability, and narrative retelling (Davis et al., 2024). With the additional enhancement of illustrations offered by AR technology (e.g., 3D animation), AR books have the potential to enhance or extend children's shared reading experiences and book-talk in different ways. However, there is currently no research which has explored this.

6.5. Research rationale and aims

Given the prevalence of reading difficulties, and the need to identify effective ways to increase children's reading enjoyment and engagement, this study examined whether AR books can foster positive and productive social reading experiences for children with reading difficulties. There were two aims:

To explore whether AR features influenced the quantity and quality of book-talk between children with reading difficulties.

To understand the perspectives and experiences of children with reading difficulties, following reading an AR and non-AR book with a peer.

This study was preregistered and can be found here: https://osf.io/x6r4z

6.6. Method

6.6.1. Participants

Children were eligible for participation if they had difficulties with reading, either decoding and/or comprehension (as identified by their teacher), and received learning support, either through a class teacher or support for learning (SFL) teacher. The participants include 32 UK children (aged 8-10, 15 boys, 17 girls) with reading difficulties from nine different classrooms across two primary school settings. In total, seven different nationalities were represented, and three children spoke English as an Additional Language (EAL). Teacher-reported reading difficulties were as follows: 16 children with difficulties in both decoding and comprehension, 12 with comprehension only, and four with dyslexia diagnoses. All students received Support for Learning (SFL), planned by the SFL teacher, and delivered by the SFL teacher (19 students) or class teacher (13 students). The study followed ethical guidelines from the British Psychological Society. Ethical approval was given by the University of Edinburgh. Headteacher, parent/guardian, and child consent was required and obtained prior to participation.

6.6.2. Procedure

Prior to the study, children participated in a short demonstration to learn how AR books work. Following this, all children participated in two shared book reading sessions (one AR, one non-AR) (see below for details), with one immediately following the other. Each session lasted approximately 15 minutes with the same two children reading together in the presence of the researcher; these dyads were selected by the class teacher. Books used (Book 1 and Book 2) and

order of sessions (AR and non-AR) were counterbalanced. Books 1 and 2 were both fiction texts and almost identical in terms of the characters, text/book size, length, layout and AR features. Therefore, in one session AR features were enabled and in the other they were not. After reading the book together (10 min), children took part in a book-talk session (5 min) to discuss the book together based on two prompt questions: 1) Talk with your classmate about what you liked most about the story, and what you did not like. 2) What can you remember most about the story? Book-talk sessions were audio recorded and transcripts were used to analyze the quantity of book-talk (i.e., the number of spoken words spoken, word length and sentence length) in each condition. Furthermore, written (anonymized) notes were made during the observation (dyad's reading preference: e.g., reading aloud or silent). Following both 15-minute sessions, children then participated in a 10-minute discussion session with the researcher, to learn more about their perspectives and experiences of reading with a peer, and using an AR and non-AR book. Finally, children were asked to complete a short survey measuring reading anxiety (Reading Anxiety Test – Children, Francis, al, 2020) with the support of the researcher (reading the items aloud where children communicated this as a preference (see Table 3 for description of the entire reading session). All sessions took place in a quiet space in the child's school.

Table 3

Overview of each reading session

Short demonstration	5 min	Seeing a short demonstration of how the AR book works and activating one page of the book.
Shared book reading session (1)	10 min	Reading together (AR/non-AR, book 1/2 counter balanced).
Book-talk session (1)	5 min	Discussing the book together.
Shared book reading session (2)	10 min	Reading together (AR/non-AR, book 1/2 counter balanced).
Book-talk session (2)	5 min	Discussing the book together.
Discussion session	10 min	Sharing their perspectives and experiences of reading with a peer, with both the AR and non-AR book.
Survey/ self-report	10 min	Completing the Reading Anxiety Test for Children – Self Report (RAT-C).

6.6.3. The AR and non-AR storybook

Using online bookstore catalogues, AR books were reviewed to find a book suitable for the age group of the study. Following discussion among the research team, Arbi 1 and Arbi 2 were selected due to the simplicity of AR interaction (device held over full page image), suitability of language/content for age range, genre (fiction), length (appropriate for assessment sessions), quality of story, illustrations, and AR features, and suitability for counterbalanced implementation design. In addition, this book had been found to be suitable in a different project with this age range (Alhamad et al., 2024). The two books were published by the CreateSpace Independent publishing platform in 2015 and 2016. Book 1 App and Book 2 App were downloaded from the App Store to access the AR features through the iPad (A2197-10.2-inch-7TH Gen). The theme of both stories is around friendship, where friends with different abilities work together to protect their village (Book 1) or to find a treasure (Book 2). Book 1 contained 40 pages (16 pages of text

on the left hand and 16 pages of full-page illustration on the right hand), with additional pages providing general information and instructions, and Book 2 contained 20 pages of text on the left hand and 20 pages of full-page illustration on the right hand.

6.6.4. Data Analysis

Survey/ self-report. *The Reading Anxiety Test for Children – Self Report* (RAT-C; www.motif.org.au) was used. While the full test consists of three subscales: Generalised Reading Anxiety, Social Reading Anxiety, and Physical Symptoms, the researcher only used the *Social Reading Anxiety Subscale* for ease and speed. This consists of six statements (e.g., "I worry when I have to read aloud in front of my classmates") with the following response options: Never, Sometimes, Often, Always, Don't know. Individual responses were summed using RAT-C scoring guidance to generate a *Social Reading Anxiety* score. Based on the NORMS TABLE RAT-C, 13 students included in this study had elevated Social Reading Anxiety. This was included in background information about the participants (see Table 4).

Book-talk sessions. All book-talk sessions were audio recorded and transcribed in full by the first author. The *ATOS Analyzer Tool* was used to calculate the word count, average word length, and average sentence length in both the AR and non-AR condition. A *paired samples t-test* was carried out to compare AR and non-AR conditions.

Discussion sessions. All discussion sessions were audio recorded and transcribed in full by the first author. Themes were identified using a data-driven inductive approach, using the six phases of thematic analysis outlined by Braun and Clarke (2006). Furthermore, analysis involved continual consensus-building among team members (Peacock et al., 2017); the first author and the third author fully analyzed the first five interviews independently and then cross-referenced findings before the first author carried out a thematic analysis on the whole data set. Data was

managed through NVivo, which allowed prevalence information related to each subtheme to be calculated. Codes were created to provide background information about the participants: codes alongside quotes provide the student's age, gender, reading difficulties, and social reading anxiety. Table 4 explains the participant codes used in the quotes.

Table 4

Participant codes

Participant information	Code
1. Age	8, 9, 10
2. Gender	M = male F = female
3. Reading Difficulties	X = difficulties with both decoding and comprehension C = difficulties with comprehension only D = diagnosed with dyslexia
4. Elevated Social Reading Anxiety	Y = Yes N = No

For example: 9FCN (Female, age 9, difficulties with comprehension, no social reading anxiety

6.7. Result and discussion

To integrate results from this mixed methods study, and discuss the results fully, a combined results and discussion section is provided, framed in relation to the two research questions.

RQ1: To what extent does AR influence the quantity of book-talk between children with reading difficulties?

All skewness and kurtosis values indicated a normal distribution and therefore were suitable for the planned analyses (with one exception: average word length under non-AR condition, used in the exploratory analyses). See Table 5.

Table 5

Mean, standard deviation, skew and kurtosis values for book-talk sessions.

Book-talk	Mean	S.D.	Skewness	Kurtosis
Number of words spoken (NON-AR)	150.25	60.41	-.51	-.17
Number of words spoken (AR)	298.19	142.16	.48	.07
Average word length (NON-AR)	3.82	.23	1.89	4.62
Average word length (AR)	3.83	.15	-.06	.23
Average sentence length (NON-AR)	8.83	2.87	1.00	1.02
Average sentence length (AR)	10.02	2.42	.67	1.23

6.7.1. Quantity of book-talk after reading an AR vs non-AR book.

Using the openly available *ATOS Analyzer Tool*, the number of words spoken in each dyad were compared in the book-talk session, which immediately followed reading the AR and non-AR book.

Number of words spoken. The average number of words said by children in the non-AR shared reading condition, M = *150.25, SD = 60.41*, was lower than in the AR shared reading condition, M = *298.19, SD = 142.16*. A paired samples t-test demonstrated a statistically significant difference between the two conditions, and the size of this effect was large: t = -5.290, df = 15, p <.05, two-tailed, d = 1.46.

In addition, exploratory analyses were carried out (not preregistered) to examine whether the word length or sentence length differed between the two conditions:

Average word length. The length of words said by children in the non-AR shared reading condition, M = *3.82, SD = .23* was almost similar to the AR shared reading condition, M = *3.83, SD = .15*. A paired samples t-test illustrated no significant difference between the two conditions, *t (15) = -.20, p> .05*.

Average sentence length. The length of sentences said by children in the non-AR shared reading condition, M = *8.83, SD = 2.87* was lower than in the AR shared reading condition, M = *10.02, SD = 2.42*. A paired samples t-test demonstrated a statistically significant difference between the two conditions, although the size of the effect was small t =1.95, df =15, $p < .05$, two-tailed, d= 0.29.

Therefore, compared to shared non-AR books, shared AR books significantly increased the number of words spoken (large effect size d = 1.46) and extended the length of sentences (small effect size d= 0.29.) used when readers discussed the book. However, additional analysis was carried out to examine the content of the book-talk following reading with an AR vs non-AR book (not preregistered). The unplanned analysis was carried out to further examine whether the AR book condition may have resulted in more book-talk related to the technology/AR features, rather than the book/story content specifically. Following discussion within the research team, a decision was made to exclude all words/statements related solely to technology, including those referring to the device, AR technology and AR features (e.g., iPad, activating pictures via iPad, app, 3D, animation, interactive questions). Across all dyads, the average number of technology specific words was M = *38.19* (which represented 12.81% of all talk) (see Table 6), while the average number of words related to the story M = *260,* which was higher than in the non-AR shared reading condition, M = *150.25.* A paired samples t-test demonstrated a statistically significant difference

between the two conditions, and the size of this effect was large: t = -4.63, df = 15, p <.05, two-tailed, d = 1.10.

Table 6

Quantity of book-talk (number of words spoken)

Group	Non-AR shared reading	AR shared reading		
		Total talk	*Technology talk*	*Story content talk*
1	141	275	52	223
2	86	148	25	123
3	102	343	40	303
4	177	261	48	213
5	95	302	78	224
6	166	172	0	172
7	170	163	0	163
8	227	278	21	257
9	106	236	30	206
10	16	46	0	46
11	122	307	14	293
12	211	311	82	229
13	137	314	0	314
14	202	515	71	444
15	224	561	49	512
16	222	539	101	438

RQ2: What are children with reading difficulties' perspectives and experiences of reading with a peer, using an AR and non-AR book?

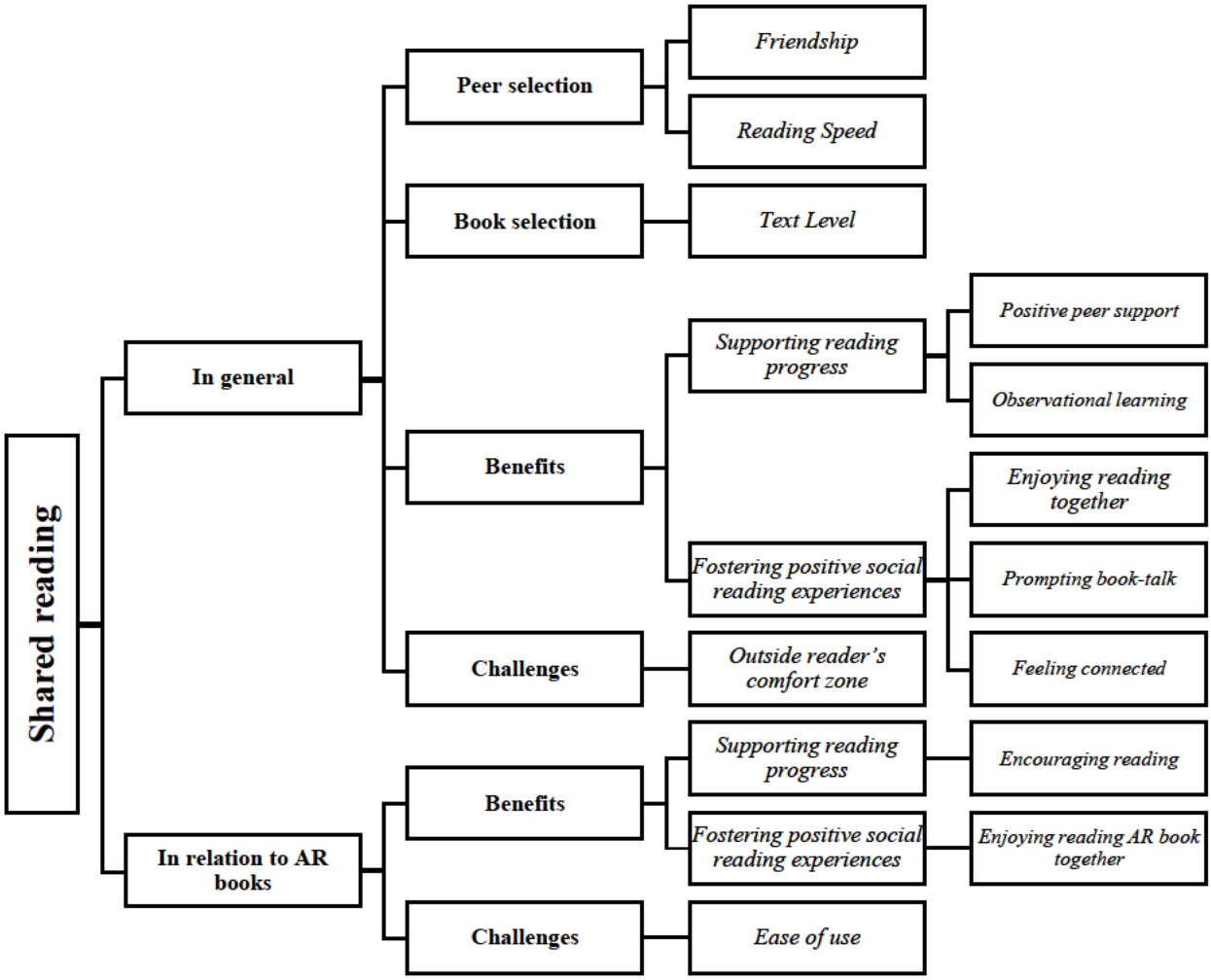
6.7.2. Children's perspectives and experiences of shared reading

Themes and subthemes were identified to reflect children's perspectives and experiences of reading with a peer, using the AR and non-AR book. As many similar themes were identified across both conditions, results are integrated to illustrate the similarities in children's perspectives

and experiences of reading in these different conditions. However, there were also some notable differences, with some comments specific to AR books, which are provided separately. See Figure 16 for a summary. Prevalence information is sometimes based on dyads (/16) or individual students (/32) as appropriate, and is provided below. In addition, codes alongside quotes provide the student's age, gender, reading difficulties in either word reading and/or comprehension, and whether the student had elevated social reading anxiety. Table 4 explains how to read these codes.

Figure 16

Children's perspectives and experiences of reading with a peer, using an AR and non-AR book



6.7.2.1. Children's perspectives and experiences of shared reading: Shared reading in general

Peer selection.

Friendship: Most dyads (prevalence: 11/16) reported that they enjoyed reading both books together, especially when the dyad selected by the teacher was two friends: *"I got to read it with one of my friends"* 9MXN; *"I like like my friend and love being around with me when I'm reading*

books" 8FXY. Half of the participating children (16/32) mentioned that they prefer reading a book with a friend: *"I prefer doing it with a friend"* 9FXN rather than reading with a classmate: *"I don't really work well with my classmate. I worked well with my friends"* 9FCN. For some children with reading difficulties, reading with a classmate makes them feel frustrated: *"It makes me feel like frustrated like don't want to read this"* 8FXN for numerous reasons, for example: *"talk to you when you're trying to do your turn"* 10MCN; *"getting told off"* 8FCY; *"they always interrupt me"* 10MCY; *"my classmate might be like, do like confuse me.... doesn't put his finger on the page, so I don't know whether it's time for me to read"* 8FXN. Friends are considered one of the social support sources that supports children's engagement in reading at school (Pelletier et al., 2024). As reading can often be quite difficult, stressful, and anxiety-provoking for children with reading difficulties (Francis et al., 2022), participating in shared reading experiences, particularly with a friend at a similar reading level, offered a relaxed and positive reading experience.

Reading Speed: Almost half of the dyads (7/16) reported that they enjoyed reading both the AR and non-AR books together, particularly when they read at the same pace: *"... is a really good reading partner and she goes at the right pace. We go like basically at the same pace and that's really good"* 8FXN. Children reported that reading with a peer who is slower or faster than their reading speed would disrupt reading flow: *"It's hard to keep up. Hm. So sometimes if it's a fast reader"*9FCN; *"and then if it's a slow reader, it's like you just want to go to the next page"* 9FCN; *"when they're going too fast or too slow. If they are going too fast, it's hard to understand what's going on. Yeah, when they're going too slow, sometimes it is just bothering"* 9FXN. Previous research has reported a positive influence of dyad reading, a lower-level reader with a higher-level

reader (Downs & Mohr, 2024), on reading comprehension (Flores et al., 2024; Van Keer, 2004) and reading fluency (Duran et al., 2019). However, for some readers with reading difficulties, reading with a peer with a different reading skill level, either higher or lower, can negatively affect the flow of their own reading. Previous research reports that reading flow is a key element in increasing readers' enjoyment, involvement, and engagement in reading (Thissen et al., 2018) and therefore its importance should not be underestimated.

Book selection.

Text level: The books selected for the project were designed to be reading level appropriate for children with reading difficulties of this age group. Indeed, among all participating children, only two dyads (2/16) referred to the difficulty level of the books, but perceived this differently, either as an unpleasant experience: *"It depends on if you are a good reader., yes, but if you are not so good reader, no. I found it quite difficult story"* 8MCN, or an enjoyable challenge: *"I think that was a bit harder for reading. It sounded like some struggling words for me, but I didn't really say them right. I don't think I did, but I really like that"* 9FXN. Book selection is essential to create a successful shared reading experience for readers (Parkes, 2023). For example, research has studied the effect of using above-grade-level texts and suggested that challenging texts are important for all readers to strengthen their reading skills (Brown et al., 2018). Challenging texts, however, would be beneficial if strong support was offered (Kuhn & Stahl, 2003) so above-grade-level texts may be more suitable for adult-child than child-child shared reading.

The benefits of shared reading: supporting reading progress.

Positive peer support: Most dyads (11/16) described their reading experience with a peer, using an AR or non-AR, as a risk-free reading experience since they could easily ask for help whenever they needed it, especially for decoding hard, long, and tricky words: *"if you're stuck on*

a word, you can always say: What is this word" 8FCY*; "It's quite fun even if you get stuck on the word, you can ask could you help on this word"* 8FXY*; "I probably enjoyed it because (….) would read with me and help me know the words and put words in that long sentence"* 8FCY. In addition, while some children (15/32) reported that they were open to receiving help from peers: *"They could help you, correct me and I'm not bothered if somebody does that"* 9MDN;*"... helped me quite a lot. So that's why I like reading books"* 8FCY, one child (1/32) found it hard to accept help: *"Uh, yeah. Yeah, getting corrected hard"* 8FXY*,* even though she reported that it is also hard for her if she does not get help*: "It's a challenging bit, is when you stuck on the word, and they do not correct you and they leave me to do the word on your own, then it's really hard and will get stuck in there for hours"* 8FXY. Compared to individual readers, reading in pairs allows children to cooperate and help each other (Dünser & Hornecker, 2007a). Some readers, however, feel worried due to risk of embarrassment (Francis et al., 2022) if they make a mistake. Interestingly, most participating children were open to asking for help, particularly asking their friends, which shifted their concern from being judged to being involved more in reading, highlighting the valuable role that friends play in supporting their peers in reading at school (Pelletier et al., 2024).

Observational learning (how others read): While not prevalent, one dyad (1/16) reported that reading with a peer offers an opportunity to observe and discover how others read: *"see how they read. It's fun because you can see how they read"* 9FDY*; "also you can discover how other people read"* 9FXY. Children learn from each other by observing their peers (Gambrell, 2011), and interacting socially during reading (McGeown & Conradi-Smith, 2024). A concern could be raised regarding providing a suitable model since both readers reported reading difficulties. However, children are not supposed to be flawless readers to learn from each other. For example,

they can learn how their partner deals with the challenging text (Klvacek et al., 2019), which may foster their confidence to succeed in reading when they observe the progress of their peers (Gambrell, 2011).

The benefits of shared reading: fostering positive social reading experiences.

Enjoying reading together: While also not prevalent, two dyads (2/16) reported that they enjoyed reading together, using both the AR and non-AR book; *"Because it's more interesting when two people are reading it because it's more fun"* 9FDY*; "It's because we enjoyed reading it together because it's really fun"* 8FXY. Given that shared reading is a social reading practice (Parpucu & Ezmeci, 2024), reading with a peer offers opportunities for some children to share fun with peers within reading and gain enjoyment.

Prompting book-talk: Some dyads (5/16) reported that reading with a peer, using AR and non-AR books, allowed them to share their thoughts, whether their thoughts were related to the story (2/5): *"If you're alone, you can't really talk to anyone about the book"*10MDN*; "I really like reading and say favorite thing"*8FXY*;* the static images (1/5): *"because it's more fun because you can discuss the pictures"* 9FXY, or the dynamic images (2/5): *"fun to look around and see what's happening in the book with a friend. You can talk together about them"* 9FXN. Readers feel positive about having something relevant to share (Davis et al., 2024). Previous research has demonstrated the importance of talking about text with peers (Gambrell, 2011; Lee et al., 2021; McGeown & Conradi-Smith, 2024), and its positive influence on reader identity (Cremin et al., 2024) and reader's social engagement (Lee et al., 2021a).

Feeling connected: Some dyads (5/16) reported that reading alone made them feel lonely, so reading with a peer made them feel connected: *"You're not alone and you can read with*

someone" 10MDN*; "I like how I was not alone"* 10MXN.. Readers" sense of connection to their peers is essential for their willingness to engage (Cantrell et al., 2017). Shared reading as a social reading practice (Parpucu & Ezmeci, 2024) offers opportunities for readers to connect, interact with their peers (Lee et al., 2021a) and to be socially engaged (Gambrell, 2011; McGeown & Conradi-Smith, 2024).

The challenges of shared reading.

Outside reader's comfort zone: Among the participating children, four children (4/32) reported that reading with a peer experience was out of their comfort zone due to different reasons. For example, reading with a peer was an unfamiliar practice for some readers (2/4): *"Because I'm not really used to reading with someone just reading by myself"* 8FCY*; "Because I am not really read with another person for a long time"* 8FXY. On the other hand, some readers (2/4) reported that they do not feel comfortable sharing, whether the child (1/2) did not like to share in general: *"Well, I like reading but I just don't really like sharing"* 9FXN or only would like to share in specific conditions: *"when I feel confident I can do it because some words are quite longer than others and the longer ones are really hard to pronounce"* 8FXY. Of the four children who commented on this, three were diagnosed with dyslexia and three reported elevated levels of social reading anxiety. Children with dyslexia are at elevated risk of anxiety and they often reported having stress related to their school experience (Wilmot et al., 2023). For example, being at risk of embarrassment evokes worry about reading aloud (Francis et al., 2022). The shared reading practice in this study was unfamiliar to some participating readers and gaining more experience with shared reading may lead to different perspectives. For example, it was found that as children, who struggle with reading, gain more experience with dyad reading practice, their confidence as

readers increases (Klvacek et al., 2019). However, the presence of this theme does highlight the importance of recognizing individual differences in children's preferences for shared reading.

6.7.2.2. Children's perspectives and experiences of shared reading: Shared reading in relation to AR books.

While there was considerable overlap in the themes identified when children spoke about AR and non-AR books, other themes were identified which were specific to the AR book only. These are discussed below:

The benefits of shared reading: supporting reading progress.

Encouraging reading: One dyad (1/16) reported that reading with a peer using an AR book encourages reading, especially if you do not like to read: *"If we just been reading AR, if you don't like reading at all then you start reading AR can make you read more. You wouldn't have to read stories you don't really like and just the AR ones what you do like. So, if you hate reading absolute, absolutely everything about it, you can start getting an AR book, and you might start wanting to read a lot more. It might encourage you and inspire you, because there's like 3D pictures and it is easier I think it's very funny. So, I think it would be I think it would make you want to read more AR and it's also made me want to read more AR and get AR books"* 9FCN*; "I don't like reading at all, but the AR is very fun. I much prefer that books now"* 9FXN. Children who struggle in reading have low motivation to read and less likely to read for enjoyment (Guthrie & Davis, 2003). The use of technology can bring the reader closer to reading (Fernandes & Leite, 2023; Karemaker et al., 2017), and make reading experiences more engaging and enjoyable (Avila-Garzon et al., 2021; Othman et al., 2021; Yilmaz et al., 2017); whether this can encourage reading beyond AR books is a different question, but one which would be important to explore.

The benefits of shared reading: fostering positive social reading experiences.

Enjoying reading AR book together: Some dyads (5/16) reported that they only shared fun when they were reading the AR book together: *"It's fun reading like an AR with a classmate, but if it wasn't with a classmate and it's not an AR, I don't think I would find it very fun"* 9FCN*;"Because it becomes more exciting when it comes to life, but when you just to read the book together, normally it's not really that much fun"* 9MXN, as blending tech with reading allowed them to explore the dynamic images together (4/5): *"It's like fun to bring it to life together than alone"* 9MXN*; "It made me feel happier. It was come to life book and I got to read it was one of my friends, because it's like fun looking at the pictures together on the iPad"* 9MXN*; "With that kind of book AR book, it's kind of fun to look around, and see what's happening in the book with a friend"* 9FXN*; "Because it was also very funny and I like the 3D on it and yeah if I was reading that by myself, I wouldn't be laughing at all, but since I'm with a friend, I am laughing at it and I think that one was a bit more fun. Well, I mean, if I was reading that by myself, I would probably find it quite boring, but reading it with a friend, I find it fun and interesting"* 9FCN, and accessing the book through the iPad (2/5): *"It was quite a cool thing with the iPad thing, which was quite nice because one person would hold the iPad and the other person would read the story"* 9FCN; *"I prefer sharing that one with someone else because it's fun holding the iPad and looking at the pictures together"* 9FXN. Reading enjoyment leads to promoting children's performance in reading (Vermont Agency of Education, 2022). Combining AR technology with physical book transfer reading practice to be an interactive experience (Fernandes & Leite, 2023). For young readers, the use of technology makes the reading experience more engaging and enjoyable (Alhamad et al., 2024; Avila-Garzon et al., 2021; Blachowicz et al., 2009; Ciampa, 2016; Huang,

2015; Othman et al., 2021; Yilmaz et al., 2017), particularly if they shared this experience with someone else. For example, when children interacted with an AR storybook, the longer interactive time spent by pairs was related to playfulness, however for individual readers,, it was related to being frustrated or facing a problem (Dünser & Hornecker, 2007a).

The challenges of shared reading.

Ease of use: Some dyads (5/16) reported that after passing a couple of pages, they found themselves getting into a rhythm with reading and exploring (3/5): *"We got in a rhythm and then we found that we can read"* 9MDN; *"we got like three and then three. If it was like four, we would have went two and the two together"* 8FCY, and with sharing the iPad (2/5):*"It's like we share holding the iPad in front of the book mm hmm like I I'd hold it and then … hold it. I prefer sharing that one with someone else"* 9FXN. Ease of operation should be priortised when integrating AR technology into children's picture books to facilitate reading experiences (Wang, 2022). Compared to print and digital books, AR books require managing the physical book and electronic device together (Fernandes & Leite, 2023). Unlike child-adult shared reading when the child tends to handle only the electronic device while the adult handles the book (Järvenpää, 2022), dyads tend to exchange handling both; the book and the iPad. Thus, considering the balance between AR books' elements such as images and text (Fernandes & Leite, 2023) would make shared AR book reading easier to operate, allowing more time to focus on the book and its contents.

6.8. General Discussion

This study makes a novel and significant contribution to our understanding of whether, and how, AR books support the reading enjoyment, engagement and book-talk of children with reading difficulties. Given that a significant proportion of children have difficulties with reading, which

often has consequences for their reading enjoyment, engagement and anxiety, it is essential to understand whether new technologies have the potential to facilitate positive reading experiences. Interestingly, AR books significantly increased the quantity of children's book talk (illustrated by average number of words said), and, to a lesser but also significant extent, increased the length of sentences used during book-talk. This significantly extends previous research which has been carried out with print books and has illustrated the positive impact of high-quality illustrations on children's narrative ability, narrative retelling, and vocabulary usage (Davis et al., 2024). Given that AR offers dynamic and interactive rather than static illustrations (ChanLin, 2018) within books, they may encourage a richer or more extended discussion. In addition, as children with reading difficulties often have a lower level of oral narrative production compared to readers without difficulties (Westerveld et al., 2008), this facilitation may be particularly important and impactful.

Previous AR research has suggested that this technology could enhance children's story-retelling (Liu et al., 2024; Şimşek, 2024), as presenting information through visual and auditory channels simultaneously may enhance readers' processing and recall of information (Montali & Lewandowski, 1996); however this is the first study to have directly tested this within a robust methodological paradigm (AR/non-AR counterbalanced and matched in content). In this study, analyses also controlled for 'technology related' book-talk, to ensure this was not driving the difference between conditions, as previous research has suggested that device use alters children's language during shared reading (Ewin et al., 2021). After excluding this content, there was still significantly more book-talk in the AR rather than non-AR condition. This finding may be explained by the design of the AR books used in this study, which only activated story-relevant

enhancements, aligning with Strouse et al (2023), who reported that the quality of the talk (content-related) would not be negatively affected if the digital books included only story-relevant hotspots.

6.9. Educational implications

Previous research has demonstrated the importance of talking about text with peers (Gambrell, 2011; Lee et al., 2021; McGeown & Conradi-Smith, 2024), and its positive influence on readers' social engagement (Lee et al., 2021a). Enabling positive social reading experiences for children who have difficulties with reading is essential, and AR books offer promise in this regard. Further, in addition to generally being a positive reading experience, analysis of book-talk immediately following AR and non-AR conditions illustrates that the quantity of children's book-talk increases significantly after reading an AR book. Positive social reading practices should consider multiple factors, including book suitability, for example, text difficulty (Brown et al., 2018) and alignment with students' interests and preferences (Batchelor & Cassidy, 2019; K. W. Hall et al., 2014), in addition to selection of reading partners (Watkins, 2020), and how the integration of AR technology contributes to the story (Dünser & Hornecker, 2007a).

6.10. Limitations and future research directions.

Prior to this project, participating children had not read an AR book, and therefore their experiences with the AR book was novel, and this may have influenced the volume of their book-talk following the AR condition. More research is needed as readers become more familiar with AR books to understand whether increased book-talk is maintained, or whether it is a function of the novelty of this book type. Further, whether and how increased book-talk can be extended to more print books is an important area for future research, as these are more typically found in elementary school classrooms. Finally, researching other AR book types (e.g., non-fiction) would be of interest, as some research suggests that compared to fiction books, more conversation arises while discussing nonfiction books during dyad reading (Klvacek et al., 2019).

This study focused on children with reading difficulties, however, future research could explore whether the benefits found with AR books in this study (i.e., increased book-talk) extend to other groups of readers (e.g., reluctant but able). Finally, it is important to note that children with reading difficulties are heterogeneous (McArthur & Castles, 2017) and therefore practices to support readers need to be personalized, and responsive to individual feedback.

Overall, this study highlights the importance of ensuring the supports for children with reading difficulties attend to their affective needs (McArthur, 2022). In classroom settings, children are often assigned in pairs based on different criteria such as a cross-ability approach (Topping et al., 2015). While this approach is beneficial for some reading practices, the findings from this study offer avenues for future research to investigate different criteria for assigning readers in pairs for shared reading in further detail, particularly for those with social reading anxiety.

6.11. Conclusion

This study provides novel and educationally important insights which can inform the reading practices of children with reading difficulties, as it is the first study to explore the potential impact of AR books on the book-talk and reading experiences of children with reading difficulties. Notably, AR books increased children's quantity of book-talk and led to some enhancement of their reading experiences (e.g., increased desire to read more, and an extension of 'fun' reading experiences). However, caution remain as to the 'novelty' effect and continual changes in AR technologies may shift how children interact with AR books in the future. However, AR does offer a new direction for book publishing (Gudinavičius & Markelevičiūtė, 2020; Lai et al., 2015) and therefore developing our understanding of how best to integrate AR into books to facilitate positive engaging and enriching reading experiences is therefore essential.

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Disclosure statement

The authors report no conflict of interest. The research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

Data Availability Statement:

The authors do not have permission to openly share data from this project, however the corresponding author can be contacted with a request for data access.

Ethics statement

The studies involving humans were approved by the School of Education and Sport Ethics Committee, The University of Edinburgh. The studies were conducted in accordance with the local legislation and institutional requirements. Written informed consent for participation in this study was provided by the participants' legal guardians/next of kin.

Chapter 7

Augmented Reality Books: Reshaping Our Reading Experiences

Overview

This chapter presents an article written for children, aged 8-11, to communicate research with young readers and share AR book reading research with children. This article has been reviewed by adults (associate editor and mentors) and young reviewers (children) and published on July 11 2025, by *Frontiers for Young Minds*. Receiving feedback from young readers about research expands researchers' experience, as their comments and questions demand a deeper understanding of the topic to share the research at a suitable readability level for children.

Note: This chapter adopted US English spelling and a different citation style.

Brief summary

New technologies are offering different ways for children to read and engage with books, and Augmented Reality (AR) books are an exciting development that can attract young readers. AR books use print books with special features which can be accessed via digital devices (e.g., iPads or smartphones), and researchers are just beginning to understand how AR books may reshape our reading experiences. In this article, we explain what AR books are, and describe different research studies which have explored parents' and children's views of AR books. We hope that this article will interest you, encourage you to think about new books types, and understand how AR books may shape your reading experiences, engagement, and learning.

Augmented Reality Books: Reshaping Our Reading Experiences

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Abstract

Augmented Reality (AR) books are an exciting development that provides a different way to read and engage with books. AR books look like any paper book you would usually see. So, what is new about AR books? AR books are augmented printed books, that is, they have digitally added features such as 3D animations, questions, quizzes and sounds which come alive on the digital device (e.g., iPad, smartphone) but are related to the printed book. Researchers are interested in learning from children and parents about how AR books influence reading experiences and whether AR books can help children better understand text. For example, children talk about experiencing a range of feelings while they read an AR book (e.g., it's fun, enjoyable, impressive, cool, and weird), and many want to share the AR reading experience with their friends. However, while some children like the extra features in AR books because it helps them to see the story, other children say they prefer to use their own imagination. Research with parents has shown that parents have different views about AR books: while some think AR books could help children to understand what they read, others think AR books would distract children from reading. Finally, AR books may be able to support children's ability to understand text. Research found that children who read an AR book did better in answering questions that required deeper thinking compared to

children who read the same story but in a paper book. While AR books continue to evolve, this article looks at what researchers have discovered about AR books up to now!

Keywords:

Reading; children; parents; technologies; Augmented Reality (AR) books.

7.1. Introduction

If I ask you to think about different types of books, what would you think about? Fiction? Non-fiction? Graphic novel? Adventure? Comedy, Fantasy? Or would you think about different book styles, such as paper, digital, audio, books with illustrations, or pop-up pictures? Our lives are full of books and there are so many different types! But have you ever heard of Augmented Reality books, books that some claim make stories come to life? Over the last decade, new technologies have offered new ways to read and engage with books, and Augmented Reality (AR) books are an exciting new development. AR books use print books, with special features which can be accessed via digital devices (e.g., iPads or smartphones) and researchers are just beginning to understand how they may reshape our reading experiences and influence our engagement and learning.

7.2. What do AR books look like?

AR books look like any paper book you would usually see, where you can flip through the pages, look at images and read the text. However, AR books also allow you to access additional features such as 3D animations, sounds, and/or graphics related to the book. Those features are considered virtual objects, generated via a digital device which allow the book to come to life! Reading an AR book is simple – open the book, read the text, point your digital device at the printed page, and watch as virtual objects join you in the real world! [1] (see Figure 17)

Figure 17

Example of an Augmented Reality book

7.3. What do parents think about AR books?

Recent research has explored parents' perspectives on reading an AR book with their child and whether they would use AR books again in the future [2]. In this study, 47 parents were invited to read an AR book with their child (aged between 4 and 9 years) for 20-30 minutes and were then asked to share their thoughts with the researcher. In the project, 35 parents liked how real the 3D images felt, and the sense of being completely involved in the book. In addition, parents were surprised that they could explore the AR book without the need to use a specific device or wear special AR glasses! The researcher found that while some parents held positive thoughts about the AR book, others held negative thoughts. For example, 16 parents reported that the AR book would help children understand and remember what they had read, and 12 parents thought the AR technology could distract their children from reading. Parents' views about AR books, either

positive or negative, could affect their decision to use them in the future. If your parents took part in this research, what would they think?

7.4. How do AR books influence children's reading engagement?

We have recently completed a study to explore children's thoughts and experiences of reading AR books. In our study, we were looking at children's reading engagement [3]. Reading engagement has four aspects to it: behavioral (what we do), cognitive (how we think), affective (how we feel), and social engagement (how we participate in reading activities with others) [4]. *Behavioral engagement* refers to our reading behaviors - how much time we spend reading, what we read, and how we read. *Cognitive engagement* refers to the mental effort we put into reading and the strategies we use to understand the text. *Affective engagement* refers to the feelings and emotions we experience while we read, while *social engagement* refers to taking part in reading activities with others [4].

In our research, we invited 38 children aged 8-10 with different levels of reading interest, experience, and ability to take part. Children read an AR book either by themselves or with a classmate, depending on their preference, before we interviewed them about their reading experiences. From our interviews we found that AR books changed aspects of:

Behavioral engagement (how children read): "*I always read the text first, but today I read the picture first*" (girl, age 9); "*I read the text a bit faster and get the iPad and I point it to the pictures*" (boy, age 8).

Cognitive engagement (strategies children used while they read): "*Pictures always help. Maybe if you are like, not understanding what's happening in the book or something, and then you just have a look at picture that can help, especially the picture kind of moving*" (boy, age 8); " *'I would not*

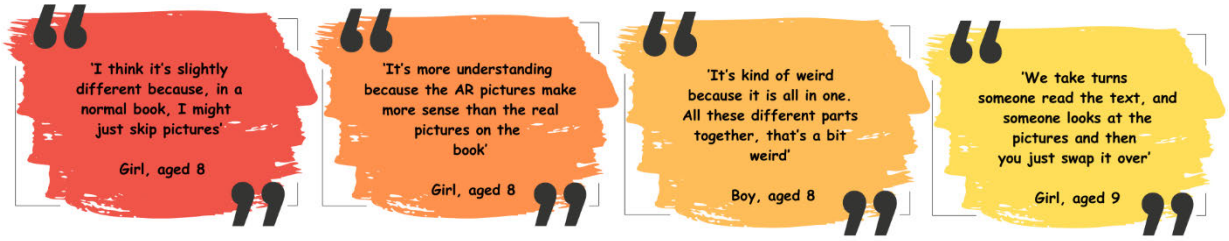
say I would not understand it if I did not have a gadget, but I might understand it a bit more because it is 3D so I can actually see what's going on and how it actually happens" (girl, age 9).

Affective engagement (what children feel): *"It feels like amazing mixing with happiness into like one"* (boy, age 8); "*I actually liked when I picked the iPad up and put it in the picture actually, kind of enjoy reading that with some music*" (girl, age 9).

Social engagement (how children interact with their peers while reading): "*We like to share thoughts and then we share thoughts about what's funny and why that's funny, and then we laugh about it"* (girl, age 8); "*If I was just looking at it on my own, I wouldn't find it as enjoyable*" (boy, aged 8) (see Figure 18 for more examples of what children said).

Figure 18

Children's AR reading engagement (from left to right: behavioral, cognitive, affective, and social).



However, while many children were positive about the AR books, others were not, for example, some felt that AR books did not allow them to use their own imagination when reading or were '*a little bit of a waste of time*' (boy, aged 9). Have you ever read an AR book before? After hearing what other children have had to say, would you like to try one?

7.5. Do AR books influence children's ability to understand the text?

One group of researchers conducted a study to examine whether AR books influence children's ability to understand text [5]. In this study, two groups of students (aged 7 to 9) read the same book, but in one group, the AR features were activated, and children had an iPad to access these features. However, in the other group, only the printed book was read without access to AR features. After reading, students were asked to do two things: 1) retell the story, and 2) answer questions to measure their understanding. Students were asked questions that required simple remembering of details (e.g., "in which direction did the boy ride the boat?"), and questions that require deeper thinking since the answer could not be directly found in the book (e.g., "How do you think the boy is feeling here?"). The researchers found that the group reading the book with AR features performed better in retelling, and in answering questions that required deeper thinking, however, there was no difference in the quality of their answers to questions that required simple remembering of details. Of course, we can't assume that all AR books will support our ability to better understand text. For example, AR books vary in terms of the quality of their AR features [1] and AR books with higher-quality features which are more directly connected to the text may be better at supporting our understanding.

7.6. Conclusion

Augmented Reality (AR) books are a new form of book, which can change our reading experiences. AR books combine two worlds: the virtual world and our real world, integrating print books with AR features. AR features (e.g., sounds, 3D animation, and graphics) can affect our reading experiences and have a positive influence on our reading engagement and our ability to understand the text. There are lots of different AR books available (you can find them online and in some bookstores), with many different features and designs [1] – and some will be better than

others. We hope that our research, and the research of others, can influence AR book designers to create books that will better support children's reading enjoyment, engagement, and understanding.

Glossary

Augmented Reality (AR) book: A paper book with additional features, such as 3D animations, sounds, and/or graphics, which the reader can access by pointing the camera of the digital device to the printed page.

AR features: Additional features such as 3D animations, sounds, and/or graphics related to the book. These features are activated by the AR technology.

Virtual objects: Animated images, which are generated via computer, so the objects do not exist in our real world, but they appear behind the camera.

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Chapter 8

Thesis Discussion

The findings of Study 1 and Study 2 were discussed in Chapters 4,5, and 6. Both studies have been written up and submitted for peer review, and published. Due to word length restrictions on manuscript submissions, the full account of each study's findings could not be shared. Therefore, in this chapter, additional study findings (e.g., Study 1 observations) will be discussed. This chapter will start with a brief overview of the research. Second, the findings of both studies will be integrated and discussed in terms of how they relate to previous theory and research. Moreover, academic contribution to the field, implications for educational practice and AR book development will be discussed, followed by limitations and future research directions.

8.1. Overview

Declines in children's book reading enjoyment and engagement (Clark et al., 2024) have prompted researchers and educators to critically examine the impact and opportunities of digital technologies and identify whether and how new technologies can foster more positive reading experiences for children, including children with reading difficulties. Therefore, Augmented Reality (AR) books, where paper books are augmented with digital features (e.g., animations, sounds, comprehension questions), were implemented within educational settings (i.e., primary schools), in two different forms (one-on-one i.e., individual reading, and shared reading i.e., reading with a peer) to investigate children's (aged 8-10) experiences with AR books, as this form of books affords new opportunities for engaging children in reading, including children with reading difficulties.

8.2. Children's AR book reading experiences and reading engagement

In general, while some similarities with print books were reported by children regarding their reading engagement with AR books, children also communicated differences. For instance, children provided examples of how AR books shifted their behaviour engagement (e.g., desire to read more/extend reading practices), altered their cognitive engagement (e.g., reading strategies, visual representation, comprehension monitoring), influenced their affective engagement (e.g., diverse positive feelings/emotions), and shaped their social engagement (e.g., prompted discussion/book-talk). While these themes were discussed in detail in the relevant chapters (Chapters 4 and 6), some will be summarised again here, particularly if they relate to both studies. Further, additional insights will be shared in relation to the reading engagement framework and previous theories.

8.2.1. Behavioural Engagement

Reading behaviours and AR operation. Existing research suggested that AR technology demands quite intensive interaction, motor skills (Avila-Garzon et al., 2021; Cheng & Tsai, 2013; Yang et al., 2025), and new types of interaction with the AR book were reported by children in this research (e.g., rotating the device to explore 3D models from various angles, zooming in and out, touching the screen to answer questions), and observed (e.g., standing while reading). For example, in Study 1, although most participants were sitting while reading the AR book, five children chose to stand, either always standing (3/5) or switching between sitting and standing (2/5) while reading. AR books prompted different reading behaviours, and previous research suggested that the implementation of AR technology in classrooms can activate students' participation (Fernández-Batanero et al., 2022), and offer autonomy support for young readers as

they use the AR device and features independently. The reading engagement model (Guthrie & Wigfield, 2000) highlighted that being in command of the reading environment was sought by children. Indeed, the absence of autonomy affects students' engagement (Cheng & Tsai, 2016), and it was found that students (aged 10 years) were less engaged when most of the AR operation was demonstrated by the teacher rather than the children (Cheng & Tsai, 2016; Kerawalla et al., 2006). Thus, ease of operation should be prioritised when integrating AR technology into children's books to support the reader's autonomy and facilitate interaction with the AR books, which have positive consequences for children's engagement (Cheng, 2019; Cheng & Tsai, 2013; Daşdemir, 2022; Wang, 2022). Moreover, AR books require managing the physical book and electronic device together compared to print and digital books, where the reader handles only one reading medium, either the physical book or the electronic device (Fernandes & Leite, 2023). Across two studies, it was noticed that when dyads shared reading the AR book, they tended to exchange handling both the book and the iPad, which is different compared to child-adult shared reading, where the child tends to handle only the electronic device while the adult handles the book (Järvenpää, 2022). Thus, the findings of this research highlighted the importance of simplifying the AR operation (e.g., holding the device over the full-page image) to make the shared AR book reading experience easier to operate, allowing more time to focus on the book and its contents.

Participating in reading (silent and aloud reading). Behavioural engagement has been defined as reading behaviours, including the way children read (McGeown & Conradi-Smith, 2024). In this research, children were given the choice to select how they would participate in reading, either silently or aloud. Based on the observations, in Study 1, 38 children participated, and could choose to read with someone or alone – this led to 16 dyads, while 6 children chose to read alone. All dyads read aloud (16/16), whether they read aloud together at the same time (15/16)

or took turns, one read while one listened and then exchanged roles (1/16). However, most children who read alone (4/6) read the text silently. In Study 2, all children were instructed to read in dyads and dyads' reading preferences were the same across both AR and non-AR conditions - most dyads read aloud (14/16), whether they read aloud together at the same time (2/14) or took turns, one read while one listened and then exchanged roles (12/14), as follows: two pages for each (1/12), one page for each (9/12), except long pages; half page for each (3/9), two sentences for each (1/12), two sentences for one reader and the rest of the page for the second reader (1/12). Only two dyads (2/16), however, read both books silently. Therefore, AR books do not seem to change dyads' reading preferences (i.e., the way children read: silent or aloud reading), and shared reading may prompt children to read the text aloud. Indeed, giving children the choice to select how they would participate in reading, either silently or aloud, was one of the practices suggested by the reading engagement model (Guthrie & Wigfield, 2000) to support autonomy. While previous research has suggested there are no significant difference in reading comprehension performance between silent and oral reading (Hale et al., 2011; McCallum et al., 2004), some concerns have been raised regards to follower reading, which involves being exposed to the text while listening to someone read the text aloud, due to consuming more cognitive resources (García-Rodicio et al., 2018). However, for readers with below-average reading skills, in particular, it has been noted that both listening and oral reading lead to equal reading comprehension, exceeding the effectiveness of silent reading (Miller & Smith, 1989). Even though silent reading consumes less time compared to reading aloud (McCallum et al., 2004), saying words aloud has been suggested to make the words more memorable; whether the readers read the words loudly by themselves, listen to the words, or read the words loudly together with someone else (MacLeod, 2011).

8.2.2. Cognitive Engagement

Reading strategies. The reading engagement model (Guthrie & Wigfield, 2000) reported that less engaged readers used fewer strategies to support their reading comprehension compared to engaged readers. In line with that, AR books offer new features (e.g., 3D animation and interactive questions) that can open new ways for readers to implement different strategies to support their understanding. For example, in Study 1, some children reported that AR books altered their reading strategies as they implemented not only text-based strategies to support comprehension (e.g., re-reading and using context) but also image-based strategies; specifically, some children referred to dynamic images as a way to support their comprehension. Indeed, previous research suggested that creating mental representations while reading is important for comprehension (Boerma et al., 2016), and both animations (Altun, 2018; Takacs et al., 2015) and AR technology (Cheng, 2016) could facilitate this process. Interestingly, while more children reported that dynamic images would facilitate their imagination, others thought it would be inhibitory. In addition, some children highlighted the importance of interactive questions, as these questions helped them to track their understanding while they read (i.e., comprehension monitoring). Indeed, considerations regards when and how these features (i.e., 3D animations and interactive questions) are embedded into the AR book are essential to maximise their benefits in supporting children's cognitive engagement.

Cognitive load and working memory. Previous research suggested that the additional features in digital books may distract readers from following the storyline due to the limited capacity of the working memory to process information (Altun, 2018; Krcmar & Cingel, 2014), which was highlighted by cognitive load theory (Sweller, 1994). To date, findings related to AR

books and cognitive load are inconsistent (Candido & Cattaneo, 2025), which could be justified by the variations of AR books' design (Wang, 2022). Indeed, cognitive load theory (Sweller, 1994) remarked on the quality of instructional design and reducing extraneous load to support the reader's ability to process new information (Cooper, 1998; Sweller, 2022). As additional features are embedded into AR books, it is crucial to consider the cognitive processes required by the multimedia learning environment (i.e., AR books), and the implications of instructional design to optimally align with the capacity of working memory (Candido & Cattaneo, 2025; Li et al., 2019; Mayer & Estrella, 2014). For example, adopting principles outlined by multimedia learning theory (Mayer, 2005), such as coherence (elimination of seductive details) and redundancy (exclusion of extraneous information) to maximise learning (Li et al., 2019; Sweller, 2022). In addition, multimedia learning theory (Mayer, 2005) highlighted the temporal contiguity principle, which confirmed that presenting verbal and nonverbal information simultaneously facilitates deeper learning (Takacs et al., 2015), as children form dual coding, which helps them to process and retain information (Sun et al., 2025). In the specific AR book used in this project, children were exposed to visual/nonverbal information (text and illustrations) and verbal information simultaneously; however, verbal information was presented in the form of background/sound effects and music to the story experience, rather than through narration. This aligns with the redundancy principle, highlighting the importance of not narrating text if the text was printed, as presenting the same information (i.e., redundant information) in multiple forms (written and spoken) increases the cognitive load, and negatively affects learning (Li et al., 2019; Sweller, 2024).

8.2.3. Affective Engagement

Affective reactions. Previous research suggested that affective engagement can be indicated by capturing readers' body language and facial expressions (Barber & Klauda, 2020) and the readers' expressive tone (Lutz et al., 2006) while reading. Given that affective engagement cannot always be observable (Unrau & Quirk, 2014), self-reports, therefore, were used in this research with children through interviews to understand the feelings they experienced while reading the AR book. In Study 1, most children reported different feelings they experienced while they read the AR book, such as feeling impressed, feelings of enjoyment, and fun, but that it was also a 'bit weird'. Emotional engagement was defined by engagement theory as affective reactions such as interest, happiness, anxiety and sadness (Fredricks et al., 2004), and previous research highlighted the overlap between engagement research and motivational research with emotions such as interest (Fredricks et al., 2004).

Anxiety was reported by engagement theory as one of the affective reactions that reflects emotional engagement (Fredricks et al., 2004). As children with reading difficulties typically experience higher levels of anxiety (McArthur & Castles, 2017; Novita et al., 2019; Wilmot et al., 2023), which is associated with both reading and social anxiety (McArthur, 2022), the findings of this research highlighted the necessity of creating a relaxed reading environment for children that does not prompt their anxiety. For example, shared reading with a peer rather than the whole classroom, as some children may have concerns about reading aloud due to fear of embarrassment (Francis et al., 2022).

Reading Enjoyment. Study 2's findings suggested that while children with reading difficulties enjoyed the shared reading experience either with the AR or non-AR book, almost a

third of the participants reported that they only enjoyed and shared fun when they were reading the AR book together. The enjoyment reported by children was mostly in the context of the dynamic digitally imposed images (e.g., realistic, 3D features, immersive visual experience), which is in line with previous research reporting a positive relationship between AR books and reading attitudes/enjoyment (Othman et al., 2021; Roumba & Nicolaidou, 2022; Yilmaz et al., 2017). Given the decline in children's (aged 8-11) reading enjoyment levels (Clark et al., 2024). interactive reading experiences that combine AR technology with the physical book (Fernandes & Leite, 2023), therefore, have the potential to promote reading enjoyment. Research suggests that reading experience has the potential to be more engaging and enjoyable for young readers when they use technology (Alhamad et al., 2024; Avila-Garzon et al., 2021; Blachowicz et al., 2009; Ciampa, 2016; Huang, 2015; Othman et al., 2021; Yilmaz et al., 2017), and the findings across the two studies suggested that this potential could extend particularly when children share this experience with others (e.g., peers). Finally, given that all participating children reported that they had not read an AR book before joining this research, it is worth highlighting the influence of technological novelty on children's affective experiences, as possible changes in children's affective engagement may occur as AR books become more prevalent and/or familiar.

8.2.4. Social Engagement

Social reading practices. Compared to print books, the qualitative findings (Study 1) that suggested AR books can extend children's social reading engagement (i.e., book-talk) were consistent and supported by the quantitative findings (Study 2) as AR books significantly increased the quantity of children's book-talk, including the number of words spoken and the sentence length when children discussed the book together. This is in line with the reading engagement framework

(Lee et al., 2021a), which outlined the importance of the social dimension of reading engagement. Indeed, the social aspect of engagement has received less attention than the other dimensions of reading engagement (i.e., behavioural, cognitive, and affective) (Lee et al., 2021). For example, even though engagement theory (Fredricks et al., 2004) acknowledges the relationship between classroom context (e.g., peer interactions) and engagement, the theory perceived engagement as a multidimensional concept with only three aspects: behavioural, emotional, and cognitive, and highlighted that the influence of classroom context (e.g., peer interactions) on engagement, whether additively or interactively, is not clear (Fredricks et al., 2004). In addition, the reading engagement model (Guthrie & Wigfield, 2000) outlined the role of social interaction in mediating engagement in reading (e.g., collaboration) and reported that research on the effect of collaboration (i.e., social aspect) was relatively rare (Guthrie & Wigfield, 2000). The findings of the current research extend the current practices of promoting children's social reading engagement within classrooms (e.g., book-talk and collaborative practices) by implementing different reading mediums (i.e., AR book), as AR books offer additional ways to prompt talk about the books and opportunities to collaborate. For example, shared AR book reading was preferred by most participating children in Study 1 since it allowed them to discuss the book with their peers, cooperate in handling the digital device and print book together, and collaborate in answering the interactive questions as a team.

Children's AR book reading experiences were discussed in relation to the reading engagement framework and previous theories, starting with behavioural engagement (reading behaviours and AR operation, participating in reading), cognitive engagement (reading strategies, cognitive load and working memory), affective engagement (affective reactions, reading

enjoyment), and social engagement (social reading practices). In the next section, novel academic contribution to the field will be highlighted.

8.3. Novel academic contribution to the field

This research provides novel insights into children's perspectives and experiences of using AR books, within the reading engagement framework (behavioural, cognitive, affective, and social), by amplifying children's voices to understand the potential of AR books to initiate and support reading practices. Further, it is one of the first studies to examine the four dimensions of children's reading engagement in parallelll, which is essential for recommendations of their value and use within schools and classrooms. In addition, this research makes a novel and significant contribution to our understanding of whether, and how, AR books support the social reading engagement (e.g., book-talk) of children with reading difficulties. The findings of this research suggest that AR books significantly increased the quantity of children's book talk (illustrated by the average number of words said), and, to a lesser but also significant extent, increased the length of sentences used during book-talk. This significantly extends previous research, which has been carried out with print books and has illustrated the positive impact of high-quality illustrations on children's narrative retelling and vocabulary usage. Moreover, this research highlights the importance of ensuring the supports for children with reading difficulties attend to their affective needs, and offers avenues for future research to investigate different criteria for assigning readers in pairs for shared reading in further detail, particularly for those with social reading anxiety.

8.4. Implications for practice

The findings of the two studies offer novel qualitative insights into children's reading experiences and perspectives of how AR books shape their reading engagements (behaviours, cognitive, affective, and social) and foster their social reading experiences, which provide a strong

foundation for researchers, educators, designers interested in better understanding the experiences and interactions afforded by AR books and their consequences on children' reading practices. In the following section, implications are shared to provide educators, particularly primary class teachers, and AR book designers, with a deeper understanding of how this emerging form of technology might be leveraged to enhance children's reading practices and potentially improve reading experiences and outcomes.

Engagement theory has highlighted the "tension between conceptual clarity and practical reality" and the need to investigate how different aspects of engagement operate (Fredricks et al., 2004, p. 84). Therefore, implications for practice will be outlined in detail regarding how to implement AR books in educational settings and how to enhance the design of AR books to foster children's reading engagement and social reading experiences in practical ways.

8.4.1. Implications for educational practice

Within this section, five key considerations for primary school teachers/educators to implement AR books within the classroom will be highlighted, including space/settings, reading enjoyment and comfort, book selection, book-talk, and collaboration and harmony.

Space and settings. Existing research has highlighted that reading an AR book prompts quite intensive interaction (Cheng & Tsai, 2013; Yang et al., 2025), and the findings of this thesis highlighted different reading behaviours compared to reading print or digital books (e.g., standing while reading). Therefore, it is highly recommended that teachers offer an adequate and flexible space for children to stand and move while reading the AR book (aligned with behavioural engagement). In addition, unlike reading print books, where children tend to hold the book while reading, across both studies, it was observed that children tended to put the AR book on the table

while they read, as they tend to hold the iPad. Thus, considering a space where the children would position the AR book while reading is important to facilitate AR operation (aligned with the ease-of-use aspect).

Based on personal observations across both studies, concerning the settings of implementing the AR books reading sessions within schools, it is worth noting that when arranging reading spaces, teachers need to consider where the reader sits to avoid the negative effects of the sunlight on the screen (e.g., reflection) (aligned with the ease-of-use aspect). Furthermore, left-handed children may operate the device differently. Therefore, it is recommended that teachers take this into account when arranging reading AR books within small groups (e.g., considering arranging where each child sits (i.e., left-handed children sit on the right side) as they tend to use their left hand to zoom in and out and to click on the screen.

Reading enjoyment and comfort. Given the declines in children's reading enjoyment and engagement (Clark et al., 2023), and research suggesting potential positive relationships between AR books and reading attitudes/enjoyment (Othman et al., 2021; Roumba & Nicolaidou, 2022; Yilmaz et al., 2017), it is recommended that teachers provide young readers with options to access and read AR books within classrooms – as this has the potential to extend children's reading practices, and increase their reading enjoyment, particularly when consideration of their interests is used as a criterion for AR book selection (e.g., genre, topic) (aligned with affective engagement).

Given that children with reading difficulties typically experience higher levels of anxiety (McArthur & Castles, 2017; Novita et al., 2019; Wilmot et al., 2023), specifically reading anxiety (McArthur, 2022), teachers can create positive shared reading experiences to which are comfortable and enjoyable for children through implementing different reading mediums (i.e., AR

book) and adopting different criteria for peer selection. For example, friendship (aligned with affective engagement) and reading speed (aligned with behavioural and cognitive engagement).

Book selection. Given that offering principles for teachers to select a good book is essential (López-Escribano et al., 2021), selecting AR books that include interactive questions is highly recommended as they have the potential to support children's recall and comprehension (aligned with cognitive engagement). Regardless of the importance of comprehension questions (Blewitt et al., 2009; Vanderschantz et al., 2019; Zhou & Yadav, 2017), it is also essential to pay attention to the quantity, quality, and positions (throughout or at the end of the book) of the questions, as this feature varies between AR books, and it may have different consequences on children's reading experiences. Moreover, given the role of the additional features in the digital book in distracting readers from following the storyline, which may have negative consequences on reading comprehension (Altun, 2018), it is highly recommended that teachers examine the necessity of the AR features when selecting AR books (e.g., how many pages are activated by the AR technology and how the AR technology serves the content of the book) (aligned with cognitive engagement).

Book-talk. Given the benefits of book talk (Clinton-Lisell et al., 2024; Cremin et al., 2024; McGeown & Smith, 2024), teachers can provide children with guiding questions to prompt book talk both during and after AR books (aligned with social engagement), offering a range of questions, which encourages them to, for example, recall parts of the story (aligned with cognitive engagement) and share their affective experiences with the book (aligned with affective engagement).

Collaboration and harmony. Previous research suggested that social collaboration is beneficial for children's literacy experiences and outcomes (Labbo, 1999), and technology was

used by teachers as a tool to support students' collaboration (Ottenbreit-Leftwich et al., 2012). Across both studies, AR books offered an additional opportunity to cooperate (e.g., work as a team to answer the interactive questions and manage the book and the device together). Teachers can implement AR books within shared reading activities (e.g., reading with a peer) to foster positive social reading experiences for children, particularly those with reading difficulties (aligned with social engagement). In addition, this research demonstrated that harmony between dyads is more likely to facilitate shared AR book reading practice. As teachers are familiar with their students, it would be highly recommended to consider the harmony effect while arranging groups to sustain the reading engagement during shared reading (aligned with affective engagement).

To summarise, this research highlights five key considerations for teachers/educators to implement AR books within the classroom – space/settings, reading enjoyment and comfort, book selection, book-talk, and collaboration and harmony. The next implications for AR book designers will be provided.

8.4.2. Implications for AR book development

Within this section, seven key considerations for AR book development to enhance the design of AR books will be highlighted, including AR operation, materials used and text's font size, the relationship between illustrations and text, quality of illustration, AR features and seductive details, embedding interactive questions, and children's satisfaction.

AR operation. Given that student-centred practices lead to higher reading performance compared to teacher-centred approaches (Díaz et al., 2024), and that AR books typically invite children's agency and autonomy in using AR features, it is highly recommended that AR book designers/developers consider the accessibility/ usability of AR operations when designing AR

books. For example, across both studies, most children found holding the device over the full page easy to operate, which makes activating AR images more accessible (aligned with the ease-of-use aspect).

Materials used and text's font size. This research demonstrated that dyads are more likely to position the book on the table and to leave the page open when they point the camera at images to be activated. Thus, it is highly recommended to consider the type of materials used for the book (e.g., book spine and book thickness) to keep the page open without using their hand, as the user's hand will be busy holding/operating the iPad (aligned with the ease-of-use aspect). In addition, this research demonstrated that children are more likely to put the AR book on the desk, rather than hold it, due to the need to hold the digital device. This has implications for font size in AR books, to ensure text is still readable for children at this distance

The relationship between illustrations and text. Given that the interaction between the text and the illustrations affects children's ability to process and understand texts (Brookshire et al., 2002; Sun et al., 2025), it is essential to consider the relationship between text and illustrations while designing AR books (aligned with cognitive engagement). For example, including illustrations as an additional cue (picture-independent text) as reading "picture-dependent" text, where children cannot read the text without referring back to the picture, could distract them from reading, particularly those readers with below-average reading skills or children who have just started to read (Brookshire et al., 2002).

Quality of illustration. Given that children could demonstrate cognitive engagement through verbalisations about the book content (Clinton-Lisell et al., 2024), and that high-quality illustrations in children's picture books can increase vocabulary usage, narrative ability, and

narrative retelling (Davis et al., 2024), it is highly recommended that designers consider the quality of dynamic illustrations while designing AR books, to ensure they are optimally enjoyable and engaging (aligned with affective and cognitive engagement). For example, few children (Study 1) reported that they did not like the characters because they only have hands without arms. Therefore, adopting human-like features (emotional design) is recommended as the positive influence of this design on children's experience was highlighted by previous research (e.g., Mayer & Estrella, 2014).

AR features and seductive details. Given that the additional features in the digital books could distract readers from following the storyline (Altun, 2018), and that well-designed digital books outperformed print books in this regard (Díaz et al., 2024), it is crucial to examine the necessity and the role of the AR features while designing AR books (e.g., how the AR technology serves the content and whether AR features are relevant to the content) to minimise the harmful effects of seductive details (aligned with cognitive engagement). Interestingly, the findings of Sundararajan and Adesope's (2020) meta-analysis of seductive detail, which included 58 papers and involved 7521 participants, indicated that static seductive details would disturb learners' attention more than dynamic seductive detail, and they highlighted the need for research to understand how and when this occurs (Sundararajan & Adesope, 2020).

Embedding interactive questions. Previous research has shown that children who read an AR book with interactive tasks (e.g., embedding interactive questions) show significant improvement in their verbal reading engagement compared to children who read the same AR book without embedded tasks (Yang et al., 2025). Integrating interactive questions throughout the story, therefore, is recommended to support children's comprehension monitoring (aligned with cognitive engagement). However, embedding interactive questions can also interrupt flow while

reading, introducing disruptions when children may not want them, particularly if the number of questions is excessive. In addition, as this research demonstrated that AR books are more likely to increase the quantity of children's book talk (i.e., number of words spoken and sentence length) when they discussed the AR book compared to the print book, questions for discussion could be embedded into AR books to prompt talks (e.g., open-ended questions) (aligned with social engagement).

Children's satisfaction. Given that young readers have different reading interests, and that flexible AR content is essential to meet individual children's needs and interests/preferences (Avila-Garzon et al., 2021; Kerawalla et al., 2006), different genres (aligned with affective engagement) with flexible content (e.g., selecting animations' speed) (aligned with cognitive engagement) (Kerawalla et al., 2006) could be considered while developing the content and the design of AR books. For example, fiction (i.e., story book) (e.g., ChanLin, 2018; Danaei et al., 2020; Liu et al., 2024; Yang et al., 2025) and nonfiction, such as mathematics (Wu et al., 2024), and science content (Roumba & Nicolaidou, 2022).

8.5. Limitations

Methodological challenges and factors influence how findings from this research represent children's AR reading practices. Limitations of Study 1 and Study 2 were highlighted in the relevant study chapter (chapter 4 and 5), including: i) the effect of novelty or the "wow" factor (Perey, 2011) of new technology (i.e., AR books), ii) generating the findings based on only two AR fiction books (e.g., AR books will vary considerably in their text content, the popularity/novelty of the story, illustrations, AR features, etc., iii) the limitation of observational data (i.e., limited to note-taking), and iv) the degree to which Study 1 and Study 2 participants

were representative of the population as children, including children with reading difficulties, are heterogeneous (McArthur & Castles, 2017). Indeed, Study 1 and Study 2 participants (N = 70 in total) were not representative of all UK children, as data were only collected from three schools: two classrooms (Study 1) and nine classrooms (Study 2). Additional limitations regarding both studies will be discussed in the following section.

One of the limitations of Study 1 is that the sample size of teachers is very small (n = 2). Indeed, the study primarily focused on children's experiences of AR books, while the focus on teachers' perspectives was not central to the project. However, as this research was implemented in educational settings, it is important to reflect on teachers' perceptions of the usability of AR books in classrooms. As teachers were required to have familiarity with AR books prior to taking part in the interviews, purposeful sampling was used to recruit teachers, so only those class teachers from the classes participating in this project took part in the interviews. In addition, the findings of teachers' interviews were not reported within Study 1 (chapter 4) due to the limited number of manuscript words. However, teachers' insights were used to develop the design of Study 2 and highlighted and discussed within the discussion chapter (see Chapter 7), as some of the implications were developed based on teachers' thoughts. That said, given the small sample of teachers who participated, the data are not comprehensive nor representative.

Further limitation is the assumptions of the reading engagement framework used in this work, as if its dimensions are completely separable. Reading engagement was discussed under separate sections based on the four dimensions of reading engagement (i.e., behavioural, cognitive, affective, and social). Indeed, presenting the four dimensions of reading engagement would help researchers and teachers to comprehensively think about reading engagement (McGeown & Conradi-Smith, 2024). However, these dimensions are not completely separable but interlinked,

as the implications regarding one dimension could be related to the other, as supporting one aspect of reading engagement could lead to positive consequences on other dimensions. For example, while embedding interactive questions into AR books was recommended under the cognitive engagement section to support comprehension monitoring, interactive questions offer an opportunity for children to talk, which fosters their social engagement. In addition, autonomy was discussed concerning behavioural engagement as AR books allow readers to carry on the AR operation by themselves, which reflects children's reading behaviours. Experiences that support autonomy, however, also have positive implications for children's affective engagement.

One of the limitations of Study 2 is that average sentence length was calculated by the *ATOS Analyzer Tool* (www.renaissance.com), which was developed for analysing text passages and books. Indeed, it is more likely that the nature of sentences in book text differs from book-talk's sentences (e.g., children tend to engage in the talk together and interpret each other to add more details or raise a new idea, which may affect the length of their sentences). Therefore, average sentence length needs to be interpreted with consideration of this. In addition, the researcher's presence while conducting the study may affect children's reading preferences (e.g., prompting reading aloud), book talk (e.g., talking about the content), and children's insights. For example, it was noticed that some children initially expected the AR books to be developed by the researcher, so some may have tended to share their thoughts by taking this into account (i.e., avoiding sharing unpleasant/negative thoughts about the AR books). Indeed, even though the researcher explicitly highlighted that at the beginning of the reading sessions and during the interviews, some children's thoughts may be affected by this assumption.

Finally, this research addressed how AR books have shaped and affected children's reading culture by adopting only one form of AR technology/AR books: a physical print book, which was

activated by an electronic device (phone / iPad). As technology is changing and a specific form of technology (e.g., AR books) may no longer be used, the findings of this research could be relevant to new forms of technology, as AR features could be accessible in the features through different devices, displays (Nee & Ong, 2023), or new forms of technology. For example, recently, in their research, Candido and Cattaneo (2025) not only used hand-held display (e.g., tablet and smartphone) to activate AR features, but also head-mounted display (e.g., Microsoft HoloLens 2 i.e., headset), which provides a hands-free experience for users.

8.6. Future research

Potential future research based on Study 1 and Study 2 was discussed in the relevant study chapter (chapter 4 and 5), including i) investigating dimensions of reading engagement in further detail with different methodological approaches, ii) understanding the challenges of using AR books within school classrooms, iii) exploring teachers' attitudes toward AR books and the acceptability and feasibility of using AR books in classroom practice, iv) understanding whether AR books have the potential to re-engage disengaged readers, v) understanding whether increased book-talk is maintained, or whether it is a function of the novelty of AR book type as readers become more familiar with AR books, vi) exploring whether and how increased book-talk can be extended to more print books as these are more typically found in primary school classrooms, vii) exploring other AR book types as some research suggests that compared to fiction books, more conversation arises while discussing nonfiction books during dyad reading (Klvacek et al., 2019) and viii) investigating different criteria for assigning readers in pairs for shared reading, particularly for those with social reading anxiety. Additional future research directions based on both studies will be discussed in the following section.

In terms of children's book-talk, the *paired samples t-test* was carried out to compare AR and non-AR conditions, considering the average between the two conditions among all dyads, which provided a general picture about the influence of AR book's feature on the quantity of book-talk. Future research with a larger sample could be carried out to explore differences between each child's book-talk under the two conditions, specifically focusing on those children with self-reported elevated levels of social reading anxiety. In addition, previous research reported that "it is misguided to view electronic, or digital texts, as nothing more than a printed page displayed on a computer screen" (Labbo, 1999, p. 90). As technology has evolved, it is crucial to explore how the features of new technology reshape reading practices and how that, in turn, affects reading experience and outcomes. For example, it was interesting to notice that two children who participated in Study 2 were reading the text that was printed on the AR book's pages through the screen (i.e., displaying the text on the screen through pointing the camera at the page) rather than reading the text from the printed page. Further qualitative research, therefore, is essential to gain rich insights to understand how technology's features reshape children's reading practices and their reading behaviours.

Study two focused specifically on children with reading difficulties, however, exploring the potential for AR books to support children's book-talk more generally (e.g., typical classroom population) or focusing on different subgroups, for example, children with ADHD, could also be an interesting avenue for future research. Further research investigating children's insights through non-verbal ways (e.g., drawing/sketching suggested additional features of AR books) would be of interest, as some students prefer to express their thoughts in different ways.

8.7. Conclusion

The research in this thesis provides novel insights into children's perspectives and experiences of using AR books, within the reading engagement framework, and useful insights which can support the reading practices of children with reading difficulties. Importantly, this research highlights the necessity of listening to children's voices as new technologies evolve, including evolving forms of AR books, which may alter their reading practices and social reading experiences. Further research, and its implementation, is needed to inform and optimise AR books' design and use to facilitate positive, engaging and enriching reading experiences for all children, and to make research-informed recommendations on their value and use within classrooms.

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Appendix

Appendix A1: Counterbalanced implementation design

Group	Students	Session 1	AR vs. non-AR	Session 2	AR vs non-AR
1		Book 1	non-AR	Book 2	AR
2		Book 1	AR	Book 2	Non-AR
3		Book 1	Non-AR	Book 2	AR
4		Book 1	AR	Book 2	Non-AR
5		Book 2	non-AR	Book 1	AR
6		Book 2	AR	Book 1	Non-AR
7		Book 2	Non-AR	Book 1	AR
8		Book 2	AR	Book 1	Non-AR
9		Book 1	non-AR	Book 2	AR
10		Book 1	AR	Book 2	Non-AR
11		Book 1	Non-AR	Book 2	AR
12		Book 1	AR	Book 2	Non-AR
13		Book 2	non-AR	Book 1	AR
14		Book 2	AR	Book 1	Non-AR
15		Book 2	Non-AR	Book 1	AR
16		Book 2	AR	Book 1	Non-AR

Appendix A2: List of AR books purchased and/or viewed

Book title	ARBI and the Fire-Breathing Dragon	Isolar system	Mirror Magic	Stop Telling Fibs	Part of the Party	We are all different
Publisher	Arbibook	American Museum of Natural History and Carlton Books Limited	Penguin Random House UK	Twinkl Educational Publishing	Twinkl Educational Publishing	Twinkl Educational Publishing
Date	2015	2013	2019	2019	2019	2019
Author	Iker Burguera	Eliza McCarthy, Martin Schwabacher, Sasha Nemecek	Zach King	-	-	-
Source	Amazon	Amazon	Amazon	Twinkl	Twinkl	Twinkl
Language	English Spanish Basque	English	English	English	English	English
£	14.97	9.99	6.99	6.49	6.49	6.49
App	ARBI	iSolarSystemAR	Mirror Magic	TwinklAR	TwinklAR	TwinklAR
Available	App Store Google Play	App Store Google Play	App Store Google Play	App Store Google Play	App Store Google Play	App Store Google Play
Genre	Fiction	Non-fiction	Fiction	Fiction	Fiction	Fiction
Age	Five-Ten	Undefined	Undefined	Three-Seven	Three-Seven	Three-Seven
Length	32 pages	27 pages	188 pages	26 pages	24 pages	24 pages
AR features: animation	●	●	●	●	●	●
AR features: audio	●				●	
AR features: interactive activities	●	●	●		●	
AR interaction	The device held over full-page image	The device held over full-page image or icon	The device held over the image	The device held over icons (5 icons)	The device held over icons (3 icons)	The device held over icons (2 icons)
Description	The text is on one page and the illustrations are on the opposite page. The story includes four questions the reader should answer to continue. If the	The text and the illustrations are on the same page. The reader can interact with animations by tapping on them, moving them, changing their	The book is divided into 17 chapters and some pages have pictures, comics, and play games such as finding three hidden items, allowing readers to take	Only five pages include an icon, which brings the animals to life.	Only three pages include an icon: picking a song, coloring, and activating animations.	Only two pages include an icon that brings the characters to life: when they speak different languages and play sports.

	answer is wrong, the reader must wait 44 seconds to try again. If it is right, it will be (well done). By the end, it gives you the number of mistakes you made.	sizes, or even taking a picture of them.	photos and add them to the book.
Note			The content seems suitable for +10

Appendix A3: Students and teachers' interview questions (Study 1)

SECTION 1 (students)

Hello, it's been nice to meet you all. I'm XX and today I would like to talk with you about your experience of reading the Augmented reality storybook - what you did and did not like about it.

I'll record this session, then write down what has been said, then I'll delete the recording. When I write everything down, I'll remove any names mentioned.

Had you ever read an AR book before (where you use a print book and a device at the same time) or was this your first time?

If no: Had you ever heard of an AR book before?

If yes: Does this AR book look different from the other AR books you know? In what ways?

(Affective engagement)

What did you like about reading the AR book?

Why is that? PROMPT: Was there a*nything else?*

What did you not like about reading the AR book?

Why is that? PROMPT: Was there a*nything else?*

Are there any other feelings that you'd like to describe about the AR reading session?

If I gave you another AR book, would you be interested to read it or not?

Why is that? PROMPT: *Any other reasons?*

(Behavioural engagement)

I'd like to speak to you now about how you read the AR book and how it might be similar and how it might be different to how you read typical paper books.

Let's start with what's similar first – can you tell me of any similarities between how you read the AR book and how you read typical paper books. PROMPT: Anything else?

Now the differences, can you tell me of any differences between how you read the AR book and how you read typical paper books? PROMPT: Anything else?

Do you think how you read changes when you have an AR book compared to a typical paper book? PROMPT: Please explain.

(Social engagement: promote collaborative experiences)

If you had the choice, would you prefer to read the AR book alone or with someone else?

A) alone
Why is that? PROMPT: *Any other reasons?*

B) with someone
Who would that be? friend, parent, teacher, …

Why is that? PROMPT: *Any other reasons?*

How would you describe the AR book reading experience to another person?

(Cognitive engagement)

Do you think the AR features of the book helped you to understand the story better, or not?

If no: Why do you think is? PROMPT: Any other reasons?

If yes: Why do you think that is? PROMPT: *Any other reasons?*

Which part of the story do you remember the most?

PROMPT: *Why do you think that is?*

Were there any parts of the story that you found difficult to understand?

If no: Ok, good

If yes: What strategies did you use to help you with those difficult parts?

Thank you. Is there anything else about your experience with reading the AR book that you'd like to share with me, but haven't already?

Excellent, thank you so much for talking to me about your AR book reading experience. I have really enjoyed our discussion.

SECTION 2 (teachers)

Hello, it's nice to meet you. I'm XX and today I would like to talk with you about your perceptions of Augmented Reality books and what you think may be the benefits and challenges associated with using AR books in the classroom.

I'll record this session, then write down what has been said, then I'll delete the recording.

Have you ever tried an AR book before with your students (where you use a print book and a device at the same time)?

A Yes

What went well and what didn't? PROMPT: Is there a*nything else you'd like to say about it?*

B No

Why is that? PROMPT: *Any other reasons?*

(The features of AR storybooks as supportive of reading engagement)

As part of this project, I'm interested in whether, in what instances, and how, AR books could support children's reading engagement and comprehension. First, we'll talk about engagement.

Do you think AR books have potential to support children's engagement in reading? In other words, their level of interest or engagement with books?

If yes, why? If no, why not?

Do you think AR books may be particularly useful for some readers? For example, struggling readers (students with reading difficulties) or disengaged readers?

If yes, why? If no, why not?

BEHAVIOURAL ENGAGEMENT

I'd like to speak with you about different types of reading engagement now. First we will discuss children's reading behaviours, and how they might be similar and different when reading an AR book compared to a typical paper book.

In what ways do you think children read/interact with AR books that are similar to paper books?

In what ways do you think children read/interact with AR books that are different to paper books?

Do you think AR books could increase the amount of out of school reading children do? PROMPT: Please explain.

AFFECTIVE ENGAGEMENT

I'd now like to discuss children's level of reading enjoyment and emotional engagement with the AR book

Which features of AR books do you think children will like?

Which features of AR books do you think children will dislike?

Do you think children will experience similar or different emotional reactions to reading when reading an AR book compared to a paper book?

SOCIAL ENGAGEMENT (promote collaborative experiences)

I'd now like to discuss social reading interactions that can arise with AR books and how they might be similar and different to traditional paper books.

In what ways do you think children's social reading interactions are similar when they read AR books compared to traditional paper books?

In what ways do you think the social reading interactions are different?

Do you think there are any features of AR books that could support or even improve the discussions children have about books?

If yes, in what ways? If no, why not?

COGNITIVE ENGAGEMENT

Finally, I'd like to discuss whether AR books can support children's cognitive engagement while reading.

Do you think there are any features of AR books which could support children's cognitive engagement with the story – in other words, their level of attention or depth of thinking while reading?

Do you think there are any features of AR books would could undermine children's cognitive engagement?

Why is that? PROMPT: *Any other reasons?*

(The features of AR storybooks as supportive of reading comprehension)

I'd also like to discuss whether AR books can support children's reading comprehension.

Do you think AR books have potential to support your students' word reading skills, fluency and/or comprehension? Please explain.

What features of AR books do you think may be particularly useful for developing and supporting comprehension?

Do you think there are any features that could undermine comprehension?

Finally, do you think there would be any benefits of AR books for struggling readers (students with reading difficulties)?

Why is that? PROMPT: *Any other reasons?*

(The usability of AR books in the classroom)

This is the last part of the interview, and I'd like to ask you a few questions about the usability of AR books in the class.

What would encourage you to use an AR book during reading time in your classroom?

PROMPT: *Any other reasons?*

What would make reading an AR book in the classroom a challenge?

PROMPT: *Any other reasons?*

Do you think offering these kinds of books in the school library would be possible?

Why is that?

Great! Thank you for talking to me about your perceptions of Augmented Reality books and their benefits and challenges in the classroom. I have really enjoyed our discussion.

Appendix A4: Interview schedule (Study 2)

Introduction.

Hello, my name is Kawla, it's really nice to meet you both. Today, I'm going to ask you to read two books and then discuss them afterwards. One of the books will be an AR book, which is a normal print book which has animations, sounds and graphics when used with a digital device [Note: Students will have learnt about this in an earlier session with the whole class, including a demonstration of AR], while the other will not have AR features. I'm going to ask you to read both of them together, have a discussion about them both, and then tell me your thoughts on reading together after. Do you have any questions before we begin?

If it is ok, I'll record this session, then write down what has been said, then I'll delete the recording. When I write everything down, I'll remove any names mentioned. I will store all information I collect securely.

Part 1 (counter balanced – AR or not-AR)

A- Reading the book together: (10 minutes)
I'm going to give you 10 minutes to read this book together; during this time you can talk about the book and the story as much as you'd like. It's entirely up to you how you'd like to read the book together.

B- Conversation: (≈5m)
Thank you for reading this book together. Now I would like to talk with you about your experience of reading this book together.

Discussing the book together:

First of all, I'd like to hear your thoughts on the book you just read. Could you talk with your classmate about what you liked most about the story, and what you did not like.

PROMPT: *Was there anything else?*

What can you remember most about the story?

PROMPT: *Was there anything else?*

Thank you for talking with each other about the book.

Part 2 – counter balanced (AR or not-AR)

A- Reading the book together: (10 minutes)

I'm going to give you 10 minutes to read this book together; during this time you can talk about the book and the story as much as you'd like. It's entirely up to you how you'd like to read the book together.

B- Conversation: (≈5m)

Thank you for reading this book together. Now I would like to talk with you about your experience of reading this book together.

Discussing the book together:

Let us talk about the book that you have just read. Talk with your classmate about what you liked most about the story, and what you did not like.

PROMPT: *Was there anything else?*

What can you remember most about the story?

PROMPT: *Was there anything else?*

Thank you for talking with each other about the book. I'd now like to learn a little about your experiences of reading the book together.

<u>Part 3. Talking about reading together: (≈10m)</u>

Do you usually prefer reading with someone else or reading on your own?

Why is that? PROMPT: *Any other reasons?*

How did you find reading the first book with someone else? Did you enjoy reading this book together, or not?

Why is that? PROMPT: *Any other reasons?*

How did you find reading the second book with someone else? Did you enjoy reading this book together, or not?

Why is that? PROMPT: *Any other reasons?*

In your opinion, what is the best aspect of reading together with a classmate?

PROMPT: Please explain.

In your opinion, what is the most challenging aspect of reading together with a classmate?

PROMPT: Please explain.

Thank you. Is there anything else about your experience with reading books together that you'd like to share with me, but haven't already?

Thank you so much for talking to me about your shared book reading experience. I have really enjoyed our discussion and learnt a lot from it.

Appendix A5: Observation schedule (Study 1)

Observation Schedule

(AR Reading Session)

Day - Date			
School			
Primary – 3, 4 or 5			
Group number			
Where	Library- Classroom-…….		
Start at:	:		
End at:	:		
Assistant			
AR book	ARBI and the fire-breathing dragon		
Number of words			
Student:			
Age	7-8-9-10	7-8-9-10	7-8-9-10
Gender	M-F	M-F	M-F
Ethnicity			
English is considered an Additional Language	Yes- No	Yes- No	Yes- No
If yes, student's first language:			
Level of reading skills (reported by the class teacher)	(Low, Average, High)	(Low, Average, High)	(Low, Average, High)
If low, difficulties with:	Word reading Reading comprehension	Word reading Reading comprehension	Word reading Reading comprehension
Book reading enjoyment level (reported by student)	(Low, Average, High)	(Low, Average, High)	(Low, Average, High)

Reading Process			
Reader's position during exploring the AR book	Always sitting	Always sitting	Always sitting
	Always standing	Always standing	Always standing
	Switching	Switching	Switching
How reader goes through pages	Liner way, start with the text always.	Liner way, start with the text always.	Liner way, start with the text.
	Liner way, start with the picture.	Liner way, start with the picture.	Liner way, start with the picture.
	Forward and backward	Forward and backward	Forward and backward
How reader reads the text	Silent	Silent	Silent
	Loudly	Loudly	Loudly
	Listening to peer	Listening to peer	Listening to peer
Accessibility	Easy	Easy	Easy
	Manageable	Manageable	Manageable
	Difficult	Difficult	Difficult
Signs			

P	Text	P	Image
1		2	
3		4	
5		6	
7		8	
9		10	
11		12	
13		14	

15		16	
17		18	
19		20	
21		22	
23		24	
25		26	
27		28	
29		30	
31		32	

Appendix A6: Script

The script of what the researcher will say to children before the AR reading session:

- **At the beginning of the session**

Hello, my name is Kawla. It's nice to meet you all. Today we will try a new experience.

As you can see, this is a paper storybook. It looks like any storybook you used to read. This book, however, has a special feature. As you see, when we open the book, we will see two pages, one includes the text and the second includes an image. When we point the camera to the image by iPad, the image will comes to life (The researcher will ask children to look). You will hear some sounds and see the characters move around. Sometimes, a question will pop up, asking you about what you have already read. This special feature is called Augmented Reality.

Now, would you like to try reading this book?

You have the opportunity to read the AR book by yourself or with 1-2 of your classmates. If reading with your classmates, you need to take it in turns to hold the iPad so that each one will have a chance to explore the story with the iPad. After you read the text on each page, you can point the camera to the image to explore. Here is the AR book and the iPad. You have the choice to do this standing, or sitting. stand up or to sit at any time. I'll audio record this session, but no one will be able to listen to it except for me. I'll delete the recording after I get the information that I need. Let's start.

- **During the session**

If one student does not share the iPad with a peer

The researcher will ask the student to give their partner a turn. Throughout the entire session the researcher will ensure that all children get the opportunity to take a lead in reading and exploring at least two pages of text and images with the iPad.

If students avoid reading the text and only explore the images

A) Reminding students to read the text first and then explore the image. If students struggle to read the full text independently, the researcher will provide support with specific words.

B) Waiting until the lock appears on book page and then tell students that they need to read the text to get the answer to be able to move to the next page.

If both students are willing to hold the iPad

The researcher will give instructions to students, who will start holding the iPad to explore this page will be the second on the next page and so on.

If the iPad stop working

The researcher will have an alternative iPad (another fully charged iPad)

- **At the end of the session**

Thank you for taking part. Did you enjoy this? . Now, we will move to the next stage to talk about your AR reading experience.

Appendix A7: Shared Reading Survey

Shared Reading Survey

Name: _____

Hello. This survey is provided to learn more about your experiences of shared books reading. Someone will read the questions aloud to you. Please tick the box that best fits with how you feel. There are no right or wrong answers – we are interested in what YOU really think. We will not share your answers with your teacher or anyone else in your school.

First, we would like to hear your opinion about the **first book** you have read. Please tick the box that best fits with how you feel:

	Disagree a lot	Disagree a little	Agree a little	Agree a lot
I enjoyed the book.				
I enjoyed reading the book with someone else.				
I enjoyed discussing the book with someone else.				

Now, we would like to hear your opinion about the **second book** you have read. Please tick the box that best fits with how you feel:

	Disagree a lot	Disagree a little	Agree a little	Agree a lot
I enjoyed the book.				
I enjoyed reading the book with someone else.				
I enjoyed discussing the book with someone else.				

Now we'd like to learn about your view toward reading. Please tick the box that best describes you.

	Disagree a lot	Disagree a little	Agree a little	Agree a lot
I like talking about what I read with other people				
I would be happy if someone gave me a book as a present				
I think reading is boring				
I would like to have more time for reading				
I enjoy reading				
I learn a lot from reading				
I like to read things that make me think				
I like it when a book helps me imagine other worlds				

Finally, we'd like to learn about how you feel when you share reading with others. Tick the box that best describes you.

	Never	Sometimes	Often	Always	Don't know
I feel afraid if I have to read aloud in front of my class					
I feel afraid that I'll make a fool of myself when I read aloud					
I think that reading aloud is embarrassing					
I worry that other kids will laugh at me when I read aloud					
I worry when I have to read aloud in front of my classmates					
I worry when I have to read aloud to the teacher one on one					

Thank you for completing these surveys.

Appendix A8: Descriptive Statistics and Paired Samples Test of word count, length of word, and sentence for pairs (study 2).

Table 7

Descriptive Statistics

Descriptive Statistics

	N	Minimum	Maximum	Mean	Std. Deviation	Skewness		Kurtosis	
	Statistic	Statistic	Statistic	Statistic	Statistic	Statistic	Std. Error	Statistic	Std. Error
Word_count_NON	16	16.00	227.00	150.2500	60.41468	-.505	.564	-.168	1.091
Word_count_AR	16	46.00	561.00	298.1875	142.15776	.482	.564	.074	1.091
Word_length_Non	16	3.58	4.50	3.8163	.22862	1.889	.564	4.621	1.091
Word_length_AR	16	3.53	4.08	3.8288	.14550	-.058	.564	.230	1.091
Sentence_length_Non	16	4.00	14.80	8.8269	2.86736	1.002	.564	1.016	1.091
Sentence_length_AR	16	5.79	15.88	10.0163	2.42394	.670	.564	1.228	1.091
Valid N (listwise)	16								

Table 8

Paired Samples Statistics (Word count)

Paired Samples Statistics

		Mean	N	Std. Deviation	Std. Error Mean
Pair 1	Word_count_NON	150.2500	16	60.41468	15.10367
	Word_count_AR	298.1875	16	142.15776	35.53944

Table 9

Paired Samples Test (Word count)

Paired Samples Test

		Paired Differences					t	df	Significance	
					95% Confidence Interval of the Difference					
		Mean	Std. Deviation	Std. Error Mean	Lower	Upper			One-Sided p	Two-Sided p
Pair 1	Word_length_Non - Word_length_AR	-.01250	.25489	.06372	-.14832	.12332	-.196	15	.424	.847

Table 10

Paired Samples Statistics (Length of word and sentence)

Paired Samples Statistics

		Mean	N	Std. Deviation	Std. Error Mean
Pair 1	Word_length_Non	3.8163	16	.22862	.05715
	Word_length_AR	3.8288	16	.14550	.03638
Pair 2	Sentence_length_Non	8.8269	16	2.86736	.71684
	Sentence_length_AR	10.0163	16	2.42394	.60598

Table 11

Paired Samples Test (Length of word and sentence)

Paired Samples Test

		Paired Differences					t	df	Significance	
					95% Confidence Interval of the Difference					
		Mean	Std. Deviation	Std. Error Mean	Lower	Upper			One-Sided p	Two-Sided p
Pair 1	Word_length_Non - Word_length_AR	-.01250	.25489	.06372	-.14832	.12332	-.196	15	.424	.847
Pair 2	Sentence_length_Non - Sentence_length_AR	-1.18938	2.43894	.60974	-2.48900	.11025	-1.951	15	.035	.070

Table 12

Paired Samples Statistics of word count for pairs (study 2): Word count related to the book/story

Paired Samples Statistics

		Mean	N	Std. Deviation	Std. Error Mean
Pair 1	Word_count_non	150.2500	16	60.41468	15.10367
	Word_count_AR	260.0000	16	122.57678	30.64419

Table 13

Paired Samples Test of word count for pairs (study 2): Word count related to the book/story content specifically)

Paired Samples Test

		Paired Differences					t	df	Significance	
					95% Confidence Interval of the Difference					
		Mean	Std. Deviation	Std. Error Mean	Lower	Upper			One-Sided p	Two-Sided p
Pair 1	Word_count_non - Word_count_AR	-109.75000	94.74633	23.68658	-160.23675	-59.26325	-4.633	15	<.001	<.001

Appendix A9: A questionnaire (developed to collect students' information)

Student:	A	B	C
Age	8-9-10	8-9-10	8-9-10
Gender	M-F	M-F	M-F
Ethnicity			
English considered as an Additional Language	Yes- No	Yes- No	Yes- No
If yes, student's first language:			
Difficulties with:	Word reading Reading comprehension	Word reading Reading comprehension	Word reading Reading comprehension
Book reading enjoyment level	(Low, Average, High)	(Low, Average, High)	(Low, Average, High)

Student:	D	E	F
Age	8-9-10	8-9-10	8-9-10
Gender	M-F	M-F	M-F
Ethnicity			
English considered as an Additional Language	Yes- No	Yes- No	Yes- No
If yes, student's first language:			
Difficulties with:	Word reading Reading comprehension	Word reading Reading comprehension	Word reading Reading comprehension
Book reading enjoyment level	(Low, Average, High)	(Low, Average, High)	(Low, Average, High)

Student:	G	H	I
Age	8-9-10	8-9-10	8-9-10
Gender	M-F	M-F	M-F
Ethnicity			
English considered as an Additional Language	Yes- No	Yes- No	Yes- No
If yes, student's first language:			
Difficulties with:	Word reading Reading comprehension	Word reading Reading comprehension	Word reading Reading comprehension
Book reading enjoyment level	(Low, Average, High)	(Low, Average, High)	(Low, Average, High)

Student:	**J**	**K**	**L**
Age	8-9-10	8-9-10	8-9-10
Gender	M-F	M-F	M-F
Ethnicity			
English considered as an Additional Language	Yes- No	Yes- No	Yes- No
If yes, student's first language:			
Difficulties with:	Word reading Reading comprehension	Word reading Reading comprehension	Word reading Reading comprehension
Book reading enjoyment level	(Low, Average, High)	(Low, Average, High)	(Low, Average, High)

Student:	**M**	**N**	**O**
Age	8-9-10	8-9-10	8-9-10
Gender	M-F	M-F	M-F
Ethnicity			
English considered as an Additional Language	Yes- No	Yes- No	Yes- No
If yes, student's first language:			
Difficulties with:	Word reading Reading comprehension	Word reading Reading comprehension	Word reading Reading comprehension
Book reading enjoyment level	(Low, Average, High)	(Low, Average, High)	(Low, Average, High)

Student:	**P**	**Q**	**R**
Age	8-9-10	8-9-10	8-9-10
Gender	M-F	M-F	M-F
Ethnicity			
English considered as an Additional Language	Yes- No	Yes- No	Yes- No
If yes, student's first language:			
Difficulties with:	Word reading Reading comprehension	Word reading Reading comprehension	Word reading Reading comprehension
Book reading enjoyment level	(Low, Average, High)	(Low, Average, High)	(Low, Average, High)

Student:	**S**	**T**	**U**
Age	8-9-10	8-9-10	8-9-10
Gender	M-F	M-F	M-F
Ethnicity			
English considered as an Additional Language	Yes- No	Yes- No	Yes- No
If yes, student's first language:			
Difficulties with:	Word reading Reading comprehension	Word reading Reading comprehension	Word reading Reading comprehension
Book reading enjoyment level	(Low, Average, High)	(Low, Average, High)	(Low, Average, High)

Student:	**V**	**W**	**X**
Age	8-9-10	8-9-10	8-9-10
Gender	M-F	M-F	M-F
Ethnicity			
English considered as an Additional Language	Yes- No	Yes- No	Yes- No
If yes, student's first language:			
Difficulties with:	Word reading Reading comprehension	Word reading Reading comprehension	Word reading Reading comprehension
Book reading enjoyment level	(Low, Average, High)	(Low, Average, High)	(Low, Average, High)

Student:	**Y**	**Z**	**AA**
Age	8-9-10	8-9-10	8-9-10
Gender	M-F	M-F	M-F
Ethnicity			
English considered as an Additional Language	Yes- No	Yes- No	Yes- No
If yes, student's first language:			
Difficulties with:	Word reading Reading comprehension	Word reading Reading comprehension	Word reading Reading comprehension
	(Low, Average, High)	(Low, Average, High)	(Low, Average, High)

Book reading enjoyment level			

Student:	**AB**	**AC**	**AD**
Age	8-9-10	8-9-10	8-9-10
Gender	M-F	M-F	M-F
Ethnicity			
English considered as an Additional Language	Yes- No	Yes- No	Yes- No
If yes, student's first language:			
Difficulties with:	Word reading Reading comprehension	Word reading Reading comprehension	Word reading Reading comprehension
Book reading enjoyment level	(Low, Average, High)	(Low, Average, High)	(Low, Average, High)

Student:	**AE**	**AF**	**AG**
Age	8-9-10	8-9-10	8-9-10
Gender	M-F	M-F	M-F
Ethnicity			
English considered as an Additional Language	Yes- No	Yes- No	Yes- No
If yes, student's first language:			
Difficulties with:	Word reading Reading comprehension	Word reading Reading comprehension	Word reading Reading comprehension
Book reading enjoyment level	(Low, Average, High)	(Low, Average, High)	(Low, Average, High)

Student:	**AH**	**AI**	**AJ**
Age	8-9-10	8-9-10	8-9-10
Gender	M-F	M-F	M-F
Ethnicity			
English considered as an Additional Language	Yes- No	Yes- No	Yes- No
If yes, student's first language:			
Difficulties with:	Word reading Reading comprehension	Word reading Reading comprehension	Word reading Reading comprehension

Book reading enjoyment level	(Low, Average, High)	(Low, Average, High)	(Low, Average, High)

Student:	**AK**	**AL**	**AM**
Age	8-9-10	8-9-10	8-9-10
Gender	M-F	M-F	M-F
Ethnicity			
English considered as an Additional Language	Yes- No	Yes- No	Yes- No
If yes, student's first language:			
Difficulties with:	Word reading Reading comprehension	Word reading Reading comprehension	Word reading Reading comprehension
Book reading enjoyment level	(Low, Average, High)	(Low, Average, High)	(Low, Average, High)

Appendix B.1: Ethical approval (study 1)

THE UNIVERSITY of EDINBURGH
Moray House School of Education and Sport

Research, Knowledge Exchange and Impact Office
Moray House School of Education and Sport
The University of Edinburgh
Old Moray House
Holyrood Road
Edinburgh EH8 8AQ

D/D +44 (0)131 651 4846
S/B +44 (0)131 650 1000

www.ed.ac.uk

Ref: KALH07022022

Kawla ALHAMAD
Moray House School of Education and Sport

Date: 14th March 2022

Dear Kawla,

Title: The impact of Augmented Reality (AR) books on the reading engagement and comprehension of child readers.

The School of Education and Sport Ethics Sub-Committee has now considered your request for ethical approval for the studies detailed in the above application.

This is to confirm that the Sub-Committee is happy to approve your application and amendment submitted in February 2022 and that the research meets the School Ethics Approval criterion for this particular project. A standard condition of this ethical approval is that should any amendment, or deviation from the original protocol outlined in your application need to be made to carry out or continue your research, please notify the Ethics Sub-Committee at MHSES-Ethics@ed.ac.uk

The Committee also needs to be notified if there are any unexpected results or events once the research is underway that raise questions about the safety of the research.

Should you receive any formal complaints relating to the study you should notify the MHSE Ethics Committee immediately by email to MHSES-Ethics@ed.ac.uk

Yours sincerely,

On behalf of:
Dr Fiona O'Hanlon
Director of Ethics

Appendix B.2: Ethical approval (study 2)

THE UNIVERSITY of EDINBURGH
Moray House School of Education and Sport

Research, Knowledge Exchange and Impact Office
Moray House School of Education and Sport
The University of Edinburgh
Old Moray House
Holyrood Road
Edinburgh EH8 8AQ

D/D +44 (0)131 651 4846
S/B +44 (0)131 650 1000

www.ed.ac.uk

Ref: KALH24032023

Kawla Alhamad
Moray House School of Education and Sport

Date: 10th May 2023

Dear Kawla,

Title: Shared book reading: Comparing Augmented Reality (AR) and non-AR book reading among children with below-average reading skills.

The School of Education and Sport Ethics Sub-Committee has now considered your request for ethical approval for the studies detailed in the above application.

This is to confirm that the Sub-Committee is happy to approve your application and that the research meets the School Ethics Approval criterion for this particular project. A standard condition of this ethical approval is that should any amendment, or deviation from the original protocol outlined in your application need to be made to carry out or continue your research, please notify the Ethics Sub-Committee at MHSES-Ethics@ed.ac.uk. The Committee also needs to be notified if there are any unexpected results or events once the research is underway that raise questions about the safety of the research.

If your research involves in-person research, please send your Covid Checklist form and information/consent sheets with the relevant Covid statements (in Appendix 1 of the Covid checklist) to your Head of Institute for consideration and approval. You should also include any other required documents, such as a Travel risk assessment form. The Covid checklist, and associated travel documents, can be found at this link.

Should you receive any formal complaints relating to the study you should notify the MHSES Ethics Committee immediately by email to MHSES-Ethics@ed.ac.uk

Yours sincerely,

On behalf of:
Dr Fiona O'Hanlon
Director of Ethics

Appendix C.1: Consent form (Child) (Study 1)

Augmented Reality (AR) books project

Dear Student

The project, **Augmented reality (AR) books,** explores the different ways in which children (aged 7-10) interact with AR books and whether children think AR books can support their reading enjoyment and understanding.

I hope to speak to children who have different attitudes towards book reading. Whether you are a regular book reader, or someone who doesn't like to read books (for whatever reason), we'd really like to hear from you.
The information sheet attached explains what your role would be in the project, if you decide to take part. Please read the information sheet and discuss it with your teacher and parent/guardian.

If you would like to take part, please complete the consent form and return it to school. We will also need your parent/guardian to complete and return their consent form.

If you do not wish to take part, please do not return the consent form.

Thank you,

Kawla Alhamad
PhD student
University of Edinburgh
Email:

Supervised by
Dr Sarah McGeown
Email:

Augmented Reality (AR) Books project

Information sheet

Why are we doing this research?

Augmented Reality (AR) is a new way to enhance print books through the addition of extra animations and sounds. This project aims to understand what you think about AR books after you have had the opportunity to spend time reading and interacting with one in school, during your school day…

Why me?

As part of the project, we would love to hear from children, aged 7-10, who have different attitudes towards reading books. We would like to hear from those who enjoy reading, and those who don't.

What will I be asked to do?

If you choose to participate in this project, you will be asked to read and interact with an AR book (either by yourself, or with friends, depending on your preference) and then have a conversation with the researcher afterwards. This should take approximately 30 minutes and will be carried out during school time. The researcher will come into the school for this session. During the reading session, a teacher or teaching assistant may be present in the same room, although will not be involved in our discussion.

I will audio record our discussion but will not ask for any personal information (i.e., your name) during the time we are recording. We will store all information we collect securely. Appropriate health and safety measures will be put in place to ensure your safety (e.g., social distancing, researcher wearing a mask).

Do I have to take part?

No. It is entirely up to you whether you would like to take part in this project. Please discuss this project with your parent/guardian. If you would like to take part, you both need to sign and return the consent forms. Also, you can agree to take part, but then pull out from the project at any time. You just need to let the teacher know this and they will let us know.

Augmented Reality (AR) books project

Student consent form

If you have questions before completing the form, please ask your teacher who has been given extra information about this project.

If you would like to take part, you need to tick all boxes and return this form to your teacher.

If you would not like to take part, please do not complete or return this form.

I have read the information sheet for the Augmented Reality books project and have understood what the project is about and what I will be asked to do. ☐

I understand that if I take part in the project, group or individual discussions will be audio recorded, but that no identifiable information about me (e.g., my name) will be requested. ☐

I understand that appropriate health and safety measures will be put in place to support my safety. ☐

I understand that I can pull out of the project even if I initially agree to take part. I just need to let my teacher know. ☐

I would like to take part in the project, and would like to take part in: (please choose one box) ☐

An AR session with 1-2 of my classmates

OR ☐

An individual AR session

Name: _____

Date:

_____

School/class:
_____

Appendix C.2: Consent form (Child) (Study 2)

Shared Augmented Reality (AR) book reading project

Dear Student

The project, **Shared Augmented Reality (AR) book reading,** explores how children (aged 8-10) discuss Augmented Reality and non-Augmented Reality book with their classmates during shared book reading sessions. Augmented Reality books are normal print books which ‘come to life’ with animations, sounds and graphics, when used with a digital device.

The information sheet attached explains what your role would be in the project, if you decide to take part. Please read the information sheet and discuss it with your teacher and parent/guardian.

If you would like to take part, please complete the consent form and return it to school. We will also need your parent/guardian to complete and return their consent form.

If you do not wish to take part, please do not return the consent form.

Thank you,

Kawla Alhamad
PhD student
University of Edinburgh
Email:

Supervised by
Dr Sarah McGeown
Email:

Shared Augmented Reality (AR) book reading project

Information sheet

Why are we doing this research?
Shared book reading can be fun, and a good way to learn about others reading experiences; however not everyone likes reading books with others. Augmented Reality (AR) books are a new form of book which include animations, sounds, and graphics. This project aims to understand whether children prefer reading AR or non-AR books together, and why.

Why me?
As part of the project, we would love to work with children, aged 8-10, who don't always enjoy reading, or find reading difficult sometimes.

What will I be asked to do?
If you choose to participate in this project, you will be asked to take part in two shared book reading sessions, one with an Augmented Reality book and one with a non-Augmented Reality book. Each session will last approximately 15 minutes, with the same classmate reading together in each. Then you will take part in a short conversation to talk about your experiences of the shared reading session. In addition, you will also be asked to complete short surveys asking about your reading attitudes and your thoughts about reading. You could ask to stop anytime by telling me during the sessions or by telling your teacher before the sessions. Your participation in this research is voluntary, and you can stop at any time.

I will audio record our sessions but will not ask for any personal information (i.e., your name) during the time we are recording. We will store all information we collect securely. Appropriate health and safety measures will be put in place to ensure your safety (e.g., social distancing).

Do I have to take part?
No. It is entirely up to you whether you would like to take part in this project. Please discuss this project with your parent/guardian and teacher. If you would like to take part, you and your parent/guardian need to sign and return the consent forms. Also, you can agree to take part, but then pull out from the project at any time. You just need to let the teacher know this and they will let us know.

Shared Augmented Reality (AR) book reading project

Student consent form

If you have questions before completing the form, please ask your teacher who has been given extra information about this project.

If you would like to take part, you need to tick all boxes and return this form to your teacher.

If you would not like to take part, please do not complete or return this form.

I have read the information sheet for the *Shared Augmented Reality (AR) book reading project* and have understood what the project is about and what I will be asked to do.	☐
I understand that if I take part in the project, sessions and discussions will be audio recorded, but that no identifiable information about me (e.g., my name) will be requested.	☐
I understand that appropriate health and safety measures will be put in place to support my safety.	☐
I understand that I can pull out of the project even if I initially agree to take part. I just need to let my teacher know.	☐
I would like to take part in the project.	☐

Name: _____

Date: _____

School/class: _____

Appendix C.3: Consent form (Parent) (Study 1)

Augmented Reality (AR) books project

Dear Parent/Guardian,

The project, **Augmented reality (AR) books,** aims to explore the different ways in which children (aged 7-10) interact with AR books and to examine to what extent children believe that AR books have the potential to support their reading engagement and comprehension. To do this, I hope to speak to children who have different attitudes towards book reading.

For this project, children will have the opportunity to explore an AR book either alone or with their peers (depending on their preference) and will then have a discussion with me afterwards to tell me what they did and didn't like about the AR book. This will take approximately 30 minutes and will be carried out during school time.

Your child's school has agreed to take part in this project. Information sheet and consent forms are being sent home to all children in your child's class.

The information sheet attached explains the project in more detail. If you have any questions, please do not hesitate to get in touch. Completed consent forms from parents and children are required for children to take part in this project.

Thank you for taking the time to consider this,

Kawla Alhamad
PhD student
University of Edinburgh
Email:

Supervised by
Dr Sarah McGeown
Email:

Augmented Reality (AR) books project

Information sheet

Why are we doing this research?
Recently, Augmented Reality (AR) has been introduced to enhance print books through the addition of animations, sounds, and graphics. This project will examine the different ways in which children interact with AR books and examine to what extent children and teachers believe that AR books have the potential to support children's reading engagement and comprehension.

What are the benefits of this research?
This project will be the first in the UK to provide insight into children's perceptions of, and experiences with, AR books and to use this knowledge to provide a guide for teachers interested in using AR books in their classrooms. Furthermore, we hope to share our research findings with publishers to improve the design of the AR books based on children's and teachers' feedback.

If my child takes part in the project, what will they be asked to do?
Children will take part in a session (either individually or with peers, depending on their preference) and will spend time reading an AR book before having a (recorded) conversation with the researcher to share their thoughts and experiences. The entire session will last approximately 30 minutes and will be carried out in person.

It is important that we hear from students with different attitudes towards book reading and different levels of reading skill. Therefore, we'd like students who do and don't like reading to take part, in addition to those who may struggle with reading.

Does my child have to take part in the project?
No. It is entirely up to your child and you. If your child would like to take part but then changes their mind, they can withdraw from this project, without giving a reason. They can withdraw from the project by letting their teacher know.

Data Protection and Confidentiality
To ensure a representative group of children take part, we will ask the school for information about your child (specifically their age, gender, ethnicity, whether they have English as an Additional Language and their overall reading skill and enjoyment). This information will be linked to an ID code for each child (i.e., your child's name will not be used when storing the data). Data will be processed in accordance with Data Protection Law. All electronic data will be stored on a password-protected computer. Aligned with open science practices, all data will be uploaded to the Open Science Framework, one year after project completion (February 2024).

Health and Safety considerations
We will take specific steps to minimise the risk of exposure to COVID-19 during the project by adhering to the most up to date Government guidance regarding social distancing, use of face coverings, and cleaning hands and surfaces regularly. Furthermore, your child will only interact with a researcher who has experienced no COVID-19 symptoms, nor had any known contact with COVID-19 positive individuals for the 14 days prior to the school visit. The researcher will also take lateral flow tests daily and will inform the school if a lateral flow test is positive, or the researcher starts to display any symptoms of COVID-19. If any children are deemed at higher risk, then as a precaution, we would recommend that they do not participate in the study. The

school will keep a record of all research interactions. The researcher anticipates being in school for two full days to carry out this research project.

Who can I contact for more information or to make a complaint?
Kawla Alhamad is the main contact person for this project ( ). If you have any questions about the project, you can contact her at any time. If you have concerns which you would like us to address, complaints can be made to Dr Sarah McGeown ( ).

What should I do if I'd like my child to participate?
Once you have read all the information above, you and your child can complete and return both (i.e., child and parent/guardian) consent forms to your child's teacher by **…….th May**. If your child does not wish to participate, please do not return the consent forms.

Augmented Reality (AR) books project

Parent/guardian consent form

If you have questions before completing the form, please contact Kawla Alhamad who is the main contact person for this project:

I have read the information sheet for the above study. I have had an opportunity to consider the information. If I had questions, they have been answered to my satisfaction.	☐
I understand that information about my child will be linked to an ID code rather than their name, to ensure anonymity	☐
I have read and understood the information regarding health and safety considerations.	☐
Based on the information provided, I consent for my child to take part in this project, and understand that they, or I, can choose to withdraw them from this project at any point, without giving a reason. To do this, I can contact my child's teacher or the named researcher.	☐

Please return this consent form by Wednesday 4th May, 2022. **For your child to participate in this project, all boxes above need to be ticked.**

Parent/Guardian signature: _____

Child's name: _____

Date: _____

School/class: _____

Note: Child's name is for consent only; your child will be given an ID number for reference throughout the project so that no personally identifiable information is recorded by the research team.

Appendix C.4: Consent form (Parent) (Study 2)

Shared Augmented Reality (AR) book reading project

Dear Parent/Guardian,

The research project, **Shared Augmented Reality (AR) book reading**, aims to understand whether children (aged 8-10) who have difficulties with reading or are reluctant readers, benefit from Augmented Reality books to encourage and support book-talk with others. Augmented Reality books are normal print books which 'come to life' with animations, sounds and graphics, when used with a digital device. This project is being carried out by a research team at The University of Edinburgh.

This research is based on my previous PhD project which found that children with reading difficulties/reluctant readers reading prefer to read alone, rather than with a peer. However, after taking part in an AR reading session, reluctant readers suggested that they would like to share this reading experience with others. Therefore we are interested in whether, and how, AR reading sessions have the potential to encourage reluctant readers to share and discuss their reading experiences with others.

For this project, we would like to invite children identified as reluctant readers by their class teacher to take part as we feel this project will be of most benefit to them. Teachers will be asked to select a large number of children in their class – approximately 50%; therefore please do not be concerned if you have received this letter. If they choose to take part, children will read in pairs and will take part in two shared reading sessions - one with an AR book and one with a non-AR book. Sessions will be audio recorded and children will be asked about their experiences of both sessions after.

Your child's school has agreed to take part in this project. Information sheet and consent forms are being sent home to approximately 50% of the children in your child's class. The information sheet attached explains the project in more detail. If you have any questions, please do not hesitate to get in touch. Completed consent forms from parents and children are required for children to take part in this project.

Thank you for taking the time to consider this,

Kawla Alhamad
PhD student
University of Edinburgh
Email:
Supervised by
Dr Sarah McGeown
Email:

Shared Augmented Reality (AR) book reading project

Information sheet

Why are we doing this research?
Shared book reading develops children's language and literacy skills and provides opportunities for children to discuss and share books with others, and benefit from learning about others' reading experiences. Augmented Reality (AR) books are a form of book in which AR has been added to enhance print books through the addition of animations, sounds, and graphics. This project aims to understand whether, and how, AR books can encourage and support book-talk among more reluctant readers.

What are the benefits of this research?
Our research team have a specific interest in creating contexts which encourage and support reading engagement among reluctant readers. We hope this project will provide insight into whether, and how, AR books may be able to foster book-talk and positive reading experiences among reluctant readers. We hope to use these research findings to create a guide for teachers to inform their classroom practice and share our research findings with publishers to improve the design of the AR books to support children's reading experiences.

If my child takes part in the project, what will they be asked to do?
Children will be asked to take part in two shared book reading sessions (one with an Augmented Reality book and one with a non-Augmented Reality book). Each session will last approximately 15 minutes, with the same two children reading together in each; these pairs will be selected by the class teacher to ensure ease of comfort for all children. Following reading together, children will take part in a short conversation to talk about their experiences of the shared reading session (the entire session will be audio recorded). In addition, children will also be asked to complete short surveys measuring their reading attitudes and their thoughts about reading. There are two possibilities for withdrawal (i) within a research interaction – where the child could ask to stop anytime, and (ii) before/between research interactions, where the child could tell their teacher. In addition, children will be reminded orally before each research interaction that their participation in this research is voluntary, and they can stop at any time. No personally identifiable information (i.e., student names) will be recorded, however we will request demographic information which will be linked to a child ID code. Information requested includes: age, gender, ethnicity, English as an Additional Language, and teacher reported level of reading skill.

Does my child have to take part in the project?
No. It is entirely up to your child and you. If your child would like to take part but then change their mind, they can withdraw from this project, without giving a reason. They can withdraw from the project by letting their teacher know.

Data Protection and Confidentiality
Participant's data will be processed in accordance with Data Protection Law. Information such as the consent form, surveys, audio recordings, and any other records and documents

generated in the course of the project will be linked to a unique school ID and child ID code, not the school or child's name. All electronic data will be stored on a password-protected computer on a secure drive at the University of Edinburgh. Aligned with open science practices, anonymised data from this project will be uploaded to the Open Science Framework 12 months following project completion (February 2024).

Health and Safety considerations

We will take steps to minimise the risk of exposure to COVID-19 during the project by adhering to any Government guidance regarding social distancing, cleaning hands and surfaces regularly at the time of the project. Furthermore, children will only interact with a researcher who has experienced no COVID-19 symptoms, nor had any known contact with COVID-19 positive individuals for the 14 days prior to the school visit. The researcher will take a lateral flow test on each day before data collection and will inform the school if the test is positive, or the researcher has any symptoms of COVID-19. If this is the case, data collection will be rescheduled. If any children are deemed at higher risk, then we would not recommend that they participate in the study. It is the school's responsibility to inform the researcher if anyone in the participating classes have experienced COVID-19 related symptoms, in the last 7 days (prior to the research being carried out).

Who can I contact for more information or to make a complaint?

Kawla Alhamad is the main contact person for this project ( ). If you have any questions about the project, you can contact her at any time. If you have concerns which you would like us to address, complaints can be made to Dr Sarah McGeown ( ).

What should I do if I'd like my child to participate?

Once you have read all the information above, you and your child can complete and return both (i.e., child and parent/guardian) consent forms to your child's teacher by **/ /2023**. If your child does not wish to participate, please do not return the consent forms.

Shared Augmented Reality (AR) book reading project

Parent/Guardian consent form

If you have questions before completing the form, please contact Kawla Alhamad who is the main contact person for this project:

I have read the information sheet for the above study. I have had an opportunity to consider the information. If I had questions, they have been answered to my satisfaction.	☐
I understand that information about my child will be linked to an ID code rather than their name, to ensure anonymity.	☐
I understand that all data will be anonymised and held securely, and that fully anonymised data from this project will be uploaded to the Open Science Framework in February 2024, in line with open science practices.	☐
Based on the information provided, I consent for my child to take part in this project, and understand that they, or I, can choose to withdraw them from this project at any point, without giving a reason. To do this, I can contact my child's teacher or the named researcher.	☐

Please return this consent form by / /2023. **For your child to participate in this project, all boxes above need to be ticked.**

Parent/Guardian signature: _____

Child's name: _____

Date: _____

School/class: _____

Note: Child's name is for consent only; your child will be given an ID number for reference throughout the project so that no personally identifiable information is recorded by the research team.

Appendix C.5: Consent form (Headteacher) (Study 1)

Augmented Reality (AR) Books Project

Dear [Headteacher name/name of school],

The research project, **Augmented reality (AR) books,** aims to explore the different ways in which child readers (aged 7-10) interact with AR books and to examine to what extent children and teachers believe that AR books have the potential to support reading engagement and comprehension. This project is being carried out by a research team at The University of Edinburgh.

We hope children with diverse attitudes towards book reading, and varying levels of reading skill, will take part in an AR storybook reading session and a short discussion after so we can learn about their engagement and comprehension of the AR book, and the comparisons (positive and negative) they make between AR books and traditional print books.

If your school would like to take part in this project, we would be more than happy to discuss the project in more detail via email, phone or video call. We can organise for this project to be carried out online or in person, depending on your preference. Participating schools will receive two AR books per class and a £60 book voucher as a thank you for participation.

The information sheet attached explains the project in more detail. If you have any questions, please do not hesitate to get in touch.

Thank you for considering this project,

Kawla Alhamad
PhD student
Email:

Supervised by
Dr Sarah McGeown
Email:

Dr Andrew Manches
Email:

Augmented Reality (AR) books Project
Information sheet

Why are we doing this research?
Book reading develops children's language and literacy skills, knowledge and understanding of the world, sparks imagination, and provides opportunities for children to relax. Recently, Augmented Reality (AR) has been introduced to enhance print books through the addition of animations, sounds, and graphics. This project will examine the different ways in which child readers interact with AR books and examine to what extent children and teachers believe that AR books have the potential to support children's reading engagement and comprehension. Questions regarding acceptability and usability of AR books in classroom contexts will also be examined through discussion with teachers.

What are the benefits of this research?
This project will be the first in the UK to provide insight into children's perceptions of, and experiences with, AR books and to use this knowledge to provide a guide for teachers interested in using AR books in their classrooms. Furthermore, we hope to share our research findings with publishers to improve the design of the AR books based on children's and teachers' feedback.

What will students be asked to do?
This project involves providing children (aged, 7-10) with the opportunity to interact with an AR book before hearing their thoughts and experiences of it. These sessions will last approximately 30 minutes, and can be carried out online or in person, depending on school preference. No personally identifiable information (i.e., student names) will be recorded, however we will request demographic information which will be linked to a child ID code. Information requested includes: age, gender, ethnicity, English as an Additional Language, and teacher reported level of reading skill (low, average, high). This is to ensure a representative group of students participate.

In person research
For in person research, audio recorded observations will be carried out by the researcher while children interact with the AR book, followed by an audio recorded in person discussion with the children. We will take steps to minimise the risk of exposure to COVID-19 during the project by adhering to the most up to date Government guidance regarding social distancing, use of face coverings, and cleaning hands and surfaces regularly. Furthermore, children will only interact with a researcher who has experienced no COVID-19 symptoms, nor had any known contact with COVID-19 positive individuals for the 14 days prior to the school visit. The researcher will also take lateral flow tests daily and will inform the school if a lateral flow test is positive, or the researcher starts to display any symptoms of COVID-19. If any children are deemed at higher risk, then we would not recommend that they participate in the study.

Please note the school will need to record and retain a note of all research interactions between pupils and the researcher (i.e., record pupil names and date/time of interaction with the researcher). It is also the school's responsibility to inform the researcher if anyone in the participating classes have experienced COVID-19 related symptoms, in the last 14 days (prior to the research being carried out).

Online research
If the research is carried out online, your school will be sent two AR books and we will set up a Microsoft Teams meeting. We will ask that children spend approximately 15 minutes interacting with the AR book (the researcher will view this interaction over the Teams meeting, which will

audio recorded) and will then have an audio recorded conversation with the children. **Microsoft Teams** is approved for official use by the University of Edinburgh and supports audio/video calling. We will send the school a link with some information on how to use it, and also be available to support them if needed. Please note: The online research option does require more input from the class teacher, so please discuss this with them, and ask them to contact us if they have questions regarding this.

Do my students have to take part in the project?
No. It is entirely up to you whether you would like your school to take part in this project. If you decide that your school would like to participate, information sheet and consent forms will need to be sent to students and their parents. We require consent from students and their parents prior to involvement. Please ensure all students fully understand the project before taking the consent forms home.

Are there any known risks of taking part?
We do not anticipate any risks associated with participating.

Data Protection and Confidentiality
Participant's data will be processed in accordance with Data Protection Law. Information such as the consent form, meeting recordings, and any other records and documents generated in the course of the project will be linked to a unique school ID and child ID code, not the school or child's name. All electronic data will be stored on a password-protected computer on a secure drive at the University of Edinburgh. Aligned with open science practices, anonymised data from this project will be uploaded to the Open Science Framework 12 months following project completion (February 2024).

Who can I contact for more information or a complaint?
Kawla Alhamad is the main contact person for this project ( ) If you have any questions about the project, you can contact her at any time. If you have concerns which you would like us to address, complaints can be made to Dr Sarah McGeown ( ).

What should I do if I'd like my school to participate?
Once you have read all the information above and have contacted the researcher to ask any questions you may have about your schools participation, **please complete the consent form** attached and return it to Kawla Alhamad ( ).

Thank you again for your time, and for considering this project. We genuinely hope this will be an interesting and enjoyable experience for those students involved.

Augmented Reality (AR) Books Project

Headteacher/teacher consent form

If you have questions before completing the form, please contact Kawla Alhamad who is the main contact person for this project:

I have read the information sheet for the above study. I have had an opportunity to consider the information. If I had questions, they have been answered to my satisfaction.	☐ **Yes** ☐ **No**
I understand that I am able to ask further questions about this research any time by contacting Kawla Alhamad ( ). A phone or video call can be arranged to discuss the project.	☐ **Yes** ☐ **No**
I understand that all data will be anonymised and held securely, and that fully anonymised data from this project will be uploaded to the Open Science Framework in February 2024, in line with open science practices.	☐**Yes** ☐**No**
I consent for students in my school (aged 7-10) to be invited to take part in this project. I understand that the students and their parents/guardians will receive full information about the project and will need to provide their own consent before participating.	☐ **Yes** ☐ **No**
My preference is for this project to be carried out:	
In person / Online (delete as appropriate)	
I will discuss and agree with Kawla Alhamad the procedure for carrying out data collection online / in person prior to the project commencing.	☐ **Yes** ☐ **No**

Signature: _____

Name: _____

Date: _____

School: _____

Appendix C.6: Consent form (Headteacher) (Study 2)

Shared Augmented Reality (AR) book reading project

Dear [Headteacher name/name of school],

The research project, **Shared Augmented Reality (AR) book reading,** aims to understand whether children (aged 8-10) who have difficulties with reading, benefit from Augmented Reality books to encourage and support book-talk with others. Augmented Reality books are normal print books which 'come to life' with animations, sounds and graphics, when used with a digital device.This project is being carried out by a research team at The University of Edinburgh.

This research is based on my previous PhD project which found that children who have difficulties with reading prefer to read alone, rather than with a peer. However, after taking part in an AR reading session, children with reading difficulties suggested that they would like to share this reading experience with others. Therefore we are interested in whether, and how, AR reading sessions have the potential to encourage reluctant readers to share and discuss their reading experiences with others.

For this project, we would like to invite children with below-average reading skills to participate, as identified by their class teacher. Children will work in pairs (pairs decided by class teacher) and will take part in two shared reading sessions together - one with an AR book and one with a non-AR book. Sessions will be audio recorded and children will be asked about their experiences of both sessions after.

If your school would like to take part in this project, we would be more than happy to discuss the project in more detail via email, phone or video call. Participating schools will receive a £100 book voucher as a thank you for participation.

The information sheet attached explains the project in more detail. If you have any questions, please do not hesitate to get in touch.

Thank you for considering this project,

Kawla Alhamad
PhD student
Email:

Supervised by
Dr Sarah McGeown. Email:
Professor Andrew Manches. Email:

Shared Augmented Reality (AR) book reading project

Information sheet

Why are we doing this research?
Shared book reading develops children's language and literacy skills and provides opportunities for children to discuss and share books with others, and benefit from learning about others' reading experiences. Augmented Reality (AR) books are a form of book in which AR has been added to enhance print books through the addition of animations, sounds, and graphics. This project aims to understand whether, and how, AR books can encourage and support book-talk among children with below-average reading skills.

What are the benefits of this research?
This project will be the first in the UK to provide insight into children's perceptions of, and experiences with, shared AR book reading and we plan to use this knowledge to create a guide for teachers interested in using AR books in their classroom. In addition, our team of researchers have a specific interest in creating contexts which encourage and support reading engagement among children who struggle with reading, in this case, children with below-average reading skills. We hope this project will provide insight into whether, and how, AR books may be able to foster book-talk and positive reading experiences among reluctant readers. Finally, we hope to share our research findings with publishers to improve the design of the AR books to support children's reading experiences.

What will students be asked to do?
Children will be asked to take part in two shared book reading sessions (one with an Augmented Reality book and one with a non-Augmented Reality book). Each session will last approximately 15 minutes, with the same two children reading together in each; these dyads will be selected by the class teacher to ensure ease of comfort for all children. Following reading together, children will take part in short conversation to talk about their experiences of the shared reading session (the entire session will be audio recorded). In addition, children will also be asked to complete short surveys measuring their reading attitudes and reading anxiety. There will be two possibilities for withdrawal (i) during the research interaction – where the child can ask to stop anytime, and (ii) before/between research interactions, where the child could tell their teacher. In addition, children will be reminded orally before each research interaction that their participation is voluntary, and they can stop at any time. No personally identifiable information (i.e., student names) will be recorded, however we will request demographic information which will be linked to a child ID code. Information requested includes: age, gender, ethnicity, English as an Additional Language, and teacher reported level of reading skill (below average; decoding and/or comprehension).

Health and safety considerations
We will take steps to minimise the risk of exposure to COVID-19 during the project by adhering to any Government guidance regarding social distancing, cleaning hands and surfaces regularly at the time of the project. Furthermore, children will only interact with a researcher who has experienced no COVID-19 symptoms, nor had any known contact with COVID-19 positive individuals for the 14 days prior to the school visit. The researcher will take a lateral flow test on the day before data collection and will inform the school if the test is positive, or the researcher has any symptoms of COVID-19. If this is the case, data collection will be rescheduled. If any

children are deemed at higher risk, then we would not recommend that they participate in the study. It is the school's responsibility to inform the researcher if anyone in the participating classes have experienced COVID-19 related symptoms, in the last 7 days (prior to the research being carried out).

Do my students have to take part in the project?
No. It is entirely up to you whether you would like your school to take part in this project. If you decide that your school would like to participate, information sheet and consent forms will need to be sent to students and their parents. We require consent from students and their parents prior to involvement. Please ensure all students fully understand the project before taking the consent forms home.

Are there any known risks of taking part?
We do not anticipate any risks associated with participating.

Data Protection and Confidentiality
Participant's data will be processed in accordance with Data Protection Law. Information such as the consent form, surveys, audio recordings, and any other records and documents generated in the course of the project will be linked to a unique school ID and child ID code, not the school or child's name. All electronic data will be stored on a password-protected computer on a secure drive at the University of Edinburgh. Aligned with open science practices, anonymised data from this project will be uploaded to the Open Science Framework 12 months following project completion (February 2024).

Who can I contact for more information or a complaint?
Kawla Alhamad is the main contact person for this project ( ) If you have any questions about the project, you can contact her at any time. If you have concerns which you would like us to address, complaints can be made to Dr Sarah McGeown ( ).

What should I do if I'd like my school to participate?
Once you have read all the information above and have contacted the researcher to ask any questions you may have about your schools participation, **please complete the consent form** attached and return it to Kawla Alhamad ( ). Please share this paperwork with participating class teachers and inform the class teachers that parent/guardian information sheets will need to be sent home to families, and that these contain information about the project, including that only 50% of the class are being asked to participate; the 50% will the lowest reading skills, as this project is designed to support these learners in particular.

Thank you again for your time, and for considering this project. We genuinely hope this will be an interesting and enjoyable experience for those students involved.

Shared Augmented Reality (AR) book reading project

Headteacher consent form

If you have questions before completing the form, please contact Kawla Alhamad who is the main contact person for this project:

I have read the information sheet for the above study. I have had an opportunity to consider the information. If I had questions, they have been answered to my satisfaction.	☐ **Yes** ☐ **No**
I understand that I am able to ask further questions about this research any time by contacting Kawla Alhamad ( ). A phone or video call can be arranged to discuss the project.	☐ **Yes** ☐ **No**
I understand the health and safety information in the information sheet.	☐**Yes** ☐**No**
I understand that all data will be anonymised and held securely, and that fully anonymised data from this project will be uploaded to the Open Science Framework in February 2024, in line with open science practices.	☐**Yes** ☐**No**
I consent for students in my school (aged 8-10) to be invited to take part in this project. I understand that the students and their parents/guardians will receive full information about the project and will need to provide their own consent before participating.	☐ **Yes** ☐ **No**

Signature: _____

Name: _____

Date: _____

School: _____

Appendix D.1: supplementary analysis

Themes	Sub-themes			N
1- Practicality	1.1 Managing book/ iPad's position (alternation).	Non-AR book	Book on the table, in the middle all the time.	2 groups
			Book on the table, in the middle. The reader moved the book a little bit to be close to him/her when it was his/her turn.	13 groups
			The book was held by both readers together.	1 group
		AR book	Both the book and iPad are on the table while reading.	6 groups
			Book on the table and the iPad in the reader's lap while reading.	2 groups
			Book on the table and the iPad in the listener's lap while reading.	6 groups
			The book on the table and the iPad was held all the time with hands.	2 groups
	1.2 Managing turns (reading the text)	Non-AR book	All pages (loud reading).	3 groups
			together. (silent reading).	2 groups
			One page for each (loud reading).	7 groups
			One page for each, dividing long pages into two sections, half of the page for each (loud reading).	2 groups
			One page for each, dividing long pages a sentence for each (loud reading).	1 group
			Two sentences for one reader and the rest of the page for peer (loud reading).	1 group
		AR book	All pages (loud reading).	2 groups
			together. (silent reading).	2 groups
			Two pages each (loud reading).	1 group
			One page for each (loud reading).	6 groups
			One page for each, dividing long pages into two sections, half of the page for each (loud reading).	3 groups
			Two sentences each (loud reading).	1 group
			First page together. Due to adopting different reading speeds, they switched to one page for each and then two sentences for one reader and the rest of the page for peer.	1 group

Themes	Sub-themes			N
2- Value of images/ animation to prompt book-talk	2.1 Deducting/ allocated time to explore the images/ animation &talk about it	Non-AR book	Looking at all the pictures while reading.	1 group
			Looking at pictures only while listening to peer.	6 groups
			Looking at a few pictures while they read (2-3 pictures)	2 groups
			Skipping pictures.	7 groups
		AR book	Exploring the picture together via iPad before reading the text on the opposite page and talking about it.	6 groups
			Exploring the picture together via iPad after reading the text on the opposite page and talking about it.	6 groups
			Taking a glance at the picture through the iPad while listening, and then exploring the picture together after finishing reading the text on the opposite page.	4 groups

Themes	Sub-themes			N
3- Reading techniques Observable techniques students adopted/applied individually to manage their reading progress.	3.1 Tracking reading/turns	Non-AR book	Finger pointing.	15 students
			Moving lips while listening to peer.	2 students
		AR book	Finger pointing.	11 students
			Moving lips while listening to peer.	2 students
	3.2 Managing stress	Non-AR book	Playing with clay while reading.	2 students
			Take a break (2-3 times) to breathe and drink water.	2 students
		AR book	Playing with clay while reading.	1 student
			Take a break (2-3 times) to breathe and drink water.	3 students