



An Exploratory Mixed-Methods Study of Vocabulary Growth in Multi- and Bilingual Preschoolers using a Multilingual Picture-Book App

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Abstract

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FULL CONSENT STATEMENT

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ARCHIVAL RECORD

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Abstract

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Keywords: *picture-book app, receptive vocabulary, multilingual preschoolers, language of instruction, digital picture books, emergent literacy, sociocultural learning, parent involvement, media literacy*

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1. Introduction

Reading aloud supports language development, expands vocabulary, and fosters early literacy (Batini & Toti, 2024; Combs & Higgins, 2024). Picture-book apps extend this practice by combining auditory and visual elements, creating engaging, multisensory experiences for vocabulary learning (Nilsen, 2024; Trosseth & Strouse, 2017). Early, inclusive support is especially critical for multi- and bilingual preschoolers with migration backgrounds, underscoring the need for scalable tools (Valcárcel Jiménez et al., 2024). Digital resources like picture-book apps can deliver multilingual, immersive experiences that address this need.

1.1. Theoretical framework

The study is primarily grounded in a sociocultural understanding of language learning, in which vocabulary development is shaped by meaningful input, adult mediation, and interaction across home and educational contexts. This lens provides the central interpretive framework for the study: app-based picture-book reading is examined not as a stand-alone technological intervention, but as a mediated literacy practice whose value depends on how adults and children use it. Emergent literacy theory and multimedia learning theory are used as complementary perspectives to explain why story-based, multimodal resources may provide opportunities for vocabulary exposure. The broader literature on educational inequality, migration, and multilingualism frames why access to linguistically responsive resources matters. To avoid an overly eclectic framework, the interpretation of the findings centres on scaffolding, mediation, engagement, and contextual conditions of use.

1.2. Proficiency in the LoI and educational inequality

Language proficiency in the LoI is a key determinant of academic achievement and is profoundly linked to future socioeconomic success (Stanat & Edele, 2016; Valcárcel Jiménez et al., 2024). Proficiency in the LoI is often treated as a prerequisite for participation in curriculum content, especially in linguistically demanding subjects such as mathematics and science (Schlager, 2019). However, this conventional emphasis on LoI proficiency can marginalise children from migration or refugee backgrounds, whose multilingual repertoires and communicative practices, shaped by their multicultural environments, are often overlooked (Galante et al., 2020; Krulatz & Christison, 2019). The prioritisation of monolingual academic language norms perpetuates structural inequalities by systematically disadvantaging learners who do not align with the expectations in the dominant language (Becker, 2019; Hövelbrinks et al., 2020). Recognising multi- and bilingualism as a valuable resource rather than a challenge requires inclusive pedagogies, targeted academic language support, and school environments that validate students' linguistic and cultural identities (Conteh & Riasat, 2014; Raikes et al., 2018).

1.3. Sociocultural approaches to language exposure

From a sociocultural perspective, learning occurs through guided social interaction. Vygotsky's (1978) concept of the Zone of Proximal Development highlights the importance of scaffolding children's development beyond their current abilities. Central to this process is providing children with abundant and meaningful language input: hearing a wide variety of words and structures in both their first

and second languages supports robust vocabulary growth. Research shows that extensive language input enhances both receptive and expressive vocabulary (Hidayatullah et al., 2023; Şimşek & Erdoğan, 2021), in line with Krashen's (1982) input hypothesis, which emphasizes comprehensible input slightly above learners' current levels.

Digital contexts can further amplify these opportunities. Digital picture books can deliver rich linguistic input through narration, embedded vocabulary, and interactive features, offering children repeated exposure to words and structures in engaging ways (Clinton-Lisell et al., 2021; Hui et al., 2020; Smeets & Bus, 2014). In multicultural classrooms, such tools can also serve as culturally responsive resources, reflecting children's languages and experiences and enhancing engagement and motivation (Kim et al., 2023). Technology thus allows educators and caregivers to immerse children in language, supporting vocabulary development across both first and second languages while maintaining comprehension and interest.

1.4. Multimedia learning theory and digital literacy

Multimedia learning theory provides an additional lens for analysing the potential of digital picture books. According to Mayer (2001), children learn more effectively when information is presented through multiple modalities (e.g., text, images, and sound). This method can reduce cognitive load and support comprehension. Meta-analyses confirm that multimedia features, such as animations, sound effects, and highlighting, can promote comprehension and vocabulary acquisition (Savva, Higgins & Beckmann, 2022; Verhallen et al., 2006). However, interactive features that are not directly tied to the narrative may distract from learning, especially for children from disadvantaged backgrounds (Takács et al., 2015).

Taken together, multimedia learning theory is used here not to assume that digital features automatically produce learning gains, but to identify design conditions under which audio, image, and text may support comprehension when they are aligned with the narrative and accompanied by meaningful adult guidance.

1.5. Current state of research

The role of digital picture books in supporting vocabulary development has become increasingly prominent in recent years. A robust body of evidence highlights the potential of these books to foster early literacy skills, particularly when adult mediation and dialogic strategies are integrated. Meta-analyses confirm significant positive effects of e-books on vocabulary and comprehension when the books include supportive features, such as narration and highlighting (Bus et al., 2021; Day et al., 2024; Savva et al., 2022).

At the same time, research cautions that effectiveness is not uniform. Multimedia features, such as animations and sounds, support comprehension and vocabulary, but interactive elements that distract from the narrative can hinder learning, particularly for children from socioeconomically disadvantaged backgrounds (Bus et al., 2021; Day et al., 2024).

The multilingual dimension has also become increasingly relevant. Research shows that digital picture books can support vocabulary development across both first and second languages. For example, studies with Polish-Norwegian bilingual preschoolers demonstrated that digital books can effectively assess and promote both receptive and expressive vocabulary (Hjetland et al., 2022). This observation aligns with broader findings that home literacy environments and parental involvement shape the language trajectories of bilingual children (Nag et al., 2024).

Furthermore, a study by Tunkiel (2022) examined how sharing digital picture books in a child's first language (L1) at home before reading them in a second language (L2) in kindergarten affected L2 book-specific vocabulary learning and story comprehension. The study found that reading digital picture books in L1 at home before rereading them in L2 in kindergarten was more beneficial for dual language learners' acquisition of book-specific L2 vocabulary and story comprehension, compared to reading only in L2 (Tunkiel, 2022).

Additionally, research by Sun et al. (2020) explored the impact of multimedia input at home on bilingual children's language outcomes. The study demonstrated that the diversity of multimedia input, including digital picture books, was more important than the amount of multimedia input in promoting children's Mandarin language maintenance, highlighting the unique contribution of multimedia diversity to children's early heritage language development (Sun et al., 2020).

Building on this body of research, digital picture books appear promising for supporting vocabulary exposure in multilingual children, particularly when they integrate multimodal features, scaffolding, and adult mediation. However, gaps remain regarding how such tools are taken up in multilingual and multicultural preschool contexts, especially among children with migration backgrounds who navigate diverse linguistic environments. Prior studies indicate that digital-book content and surrounding literacy practices, such as parental involvement, language of reading, and exposure to heritage languages, can shape learning opportunities (Tunkiel & Bus, 2022; Sun & Yin, 2020; Nag et al., 2024). Yet there is still limited empirical evidence from Swiss early childhood contexts on how multilingual digital picture-book apps are used by children, parents, and educators, and which implementation conditions appear to support or hinder meaningful engagement. The present study therefore does not claim to test whether the app caused vocabulary development. Instead, it investigates the relationship between one available usage indicator and receptive-vocabulary growth in the language of instruction (LoI), while also examining contextual and pedagogical factors that may shape app use across home and educational settings. This leads to the following research questions:

- Research Question 1: How is book-opening frequency in a multilingual picture-book app with an auditory read-aloud function associated with changes in receptive vocabulary in the LoI among multi- and bilingual preschool children with migration backgrounds?
- Research Question 2: What contextual, pedagogical, and family-level components appear important for implementing a multilingual picture-book app as a language-learning resource in this population?

2. Materials and methods

This study employed an exploratory mixed-methods, one-group pretest-posttest design. The quantitative component examined changes in children's receptive vocabulary scores, measured with the SET 3–5, and analysed whether these changes were associated with one available app-usage indicator: the number of books opened in the app. This design was appropriate for an initial field-based exploration of app uptake in naturalistic home and early childhood settings, but it cannot support causal attribution. No comparison or control group was included, children were not randomly assigned, and vocabulary development may also have been influenced by maturation, preschool input, family literacy practices, concurrent language support, and other environmental factors. Therefore,

the quantitative analyses describe vocabulary change over time and examine associations between book-opening frequency and that change, rather than testing intervention effectiveness. The qualitative component comprised semi-structured interviews with 14 educators directly involved in educating the participating children and an open-ended survey completed by 10 parents. Children's perspectives were gathered using a picture-based questioning method with a smiley scale. Integration across datasets was pursued by using the qualitative findings to interpret possible contextual conditions behind variation in book-opening frequency, meaningful engagement, and vocabulary change.

2.1. Participants

The study involved 72 Swiss preschool children aged three to five years (mean = 61.57 months, SD = 11.95), whose first language differed from the LoI. Of the initial sample, three children (4%) were unavailable for the second assessment due to relocation ($n = 2$) and extended illness ($n = 1$). Participants were recruited through a non-probability convenience procedure via educational institutions and language-support settings across Switzerland. Teachers and educational staff informed eligible families about the study, and interested families were then approached individually by the author or local staff. This recruitment strategy made it possible to reach linguistically diverse families in naturalistic settings, but it may have favoured families and institutions that were more willing or able to participate in educational-technology activities. The sample was distributed across five kindergartens (32 participants), one playgroup (five participants), three mother-child German courses (22 participants), and three extended education institutions (13 participants). Children were therefore nested within institutions and settings. The primary correlations treated children as individual observations. To address possible non-independence of observations due to institutional clustering, the main association was additionally examined as a sensitivity analysis using linear regression with standard errors clustered by institution. Because the number of clusters was modest and cluster sizes were uneven, these estimates are interpreted cautiously. Mothers' education levels varied, with most having completed secondary school (27.78%) or holding a bachelor's degree (23.61%), while a smaller proportion had no formal education (4.17%). Fathers were most commonly educated to the level of a high school diploma or vocational qualification (37.5%), with none reporting no formal education. The children spoke a wide range of first languages, including Tigrinya, Arabic, Albanian, Spanish, Tamil, and Ukrainian. Families typically spoke two languages (51.39%) or more than two (48.61%), excluding Swiss German as a separate language. The children's countries of origin were diverse, with notable representation from Eritrea, Sri Lanka, and Ukraine.

The educator sample consisted of 14 professionals directly involved in the care and education of the participating children: six kindergarten teachers, four German-as-a-second-language (DaZ) instructors, one playgroup leader, one school-based occupational therapist, and two after-school staff members. All were selected based on their direct pedagogical relationship with the children, ensuring that insights were grounded in first-hand experience. Interviews were conducted in German and focused on capturing the perspectives on integrating picture-book apps into early language-support practices.

2.2. Materials

The picture-book app Polyino (originally Polyglutt) is a digital picture-book service for kindergartens, preschools, and libraries

(<https://www.ilteducation.com/uk/>). Developed by Inlästa Läromedel (ILT) Education and launched in 2017 in Sweden, the app offers over 1,500 picture books with audio support in more than 70 languages. Polyino is accessible via tablets and web browsers and features personalised bookshelves, QR codes, and resources developed with language experts. Since its launch, the app has expanded internationally, with versions introduced in Finland (2018), Germany (2019), and other countries, including the US and UK by 2021. It has been discussed in research highlighting the potential of web-based multilingual book portals (Dube, Schwinning & Filipovic, 2023; Marycz, 2022). This study selected Polyino because of its extensive multilingual library of professionally narrated picture books, which may provide children with repeated access to story-based language input in both home languages and the LoI. However, the app-language choices made by families were not available in the usage data, meaning that the multilingual affordances could be examined qualitatively but not tested as a quantitative mechanism.

2.3. Measures

Receptive vocabulary was assessed using the SET 3–5 language development inventory, a well-validated and standardised German language competency test (Petermann, 2016). The pre-test was administered at the respective educational institutions and scheduled according to the availability of teachers and educational staff. The SET 3–5 allows for a developmentally appropriate and comprehensive assessment of German language proficiency in preschool children. In addition to core language areas, it captures important precursor skills for language acquisition. The 12 available subtests assess vocabulary, phonetics/phonology, semantic relations, processing speed, grammar/morphology, auditory memory, and emotion recognition and empathy (Petermann, 2016). The receptive vocabulary subtest was used in this study.

Book-opening frequency was used as the available app-usage proxy during the observational phase because this was the only objective usage indicator available from the app provider for this study. It was selected over parent-reported app use because it was not dependent on memory or self-report accuracy. Nevertheless, this variable should be understood as a proxy for exposure opportunity rather than as a direct measure of engagement quality, reading quality, listening duration, book completion, repeated reading, language selection, or adult-child interaction. Opening a book does not necessarily mean that the child listened to the whole story, understood the content, or engaged deeply with it. More fine-grained analytics, such as time spent per book, completion rates, language selected, repeated readings, narration use, and co-reading behaviour, were not available and are therefore addressed as limitations.

Parents' sociodemographic data were collected using a self-developed quantitative questionnaire (Moosbrugger & Kelava, 2007). This data included, among other factors, country of origin, first language, other languages spoken by the child, and information on whether the child was receiving targeted language support. A standardised qualitative survey with parents included open-ended questions about the perceived influence, challenges, and benefits of the picture-book app on the children (Hatch, 2023).

Interview questions for educators were designed to explore the experiences and perceptions of the educators regarding the use of interactive touchscreen media, particularly picture-book apps, for vocabulary development in multi- and bilingual preschoolers. The questions were informed by prior research on digital media in early childhood education and the study's theoretical framework, which emphasises the importance of meaningful, interactive language input. For instance, educators were asked, 'What challenges do you see

in the pedagogically valuable use of picture-book apps?’ and ‘In your opinion, what factors influence the positive use of picture-book apps?’ These questions aimed to elicit insights into observed challenges and benefits of using the app for language development and to reflect on contextual influences such as parental involvement and institutional support. The interview guide structure reflects both the study’s research questions and Braun and Clarke’s (2006) emphasis on generating rich, experience-based data for thematic analysis.

The interviews were recorded online and transcribed using NoScribe transcription software. An inductive thematic analysis was conducted following Braun and Clarke’s (2012) six-phase framework: (1) familiarisation with the data, (2) generating initial codes, (3) searching for themes, (4) reviewing themes, (5) defining and naming themes, and (6) producing the report. The primary researcher read the transcripts several times and wrote analytic memos to document first impressions, recurring topics, and uncertainties. Initial semantic codes were generated manually and entered into a structured coding table. During coding, codes were compared across transcripts, merged when they captured the same idea, split when they covered distinct meanings, and renamed to make their definitions more precise. The codebook therefore developed iteratively from the data rather than being fixed in advance. Candidate themes were then checked against the coded extracts and the full transcripts to ensure that they were internally coherent, distinct from one another, and relevant to the research questions.

To strengthen analytic reflexivity and transparency, a second researcher independently coded four of the 14 educator-interview transcripts, corresponding to 28.6% of the educator-interview dataset. The transcripts were purposively selected to represent different professional roles and institutional perspectives. The purpose of this process was not to calculate interrater reliability, as the study followed Braun and Clarke’s reflexive approach to thematic analysis, in which coding is understood as interpretative rather than as the application of objectively fixed categories. Instead, disagreements and ambiguous excerpts were discussed until consensus was reached. These discussions led to refinements of code definitions, clarification of analytic assumptions, the merging of overlapping codes, and the reallocation of some excerpts to more precise categories. The revised codebook was then used to review the remaining material for coherence and distinctiveness. NVivo software was not used; coding was conducted manually using a structured coding table (Table 1 presents an example). Final themes were selected based on their relevance to the research questions, recurrence across interviews, and ability to explain contextual conditions shaping app use. No interrater reliability coefficient was therefore calculated.

The children were questioned by the study personnel, employing a picture-based approach combined with a Smiley Scale to indicate the level of interest and motivation of the children in using the app. This method has been shown to have a low barrier for interviewing children (Hurrelmann et al., 2014; Tsoi et al., 2021). Children were shown an image representing the Polyino app and asked to place it on a printed Smiley Scale to express their feelings about the app experience visually. Communication with the children varied; some understood minimal German, while others were non-verbal. Some translation into French, English, and Spanish was possible.

2.4. Procedure

Before the experiment, interested families were informed about the study by the author, teachers, and educational staff and were individually approached in person. Written informed consent was obtained from all participating families, who were encouraged to

Table 1. Sample Coding System.

<i>Code</i>	<i>Definition</i>	<i>Example</i>
Timing and Context	This code captures references to how the time of day, children’s energy levels, or situational routines shape conditions for app use and engagement.	‘After lunch, children are often more receptive to calmer activities like storytelling or exploring a picture book app. They need time to wind down, and this is a good opportunity to introduce something educational.’ (ASP1., Pos. 50)

contact the author with any questions or concerns. Participation was voluntary, and families could withdraw at any time. To ensure full understanding of the study’s objectives and procedures, we translated information sheets and consent forms into each participant’s first language. Ethical approval was obtained from the Ethics Committee of the University of Vienna (reference number 00973), and all data were collected in Switzerland in accordance with national ethical guidelines for research involving minors.

In addition to parental consent, the study also considered the assent of the child. Children were introduced to the app and study activities in an age-appropriate and playful manner. Participation in the app-based activities and the picture-based feedback method was entirely voluntary. Children could decline or withdraw at any time without consequences. The feedback method was designed to be non-intrusive and to respect the children’s developmental stages, allowing for non-verbal responses and minimising pressure.

Parents received instructions and login credentials for the picture-book app. Each login code matched the parent questionnaire code to maintain anonymity and enable data matching. The observational phase, conducted between November 2023 and June 2024, lasted three months. Parents installed the app on their own devices and were instructed to use it with their children for at least 10 minutes per day. The researchers did not observe home use directly, monitor the consistency of the 10-minute routine, or standardise how parents scaffolded reading, whether children used the app alone or with adults, whether the app complemented or replaced other literacy activities, or which language was selected for each book. Consequently, home implementation fidelity was not controlled. A collaboration with the developers of Polyino enabled access to one usage indicator: the number of books opened.

The collection of quantitative data included vocabulary test scores from the SET 3–5 receptive-vocabulary subtest at pre- and post-test and the app-usage indicator provided by the developers. Sociodemographic data were collected via a questionnaire during the observational phase. At the end of the phase, a qualitative survey was completed by parents; the survey was administered in writing and translated into participants’ native languages to enhance understanding. Only 10 out of 69 eligible parents returned the completed qualitative survey (14.5%). These parent responses are therefore treated as illustrative insights into possible home experiences rather than as representative evidence of parental perspectives across the sample. The low response rate is important because responding parents may have differed systematically from

non-respondents, for example in interest in literacy, digital media, education, or available time.

Additional qualitative data were gathered at the end of the observational phase through interviews in German with the educators. During the observational phase, children's views on various learning software were also collected using the picture-based method. This approach allowed for non-verbal responses and contributed to a more comprehensive understanding by incorporating perspectives from multiple stakeholders.

2.5. Analytical strategy

The quantitative analysis proceeded in five steps. First, descriptive pre-post changes in receptive vocabulary were calculated to document within-group development during the three-month period. Second, Pearson and Spearman correlations were used to examine whether book-opening frequency was associated with vocabulary-score change. Third, baseline receptive-vocabulary scores were correlated with book-opening frequency to explore whether children with stronger initial German vocabulary were more likely to use the app. Fourth, because children were recruited through multiple institutions and observations may therefore not have been fully independent, the main association was additionally estimated using linear regression with cluster-robust standard errors at the institution level. Fifth, a sensitivity analysis was conducted with and without high-use cases identified by the IQR method. This analytical strategy aligns with the revised Research Question 1 because it examines associations between book-opening frequency and vocabulary change. It does not estimate causal effects, and no multivariate covariate-adjusted or multilevel models were fitted because the sample size, unequal institutional clusters, and limited covariate data would not support robust modelling.

3. Results

3.1. Quantitative results

To address Research Question 1, the study examined the relationship between the number of books opened in the app (range = 0–100) and change in receptive-vocabulary scores from pre- to post-test. There was a statistically significant, moderate positive correlation between the number of books opened and vocabulary gains, $r(70) = .39$, $p < .001$. A non-parametric Spearman's correlation yielded a comparable result, $\rho = .34$, $p = .004$. When the same association was estimated as a linear regression with cluster-robust standard errors at the institution level, the association remained positive, $b = 0.046$, cluster-robust SE = 0.013, $t(12) = 3.62$, $p = .004$, 95% CI [0.018, 0.074]. This finding indicates that children who opened more books tended to show larger vocabulary gains. However, because the study did not include a control group and because the available usage measure captures book openings rather than sustained reading, the result should be interpreted as an association between a proxy for exposure opportunity and vocabulary change, not as evidence that app use caused vocabulary growth.

Across the three-month period, receptive-vocabulary scores increased from pre-test ($M = 14.31$, $SD = 5.45$) to post-test ($M = 17.07$, $SD = 5.28$), with a mean within-child gain of 2.76 points ($SD = 2.48$). A paired-samples t -test confirmed that this within-group change was statistically significant, $t(71) = 9.47$, $p < .001$. For transparency, the effect size is reported as Cohen's d_z , the paired-samples effect size calculated by standardising the mean difference by the standard deviation of the difference scores; $d_z = 1.12$. This within-group effect size is descriptive and should not be interpreted as an intervention effect. The score range expanded from 2–26 points at pre-test

to 5–26 points at post-test. Of the 72 participants, 62 showed improvement, six showed no change, and four showed a decrease. This descriptive increase is reported to characterise development within the sample, but it should not be interpreted as evidence of app effectiveness. Natural developmental progression, concurrent language-support activities, preschool exposure, family literacy environments, motivation, and other unmeasured influences could also have contributed to the observed gains.

To examine whether children with higher initial language abilities were more likely to open books in the app, the number of books opened was correlated with receptive-vocabulary scores at the first measurement point (T1). Results indicated a small, nonsignificant negative correlation ($r = -.14$, $p = .237$), suggesting that book-opening frequency was not systematically associated with initial receptive-vocabulary scores. This reduces, but does not eliminate, the possibility that the association between book openings and vocabulary gains was driven by initial language ability.

The distribution of book openings included four high-use cases identified by the interquartile range (IQR) method. The IQR upper threshold was 41.25 books opened; the four high-use cases opened 67, 88, 90, and 100 books. These cases represented children who opened an unusually large number of books rather than obvious data-entry errors; therefore, they were retained in the primary analysis because extreme usage patterns may be substantively meaningful. As a sensitivity check, the analysis was recalculated after excluding these four cases, reducing the range of book openings to 0–36 and the sample to 68 children. The association remained statistically significant, $r(66) = .36$, $p = .003$; $\rho = .25$, $p = .036$. The cluster-robust regression also remained positive, $b = 0.082$, cluster-robust SE = 0.026, $t(12) = 3.09$, $p = .009$, 95% CI [0.024, 0.140]. Thus, the conclusion was similar with and without the high-use cases: book-opening frequency was associated with vocabulary gains, but the study design does not permit causal claims about intervention effectiveness.

3.2. Qualitative results

The exchange with educators and the small group of responding parents revealed several perceived components that may shape the integration of a picture-book app for language and vocabulary support among multilingual preschool children with migration backgrounds. Interview participants were identified as follows: kindergarten teachers (Teacher1–6), German-as-a-second-language (DaZ1–4) teachers, the occupational therapist (OT1), the playgroup leader (Playgroup1), and two professionals from the after-school programme (ASP1–2). Insights from the parent questionnaire are included with parents labelled as Parent1–10. Given the low parent response rate, parental comments are used selectively to illustrate possible experiences and implementation conditions, not to represent the full parent sample.

3.3. The problem of general overconsumption of digital media

Many children were already spending significant time with digital media at home, prompting some teachers to hesitate in increasing its use in kindergarten or recommending it for home use. As Teacher2 explained, 'Over time, the problem became so significant with children's enormous media consumption that I felt it wasn't a good idea to use even more screen time in kindergarten or recommend it at home.' Other educators echoed similar concerns: 'Children need a lot more things than their phones or tablets at home.' (OT1).

3.4. Active engagement and interaction

Interactive features and dialogic practices were repeatedly described as important for children's engagement. Educators distinguished these practices from passive media consumption and emphasised that app-based reading is more meaningful when adults prompt children, ask questions, and connect the story to shared experiences. ASP2 illustrated this with an example: 'It's about actively interacting with the content. For example, using questions like, "Who sees the bird picking at the apples?" turns reading into a shared, playful experience.' This approach aligns with dialogic reading, which promotes prompting, prediction, and questioning during storytelling. Such interactions may create conditions that support vocabulary retention and comprehension.

Building on this, DaZ1 shared, 'In hidden-object books, we play games like, "Who finds the dog hiding in the market?" These playful interactions make children connect with the material.' These examples demonstrate how interactive reading transforms children from passive listeners into active participants in the learning process.

3.5. Timing and context

The timing and context of app use were described as relevant conditions for children's engagement. Educators noted that app-based activities appeared easier to introduce during quieter periods when children were more receptive to calm, story-oriented activities. ASP1 explained, 'After lunch, children are often more receptive to calmer activities like storytelling or exploring a picture-book app. They need time to wind down, and this is a good opportunity to introduce something educational.'

This observation is useful in structuring learning schedules. Educators found that children were more attentive during quieter periods, while high-energy times were less conducive to focused activities. As one participant observed, 'In the afternoon, children often want to move and play actively. They are less likely to sit quietly with a book or app, so it's better to schedule these activities earlier or during structured quiet times.' Aligning app usage with children's natural rhythms may support engagement and learning opportunities, although this was not tested quantitatively in the present study.

3.6. Parental involvement: challenges and strategies

Parental involvement was both critical and challenging. Many families, particularly those with limited German proficiency, struggled with the technical and linguistic demands of supporting app use. DaZ2 noted, 'Some parents can't even install the app, let alone use it meaningfully. It's not that they don't want to help (...) it's just that they lack the digital literacy or language skills needed to engage with such tools.'

To support these families, regular workshops and hands-on demonstrations are needed. ASP1 proposed, 'We need to offer sessions where parents can learn how to effectively use technology. If we teach them more media literacy, they'll feel more confident and better equipped to support their children.'

Cultural perceptions of digital learning also played a role. DaZ1 remarked, 'For some parents, screens are only for entertainment. They don't see them as educational tools. It's important to show them how these apps can help their children learn.' These comments suggest that parental understanding of educational media may influence how children encounter the app at home.

Building trust and shared understanding with parents is essential to ensure that they see picture-book apps as valuable educational tools. As Teacher2 summarised, 'Digital tools are useful, but children need guidance to use them, like any learning tool. Parents also need

media training (...) it's like nutrition; if parents eat fast food, you can't expect children to eat vegetables.'

3.7. Perceived benefits among responding parents and educators

Among the ten responding parents, one perceived benefit of the app was its extensive selection of more than 1,000 titles. Filtering options by theme, age, or new releases were described as making it easier for children to find books that matched their interests and developmental needs. As Parent4 shared, 'She was really interested in horses, so we looked up books with horses. That interested her very much, and she wanted to read a lot about horses.' Because these comments come from a small self-selected parent subgroup, they should be interpreted as examples of possible affordances rather than as evidence of typical parent experiences.

The app was also perceived as a convenient alternative to libraries, eliminating challenges such as travel, carrying books, and meeting return deadlines. Parent3 explained, 'It's just so much easier than going to the library. I usually don't have time, and I forget to return them.'

The multilingual capabilities of the app further supported inclusion by allowing children to access stories in their home languages. DaZ1 emphasised, 'Having stories in multiple languages allows the children to hear and understand a story in their mother tongue first, then transition to German. It builds a bridge between home and school languages.' ASP2 added, 'Imagine a story being read in Arabic. Not only would it benefit the child who speaks that language, but it could also introduce other children to new cultures and languages.'

3.8. Promoting media literacy

Integrating picture-book apps into early education also offers an opportunity to promote media literacy alongside language development. As DaZ1 explained, 'When children use these apps, they learn that devices can be tools for learning, not just entertainment.'

Media literacy is essential for both children and parents to use digital media meaningfully. Educators contrasted active, accompanied, and story-oriented media engagement with passive video consumption. It is vital for children to understand that tablets are not only for entertainment but can also serve as learning tools when used purposefully, briefly, and with adult support.

Teacher1 emphasised the need for early media literacy education: 'We need to teach media literacy in kindergarten so children understand that tablets are not just for passive consumption but also for learning and creating. Many of our children have excessive passive screen time, often watching videos unaccompanied, which is concerning. They must explore a different side of media that supports learning.'

3.9. Educator training and professional development

Adequate educator training is essential to implement picture-book apps effectively. As ASP1 suggested, 'Short, focused training sessions would help educators understand how to incorporate these tools into their daily routines. Confidence in using the app is key to its success.'

For instance, using the app with a projector in an after-school care setting allows multiple children to participate in a shared read-aloud session. Moreover, understanding app features, such as pre-prepared questions designed to support dialogic reading, may help educators use the app as part of interactive language practice. Training in dialogic reading can equip educators with strategies for creating more engaged and socially mediated reading experiences when using picture-book apps.

Additionally, digital tools are still largely perceived as resources confined to school settings. Teachers often overlook the potential of these tools for use in homework assignments. This limitation is reflected in DaZ1's statement: 'We've used it more in station work but less for German language support due to limited time with the children.'

3.10. Results of children's questioning

The majority of children (62.5%) rated the app 5 on a scale of 1–5, indicating strong interest and enjoyment. Children expressed enthusiasm for the picture-book app and appreciated the autonomy to explore stories independently. Many mentioned specific books that they enjoyed, suggesting that personal interests may play a role in engagement and that app content should be adaptable to diverse preferences. These child responses provide descriptive evidence of interest, but they do not indicate learning effects.

3.11. Integrative mixed-methods synthesis

The mixed-methods integration suggests that the quantitative association between book openings and vocabulary gains should be understood in relation to contextual conditions of app use. Educators and parents repeatedly pointed to adult scaffolding, parental digital literacy, timing, child interest, and perceptions of screen media as factors that may influence whether children merely open books or engage with them meaningfully. These qualitative themes help explain why the same numerical usage indicator may reflect very different learning situations. For instance, a high number of book openings could indicate repeated dialogic reading with an adult, independent browsing, or brief switching between books; the available analytics cannot distinguish among these possibilities. At the same time, integration also reveals the limits of the available data: parental digital literacy, home literacy environment, language selected in the app, co-reading practices, and implementation fidelity were not measured quantitatively and could not be modelled as predictors of either app use or vocabulary gains. The findings therefore generate hypotheses about implementation conditions rather than demonstrating which factors caused the observed vocabulary changes.

4. Discussion

4.1. Theoretical implications

The observed vocabulary gains and the association between book openings and score changes are consistent with the idea that repeated, meaningful exposure to words embedded in stories can create opportunities for lexical growth (Hjetland et al., 2022). However, the findings do not confirm that the app itself produced the gains. Rather, book-opening frequency may reflect one component within a broader ecology of language exposure, adult mediation, and children's developing language abilities. This interpretation aligns with sociocultural theory and Vygotsky's notion of learning through guided participation. Educators' strategies of questioning and prompting mirror dialogic reading practices that have been associated with vocabulary development (Hidayatullah et al., 2023; Şimşek & Erdoğan, 2021). The theoretical implication is therefore conditional: digital picture books may matter when they become part of socially mediated literacy routines, not simply because they are available on a screen.

The multilingual affordances of the app also align with the view that home literacy practices and heritage language use can function as resources rather than barriers (Karpava et al., 2021; Turner et al., 2022). Qualitative comments suggested that access to stories in

children's first languages may help build bridges between home and school languages. Nevertheless, the present study did not systematically track which languages children selected, whether families read first in the home language and then in German, or whether patterns differed across language groups. The multilingual dimension should therefore be understood primarily as a contextual and pedagogical affordance identified by educators and parents, not as an analytically tested mechanism. Future studies should measure language selection directly if multilinguality is to be examined as an explanatory variable.

4.2. Relation to current research

The findings are compatible with meta-analytic evidence that e-books can support vocabulary development when embedded in interactive, socially mediated contexts (Egert et al., 2022; Savva et al., 2022). The observed correlation between the number of accessed books and vocabulary gains resembles patterns identified in research on digital storybooks and engagement (Bus et al., 2021; Christ et al., 2019). At the same time, the current study extends this discussion by showing how strongly such associations depend on implementation conditions that were visible in the qualitative data but not fully captured by the quantitative usage metric.

The qualitative findings also highlighted parental involvement and home literacy practices as both facilitators and barriers. This result is consistent with research showing that family engagement and heritage language practices shape multilingual children's language outcomes (Duursma et al., 2007; Turner et al., 2022). Concurrently, educators expressed concern about overexposure to digital media, echoing broader debates about balancing screen time with traditional literacy practices (Teichert, 2023). These insights reinforce the notion that digital interventions are not universally beneficial and must be carefully contextualised, accompanied, and embedded in broader literacy practices.

4.3. Alternative explanations and uncontrolled confounding

A central interpretive issue is that children who opened more books may have differed from children who opened fewer books in ways that were not measured. Higher book-opening frequency may reflect stronger parental involvement, more stable routines, easier access to devices, greater parental digital literacy, stronger home literacy environments, or higher child motivation. These factors could plausibly contribute both to more frequent book opening and to stronger vocabulary growth. Because the study did not include a control group, random assignment, multivariate covariate adjustment, or direct observation of home reading practices, the association between book openings and vocabulary gains cannot be disentangled from broader family-level and institutional influences. This is why the findings are interpreted as exploratory and hypothesis-generating rather than as evidence of app effectiveness.

4.4. Contribution of the study

The scholarly contribution of this study is therefore not a causal demonstration of app effectiveness or a claim of being the first study of its kind. Instead, the study contributes exploratory Swiss field evidence on how a multilingual picture-book app is used across early childhood and family contexts; it documents an association between a basic book-opening indicator and receptive-vocabulary growth; and it identifies implementation conditions that help explain why access to a digital multilingual library alone may be insufficient. This contribution is primarily hypothesis-generating and pedagogical: it points to the need for future controlled studies that combine

richer app analytics with measures of adult scaffolding, home literacy environment, language choice, screen-time routines, and implementation fidelity.

4.5. Practical and educational implications

Taken together, the findings suggest that digital picture-book apps may be useful resources when they are integrated into dialogic, socially mediated learning practices and when families are supported to use them meaningfully. The practical implication is not to increase unsupervised screen time, but to design short, purposeful, accompanied reading routines that replace passive media consumption rather than add to it. Educators and parents should be encouraged to use the app briefly, pause for conversation, ask questions, connect stories to children's experiences, and combine digital reading with print books, play, and non-screen activities. Professional development for educators, parent workshops to strengthen media literacy, and app designs with scaffolding features such as embedded questions and narration pauses may help transform app access into richer language-learning opportunities. Aligning with recommendations by Furenes et al. (2024), app-based activities should intentionally introduce novel vocabulary while remaining accessible to children from diverse linguistic and socioeconomic backgrounds.

4.6. Limitations and future directions

Several limitations must be acknowledged. First and most importantly, the study used a one-group pretest-posttest design without random assignment or a control group. The observed vocabulary gains therefore cannot be attributed to the app. Preschool children naturally develop vocabulary rapidly, and the three-month period may also have included other sources of language input, such as preschool instruction, DaZ support, sibling interaction, parent-child reading, and broader environmental exposure. The correlational analysis shows that children who opened more books tended to show larger gains, but it cannot disentangle book-opening frequency from family-level factors such as parental involvement, home literacy environment, educational resources, motivation, or access to technology. The results therefore do not justify causal statements such as "the app improved vocabulary" or "the intervention was effective."

Second, the sample was distributed across several institutions and settings, and children were therefore clustered within kindergartens, playgroups, mother-child German courses, and extended education institutions. To address possible non-independence, the main association was repeated with institution-clustered robust standard errors. The association remained positive, but this sensitivity analysis should be interpreted cautiously because the number of clusters was modest and cluster sizes were uneven. Third, the parent survey response rate was very low (10 of 69 eligible parents; 14.5%). Parent perspectives may therefore reflect the experiences of families who were more interested in literacy, technology, or education and should not be treated as representative of the full sample.

Fourth, the available app-usage proxy was measured only as the number of books opened. This indicator does not capture duration, completion, repeated reading, language selected, whether a book was listened to or only briefly opened, whether narration was used, or whether children used the app independently or with an adult. The four high-use cases also illustrate that extreme usage patterns may be substantively meaningful rather than mere statistical noise. Fifth, home implementation fidelity was not measured or standardised. Parents were instructed to use the app for at least 10 minutes per day, but the study could not verify how consistently this occurred,

how adults scaffolded the reading, or whether the activity replaced or complemented other literacy practices.

Sixth, the multilingual dimension was central to the framing of the study but was not examined systematically in the quantitative analyses. The study did not compare language groups, home-language practices, app-language choices, or children who used the app in their first language versus German. Future research should therefore collect app-language data and examine how multilingual reading sequences, such as first-language reading followed by L2 reading, relate to vocabulary outcomes. Finally, the three-month observational period did not include longitudinal follow-up, so no conclusions can be drawn about sustained language or literacy development.

Future studies should use randomised or well-matched comparison designs, larger and more representative parent samples, fidelity-tracking protocols, richer app analytics, and follow-up assessments. They should also include measures of home literacy environment, parental digital literacy, adult-child interaction during app use, app-language choice, and screen-time routines. Such designs would make it possible to test whether and under which conditions multilingual picture-book apps contribute to vocabulary development beyond natural developmental growth and existing language-support practices.

5. Conclusion

This exploratory mixed-methods study suggests that multilingual digital picture-book apps may offer language-learning opportunities for multi- and bilingual preschoolers when they are embedded in dialogic practices and supported by equitable access, adult scaffolding, and media literacy. The observed association between book openings and receptive-vocabulary gains is encouraging, but it should not be interpreted as evidence that the app caused the gains. Rather than stand-alone solutions, such tools are best understood as resources whose educational value depends on how they are integrated into home and educational routines. Realising this potential requires supporting educators, parents, and children to use digital media purposefully, briefly, critically, and interactively while avoiding the expansion of passive screen time.

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