Efficacy of Boukili Interactive Application in Enhancing French Reading Skills among Moroccan Fourth-Grade Students: A Quasi-Experimental Study

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***Abstract*—This study examines how the Boukili app enhances fourth-grade Moroccan students' French reading skills. Improving French proficiency is vital in Morocco because French remains a key language of higher education, commerce, and administration. The study employed a quasiexperimental design with an experimental group (*n* = 33) using Boukili—an interactive application with illustrated stories—and a control group (*n* = 35) following traditional methods per textbook. The intervention lasted 6 weeks. Both groups underwent pre- and post-test assessments on word decoding and reading comprehension skills. Statistical analyses were conducted using the Mann–Whitney U test and Student's t-test to compare the learning outcomes between the groups. Notably, integrating the Boukili app into the framework significantly improved word decoding skills and specific reading comprehension aspects, especially literal and inferential comprehension, in the experimental group, compared with the control group. Thus, appropriately incorporating digital tools such as Boukili into reading instruction can positively impact students' reading abilities.**

***Keywords*—French reading skills, Boukili, reading comprehension, word decoding, educational technology**

I. Introduction

Reading proficiency is a fundamental foundation for academic success, particularly fourth grade onward, when students transition from learning to read to reading to learn [1]. At this stage, insufficient reading ability limits learning in content areas requiring comprehension of written information. In Morocco, this challenge is compounded by the continued dominance of French as the primary medium of instruction in scientific and academic fields [2, 3]. International assessments such as PIRLS 2021 [4] have consistently noted critical gaps in French reading skills among Moroccan students, emphasizing the urgent need for effective and targeted pedagogical interventions [2, 5, 6].

Recent advances in digital learning indicate that technology can enhance reading instruction; however, research on digital reading tools in Moroccan primary classrooms remains scarce. Most research has focused on linguistic and instructional issues rather than technology-based interventions, and there is minimal evidence that assist practitioners in understanding how mobile applications support decoding or comprehension at the elementary level. This limited data is compounded by documented systemic weaknesses, including weak digital literacy policies, inadequate digital readiness among teachers, and typical difficulties in successfully integrating technology into daily classroom instruction [7].

Although Boukili is an existing digital reading application, this study advances previous research in remarkable ways. First, it examines the use of a mobile reading tool in a Moroccan public primary school setting where French is the second language and learners' exposure to it outside the classroom is limited. Second, instead of treating reading as a single outcome, the study explicitly distinguishes between word decoding and multiple facets of reading comprehension. Furthermore, by employing parametric and nonparametric statistical analyses, the research comprehends the specific reading skills enhanced through technology-supported practice and those that require additional instructional support.

Concurrently, this study investigates whether incorporating Boukili can enhance French reading competencies among fourth-grade learners. It specifically examines decoding and reading comprehension and compares the outcomes between a technology-supported intervention and traditional instruction. Therefore, the guiding research question is as follows:

To what extent does the integration of the Boukili app improve decoding and reading comprehension skills among fourth-grade students compared with conventional teaching methods?

Accordingly, we formulated the following two hypotheses:

- H1: Students in the experimental group using Boukili will demonstrate significantly greater improvement in word decoding than those in the control group.
- H2: Students in the experimental group will demonstrate significantly greater improvement in reading comprehension than those in the control group.

II. Literature Review

A. Theoretical Framework

The theoretical framework of the study combines the Simple View of Reading (SVR) [8], treating reading comprehension as the product of decoding and linguistic comprehension, with dual coding theory [9], underscoring the benefits of verbally and visually processing information. The multimedia format of Boukili draws on these principles for enhancing learning outcomes. Additionally, mobile-assisted language learning [10] supports the use of mobile technology for increased engagement and autonomy in French language education in Morocco. Overall, these frameworks justify the expected improvements in reading skills for the experimental group.

B. Reading's Foundational Role

Reading is crucial in early education for shaping young

learners' academic and personal development. In early school years, building strong reading skills is essential for excelling in class and helping children cultivate their thinking, language, and social-emotional abilities. Literacy and language begin developing long before formal schooling, with early exposure to books, storytelling, and verbal interaction playing a significant role in foundational development [11]. Research indicates that emergent literacy skills—phonological awareness, vocabulary, and narrative abilities—develop during preschool and kindergarten, establishing a foundation for future reading proficiency [12]. These early abilities provide children with necessary tools to succeed in reading and academics [13]. From kindergarten to second grade, children primarily engage in the "learning to read" phase, developing critical skills such as decoding, word recognition, and basic comprehension. These skills predict later academic achievement and are strongly correlated with reading motivation and overall confidence in learning tasks [14]. By third grade, reading tasks become more complex, and students should demonstrate greater independence in their reading. This year is a critical benchmark, considering third-grade reading proficiency strongly predicts high school graduation and long-term academic success [15].

C. Dual Reading Components

Reading skills must be developed and improved through practice. Furthermore, reading improves learners' vocabulary, reading comprehension, and critical thinking. Reading is understanding, but it is necessary to "exercise the mechanisms that allow comprehension, and first and foremost decoding" [16]. Thus, reading has two components: identifying and understanding written words.

Decoding and linguistic comprehension function independently and are crucial for understanding information. Struggling readers may experience comprehension difficulties because of weaknesses in either decoding or language skills, underscoring the relevance of both skills for successful reading [17]. Understanding a text goes beyond merely pronouncing the words; decoding a text is insufficient to grasp its meaning. Comprehension is only achieved when effective decoding is reached [18–20]. Considering the vitality of these foundational skills, early learning is essential. The primary responsibility for ensuring that children learn to decode letters accurately at a young age rests with parents and educators [21].

D. Role of Digital Tools in Reading Instruction

Owing to the increasing digitalization of reading materials, teachers must seek tools to teach reading in the new digital era. Technology offers valuable opportunities to enrich students' learning environments and personalize instruction. The digital revolution has fundamentally reshaped how students read, write, and access information [22].

Mobile technology, such as apps and iPads, offers interactive and engaging educational experiences that can enhance language learning in K-12 classrooms by enabling personalized learning addressing individual needs [23]. Specifically, mobile apps improve second-language reading comprehension and increase learner motivation [24]. These apps positively influence how foreign language learners acquire reading skills, with students often reporting positive attitudes and increased enthusiasm [25]. Furthermore, assistive reading tools equipped with read-aloud technology enhance comprehension, particularly among children with reading difficulties [26].

However, the effectiveness of digital tools is not universally established and is contextual, underscoring key areas of convergence and divergence within the research. Positive relationships are observed when students engage with digital devices for broad reading projects, with students often enjoying online reading tasks more than traditional lessons, yielding better knowledge acquisition [27]. Conversely, when digital activities focus solely on specific skills, such as vocabulary practice, the impact can be negative. Frequent use of digital devices in language arts classrooms is associated with lower overall scores on reading comprehension tests [28]. Despite mixed findings regarding certain skill-specific activities, digital technologies effectively enhance reading and writing skills, although this necessitates improved teacher training for optimal integration [29].

These digital tools can effectively help fourth-grade students learn French as a second language, particularly those requiring additional support to facilitate reading fluency or comprehension. This study contributes to literature by examining the effect of a specific digital reading application, Boukili, on the reading skills of Moroccan fourth-grade students.

E. Indispensable Role of the Educator

Effective instruction depends on the intentional guidance of a skilled teacher. Technology can help students practice basic skills but cannot replace the pivotal role of an educator [30, 31]. Deliberate and thoughtful teaching essentially develops complex literacy skills such as reading comprehension, requiring background knowledge, strong vocabulary, and verbal reasoning. Teachers support students in building these skills by using high-impact teaching strategies [32, 33].

III. Method

A. Participants

We conducted this study in an urban elementary school in Salé among 68 fourth-grade students: 33 and 35 in the experimental and control classes, respectively. The data was processed using SPSS to generate frequency and percentage tables as part of the descriptive statistical analysis. Tables 1 and 2 present the demographic details of the participants.

Table 1. Gender distribution

Gender	Control group		Experimental group	
	Frequency	%	Frequency	%
Male	17	48.57	**15**	45.45
Female	18	51.43	18	54.55
Total	35	100.00	33	100.00

Table 2. Age distribution

Age (years)	Control group		Experimental group	
	Frequency	%	Frequency	%
9	2	5.71	4	11.43
10	29	82.86	26	74.29
11	4	11.43	1	2.86
13	-	-	1	2.86
14	-	-	1	2.86
Total	33	100.00	35	100.00

B. Research Design

A pre-/post-test design was used to examine the effect of a technology-supported reading intervention on decoding and reading comprehension skills. The experimental group used digital reading materials and structured technological tools to improve reading practice, whereas the control group followed the standard textbook-based instruction in the French curriculum of the school. Both groups received instruction during the same period covering the same lesson objectives to ensure instructional consistency except the intervention method.

C. Instruments

A researcher-developed analytic rubric was used to evaluate students' decoding and reading comprehension performance across eight indicators (C1–C8) covering two main areas: word decoding/fluency (C1–C4) and reading comprehension (C5–C8) and were assessed using a five-point criterion-referenced scale, ranging from 1 (minimal acquisition) to 5 (mastery). The same reading tasks and rubric were administered as pre- and post-tests to measure progress over the intervention period. The analytic structure of the rubric examined specific reading subskills, targeted by the technological intervention, in detail.

Higher rubric scores reflected independent and accurate decoding, fluent pacing with appropriate phrasing, and successful literal and inferential comprehension, whereas lower scores were linked to frequent decoding errors, disrupted fluency, and partial or inaccurate understanding. To ensure consistent score interpretation across diverse learners and testing occasions, performance levels were linked to observable reading behaviors.

1) Description of Boukili

Boukili is an educational app offering stories appearing as text on screen with illustrations. The app runs on desktops, tablets, and mobile devices and allows easier access for children. Choosing Boukili was guided by the need for a mobile app that could effectively promote students' French reading habits while encouraging parental involvement (Fig. 1).

Fig. 1. Boukili app interface.

The platform offers several reading modes that meet different learner needs. In narration mode, students click an ear icon to listen to the text (Fig. 2). Repeated exposure to spoken language supports vocabulary growth and reading fluency. Solo mode allows students to read the text on their own, developing independence in reading. In voice-recording mode, students verbally read the text and record themselves. Students must ensure the recording is clear and audible. The platform allows students to repeat the task multiple times to improve accuracy and expression.

Fig. 2. Screenshot of the reading modes.

The app interface provides a dashboard for teachers that creates individual student profiles, assigns books to read, and registers each student's reading recordings. Additionally, it comprises a student section where learners can access their password-protected profiles. An avatar allows students to customize and dress up, making the activity more enjoyable.

After completing the necessary readings, the application presents quizzes to reinforce what the learners have learned. These repetitive exercises help learners actively retain new vocabulary and equip them to apply their knowledge across different contexts. As they read and progress, children travel to other countries or unlock games or accessories for their characters.

2) Development, alignment, and limitations of the assessment rubric

The authors developed the reading assessment rubric employed herein, representing a methodological limitation despite thorough piloting and reliability testing. Unlike standardized reading assessments, the rubric has not undergone extensive validation; consequently, findings should be interpreted with caution, particularly regarding their generalizability beyond the specific context of the study.

Therefore, the rubric was grounded in established reading constructs, assessing decoding accuracy, fluency, and comprehension for elementary French reading instruction. The analytic structure of the rubric reflects subskill-based scoring approaches frequently used in elementary reading assessment, wherein distinct reading components are evaluated separately rather than via a single composite score.

The rubric was piloted over 1 week with 12 fourth graders before the main study for clarity, developmental appropriateness, and descriptor functionality for each performance level. During the pilot, responses were scored with an early version of the rubric, revealing ambiguous descriptors and the need for refinement, particularly in decoding accuracy, fluency, and inference. Exemplar responses were created for consistency in scoring pre- and post-tests.

3) Inter-rater reliability procedures

To ensure the reliability of the assessment tool, inter-rater reliability was assessed after the piloting phase (over 1 week). Approximately 25% of the pilot sample was

independently scored by the researcher and a trained French literacy teacher using the revised rubric. Inter-rater reliability was assessed with Cohen's kappa coefficient, yielding κ = 0.82, indicating strong agreement between raters. Discrepancies were collaboratively discussed to improve descriptor interpretation and establish shared scoring standards. Therefore, a scoring guide with example responses was finalized and used throughout the study to ensure consistent and unbiased scoring across learners and testing occasions. Cohen's kappa was chosen because the analytic rubric evaluates multiple distinct performance areas rather than a single overall dimension, making inter-rater agreement the most appropriate measure of scoring reliability for this type of assessment.

D. Intervention Procedure

The intervention involved using Boukili during regular reading lessons for the experimental group over 6 weeks. Students accessed the app through individual accounts. Each week, students completed two texts that aligned with the curricular theme and their reading level. Sessions were held four times per week (approximately 100 min total) and combined supervised practice in class with independent reading outside of class. When individual devices were unavailable, students worked in pairs. Technical support and introductory guidance were provided during the 1st week to familiarize students with platform functions. Activities matched the reading modes of the app, including narration, individual reading, and voice-recording features. These options offered opportunities for repeated exposure, oral practice, and self-monitoring. The comprehension questions embedded in the platform were answered toward the end of each reading session. The control group received no additional instructional support beyond the standard curriculum and continued with textbook-based reading instruction provided by the same teacher.

E. Treatment

Students took pre- and post-tests to investigate the impact of using technology on their reading abilities. The pre- and post-test reading passage, titled "La forêt," was opted from the official fourth-grade French language textbook used in Moroccan public schools. The text comprised information about forests, including their usefulness to humans and animals, their ecological functions, and elements predominantly found in natural forest environments. This grade-appropriate authentic text served as the reading support for both testing occasions.

Students read the passage and answered specific questions to assess their reading skills. This step provided insight into the classroom environment before introducing the technology. The questions were concise and closed-ended.

The assessment covered two domains—word decoding and reading comprehension—each divided into subtests. word decoding comprised syllable reading, word reading, reading aloud fluently, and considering punctuation/linking/intonation.

The reading comprehension domain comprised illustrations to find test meaning, understanding significant text elements, identifying general themes with known words, and identifying with characters/making links. We employed a grid containing the targeted reading skills, divided into eight distinct indicators (C1–C8) and detailed in Table 3:

Table 3. Reading assessment indicators (The rubric)

Skill Area	Code	Competency Description
Word Decoding and Fluency	C1	Read Syllables Correctly
	C2	Decode Words Without Error
	C3	Read Aloud Fluently
	C4	Utilize Punctuation, Linking, and Intonation
Reading Comprehension	C5	Use Illustrations to Find Text Elements
	C6	Understand Significant Text Elements (Characters, Plot, and Setting)
	C7	Identify General Theme Using Known Words
	C8	Identify with Characters and Make Personal Connections

The pre- and post-test gradings were conducted using a five-point, criterion-referenced scale designed to measure the acquisition level for each competency. This scale ranged from 1 (Minimal Acquisition) to 5 (Mastery). The evaluation rubric and specific scoring criteria (Table 4) were developed exclusively for this study by the primary investigator. This methodological approach—using researcher-constructed measures to capture intervention-specific gains—is frequently employed in reading intervention research [34]. These tailored scales help researchers assess the real gains of students and provide insights that standardized tests might miss [35].

Table 4. General scoring criteria for the five-point scale

Score	Acquisition Level	General Performance Description
5	Mastery (M)	Consistently accurate, independent, and highly expressive performance; demonstrates immediate and deep understanding
4	Proficient (P)	Generally accurate with minor, occasional hesitations or errors (1 or 2 per 100 words), successfully self-corrected
3	Developing (D)	Performance is inconsistent; frequent hesitation or moderate errors (3–5 per 100 words), often requiring focused decoding or content prompting
2	Emerging (E)	Performance is laborious and disconnected; frequent and sustained errors impede meaning, requiring significant support
1	Minimal Acquisition (A)	Cannot perform the competency reliably; relies entirely on the assessor or fails to engage with the task

This table defines the acquisition level corresponding to each score on the five-point scale, universally applied across all eight indicators (C1–C8). This scale follows standard assessment practices. We used this analytic rubric, defining five performance levels from "Minimal Acquisition" to "Mastery," because this approach is strongly supported by foundational literature on effective rubric design for educational assessment [36]. Moreover, the specific descriptions in the table, focusing on quantifying performance elements such as hesitations, number of errors (1 or 2 per 100 words), and quality of expressive performance, directly align our instrument with the established criteria for a reliable, multicomponent reading fluency assessment [37]. This alignment ensures the scale is sensitive to the exact reading skills targeted by the intervention.

Exemplar student responses for each performance level were developed during piloting and used as scoring anchors to improve scoring transparency. For instance, a

mastery-level comprehension response accurately recalled key details and justified an inference, whereas an emerging-level response showed partial recall with an unsupported or incorrect interpretation. These exemplars supported consistent application of the rubric across indicators and testing occasions.

F. Statistical Analysis

To differentiate between the experimental and control groups and how they change over time, parametric and nonparametric analyses were conducted to boost confidence in the results. Initially, Levene's test was used to verify the assumption of equal variances. Because the scores were based on a five-point analytic scoring scale—although previous research often treats such combined rubric scores as roughly interval-level data in group comparisons—independent samples t-tests were used to compare post-test performance between groups and paired samples t-tests were used to assess within-group improvement from pre- to post-test.

Considering the scale is technically ordinal and some assumptions were not completely met, the Mann-Whitney U test was employed to ensure the robustness of the findings, particularly when assumptions such as homogeneity of variance were violated [38, 39]. Finally, effect size indices were used to measure the strength of differences and supplement significance tests.

IV. Results

A. Pretest Results

Before the intervention, no significant differences were observed between the experimental and control groups for most skills (C1–C8). Tables 5 and 6 present the pretest results for all skills for the control and experimental groups, respectively.

The results of the independent samples t-test for the pretest revealed no significant differences in the assessed skills between the control and experimental groups. Levene's test of equality of variances was insignificant; thus, the t-test for samples was applied. All p-values (Sig. two-tailed) were >0.05, indicating that the mean differences in pretest scores across all skills were negligible and the two groups had comparable initial levels before the intervention (Appendix A, Table A1).

Table 5. Pretest results (Control group)

Skills	Male		Female		Total	
	Sum	Mean	Sum	Mean	Sum	Mean
Word Decoding	147.00	8.65	137.00	7.61	284.00	8.11
Reading Comprehension	88.00	5.18	85.00	4.72	173.00	4.94
Total Score	235.00	13.82	222.00	12.33	457.00	13.06

Table 6. Pretest results (Experimental group)

Skills	Male		Female		Total	
	Sum	Mean	Sum	Mean	Sum	Mean
Word Decoding	100.00	6.67	180.00	10.00	280.00	8.48
Reading Comprehension	68.00	4.53	90.00	5.00	158.00	4.79
Total Score	168.00	11.20	270.00	15.00	438.00	13.27

B. Post-Test Results

After the intervention, results indicated significant improvements in various skills, particularly in word decoding of the experimental group (C1–C4). Tables 7 and 8 demonstrate post-test results for the control and experimental groups, respectively.

Independent samples t-tests indicated that skills C1–C4 demonstrated significant improvements in the experimental group compared with the control group, with $p < 0.05$, indicating a positive effect on word decoding skills (Appendix A, Table A2).

For reading comprehension skills (C5–C8), only skill C7 (identifying the general theme) showed a significant difference between the two groups, whereas C5, C6, and C8 did not show statistically significant improvements.

Table 7. Post-test results (Control group)

Skills	Male		Female		Total	
	Sum	Mean	Sum	Mean	Sum	Mean
Word Decoding	171.00	10.06	161.00	8.94	332.00	9.49
Reading Comprehension	101.00	5.94	97.00	5.39	198.00	5.66
Total Score	272.00	16.00	258.00	14.33	530.00	15.14

C. Nonparametric Analysis

Because heterogeneity of variance was detected in two comprehension skills (C7 and C8), Mann-Whitney U test was performed to validate the t-test findings. The analysis indicated a statistically significant difference solely for skill C7, with U = 710.00 and $p = 0.031$, demonstrating higher ranks for the experimental group, substantiating that the Boukili intervention notably enhanced students' capacity to identify the global theme of a text.

Skill C8, pertaining to personal identification with characters or correlating the text to personal experience, did not exhibit a statistically significant difference ($p > 0.05$), corroborating the t-test results. The nonparametric analysis concludes that only C7 experienced a comprehension benefit attributable to the intervention.

Table 8. Post-test results (Experimental group)

Skills	Male		Female		Total	
	Sum	Mean	Sum	Mean	Sum	Mean
Word Decoding	148.00	9.87	245.00	13.61	393.00	11.91
Reading Comprehension	89.00	5.93	128.00	7.11	217.00	6.58
Total Score	237.00	15.80	373.00	20.72	610.00	18.48

D. Paired Samples T-tests

The paired samples t-tests revealed significant improvements in the experimental group for all skills (C1–C8), confirming that using Boukili helped students enhance their performance from pre- to post-test. Indeed, the sample pairs for the test comprise the grades for each skill in the pre- and post-tests (Appendix A, Table A3).

V. Discussion

Digital tools such as Boukili enhance word decoding skills (C1–C4) in fourth-grade students. These findings align with previous research demonstrating that interactive technologies improve reading performance through engaging and repetitive activities [24, 27–29]. Using Boukili enabled students to strengthen these skills through regular practice and immediate feedback, consistent with literature [33] on the impacts of tablets in elementary schools.

In contrast, the effectiveness of technology on reading comprehension skills (C5–C8) was limited, except for C7

(identifying the general theme). This pattern of results can be meaningfully interpreted through the SVR, conceptualizing reading comprehension as the product of decoding and linguistic comprehension (RC = D × LC) [40, 41]. Accordingly, successful reading requires accurate and fluent word recognition and the ability to understand and integrate language meaning [40, 41].

Herein, Boukili strengthened the decoding component (D), as reflected in gains on C1–C4, but provided fewer opportunities to develop LC processes, such as vocabulary expansion, activation of prior knowledge, and inferential reasoning. Consequently, the intervention addressed only one comprehension component. This interpretation aligns with review evidence indicating that mobile literacy applications often focus on word-level processing rather than supporting higher-level comprehension [24]. This imbalance between D and LC explains why more complex comprehension skills did not significantly improve compared with the control group. Although repetitive digital practice supports automaticity in word recognition, it does not foster the higher-order comprehension abilities, typically requiring interaction, guided questioning, and contextualized discussion, on its own [32].

From a pedagogical perspective, these findings indicate that digital tools such as Boukili are most effective when used to support decoding practice, while teacher-led instruction helps develop higher-order comprehension skills. In classroom practice, teachers can combine app-based decoding activities with guided discussions, vocabulary instruction, and inferential questioning using the same texts. This approach allows technology to reinforce foundational skills while teachers scaffold the meaning-making processes essential for reading comprehension.

These findings align with a previous study [42], which stressed that comprehension involves advanced cognitive processes, such as interpreting meaning and engaging in critical analysis. This converges with a previous study [43], which confirms weak performance in reading comprehension skills among Arabic learners.

Overall, digital tools should be incorporated into a broader educational framework wherein teachers are key figures, providing the linguistic and strategic support that is not sufficiently developed through app-based work alone. This interpretation aligns with recent reviews demonstrating that mobile literacy apps tend to improve decoding more consistently than language comprehension [24, 27, 44]. Herein, digital interventions focused primarily on decoding requirements in combination with explicit, teacher-led work on meaning-making if broader gains are to be achieved in reading comprehension, a conclusion consistent with review evidence on mobile literacy apps [24].

Overall, these findings contribute to the broader field by demonstrating how digital reading interventions impact different literary aspects. Most research notes overall gains in reading ability but rarely differentiates decoding from comprehension. Herein, technology-supported programs can improve foundational skills while requiring teacher-led instruction to develop deeper comprehension. This distinction clarifies the evidence and emphasizes the relevance of integrated teaching models wherein digital tools support—rather than replace—meaning-focused instructions, particularly by targeting the LC component highlighted in the SVR.

Finally, using Boukili stimulated students' motivation to read, a common effect observed in interactive environments. In the literature [45], digital platforms offering virtual rewards and playful elements increase students' intrinsic motivation to engage in their activities. Such increases in motivation are particularly relevant to the literature [46], demonstrating that digital resources with gamified features enhance motivation and help overcome learning difficulties. Although technology has shown positive results, this study reaffirms the relevance of human intervention in reading instruction. The literature [47] underscored that technology cannot replace teachers, particularly in complex skills such as reading comprehension. A balanced approach that combines technology with teacher involvement is, to our knowledge, the most effective way to maximize reading outcomes.

The primary limitation of this study is its small sample size (N = 68, including 33 students in the experimental group). Although the statistical analyses reveal significant effects within this sample, the small sample size reduces statistical power and increases the risk of unreliable or inflated estimates. The relevance of sample size is particularly evident for skills demonstrating only marginal or inconsistent improvement, as a larger sample can yield more accurate and reliable results. Moreover, because the research was conducted in a single urban public school, the findings cannot be generalized to the wider population of Moroccan fourth-grade students. Schools across Morocco substantially differ in linguistic backgrounds, access to digital resources, teacher qualifications, and classroom conditions, all of which could influence the effectiveness of digital reading interventions. Therefore, future research should include larger, more diverse samples from multiple schools and regions to enhance external validity. Another limitation involves the use of a researcher-developed rubric to assess decoding and reading comprehension. Although the instrument was based on established literacy frameworks and involved pilot testing and inter-rater reliability checks to improve its validity and consistency, it remains a nonstandardized measure. Therefore, the observed gains should be interpreted within the scope of this specific rubric and may not directly reflect performance on national or international standardized reading assessments. Future studies should improve generalizability by combining this rubric with standardized tests or validating the instrument across larger, more diverse populations.

VI. Conclusion

This study demonstrates that mobile-assisted reading instruction can differentially influence reading subskills in a second language context. Specifically, the integration of Boukili enhances word decoding skills (C1–C4) in fourth-grade students through engaging and repetitive activities, aligning with previous research on interactive technologies. However, the impact of digital tools on reading comprehension (C5–C8) was limited because direct instruction, classroom discussion, and parental support are required for deeper cognitive processes. Only the ability to identify the general theme (C7) showed significant improvement. This key distinction between decoding and

comprehension outcomes is the main contribution of the study, as it emphasizes how mobile reading apps affect different parts of reading in varying ways.

Moreover, Boukili increased students' motivation to read because of gamified learning. However, methodologically, the small sample size hinders the generalizability of the results. Furthermore, teacher and parental involvement remains essential, particularly for developing comprehension skills, underscoring the need for a balanced approach integrating technology with direct instruction and home support.

VII. Appendix

A. Detailed Statistical Analyses

Table A1. Independent samples T-test of skills scores in the pretest

Skills		Levene Test for Homogeneity of Variances	Test T for Equal Means							
		F	Sig.	*t*	*df*	Sig. (2-tailed)	Mean Difference	Standard Deviation Difference	Confidence Interval with 95%	
									Lower	Upper
C1	Equal Variances Assumed	0.288	0.593	−1.071	66	0.288	−0.281	0.262	−0.803	0.242
	Inequal Variances Assumed	-	-	−1.068	64.569	0.289	−0.281	0.263	−0.805	0.244
C2	Equal Variances Assumed	0.077	0.782	−0.161	66	0.872	−0.042	0.263	−0.568	0.483
	Inequal Variances	-	-	−0.161	65.977	0.872	−0.042	0.263	−0.567	0.482
C3	Equal Variances Assumed	0.662	0.419	−0.321	66	0.749	−0.075	0.234	−0.543	0.393
	Inequal Variances Assumed	-	-	−0.320	64.391	0.750	−0.075	0.235	−0.545	0.394
C4	Equal Variances Assumed	0.077	0.782	0.145	66	0.885	0.028	0.191	−0.354	0.409
	Inequal Variances Assumed	-	-	0.145	65.589	0.885	0.028	0.191	−0.354	0.409
C5	Equal Variances Assumed	2.507	0.118	1.120	66	0.267	0.231	0.206	−0.181	0.643
	Inequal Variances Assumed	-	-	1.127	64.534	0.264	0.231	0.205	−0.178	0.641
C6	Equal Variances Assumed	0.763	0.386	−0.390	66	0.698	−0.039	0.100	−0.238	0.161
	Inequal Variances Assumed	-	-	−0.387	59.856	0.700	−0.039	0.101	−0.240	0.163
C7	Equal Variances Assumed	1.123	0.293	−0.526	66	0.600	−0.034	0.064	−0.162	0.094
	Inequal Variances Assumed	-	-	−0.523	61.518	0.603	−0.034	0.065	−0.163	0.095
C8	Equal Variances Assumed	0.014	0.905	−0.060	66	0.953	−0.003	0.058	−0.119	0.112
	Inequal Variances Assumed	-	-	−0.060	65.491	0.953	−0.003	0.058	−0.119	0.112

Table A2. Independent samples T-test of skills scores in the post-test

Skill		Levene Test for Homogeneity of Variances	Test T for Equal Means							
		F	Sig.	*t*	*df*	Sig. (2-tailed)	Mean Difference	Standard Deviation Difference	Confidence Interval with 95%	
									Lower	Upper
C1	Equal Variances Assumed	0.053	0.819	−2.124	66	0.037	−0.584	0.275	−1.134	−0.035
	Inequal Variances Assumed	-	-	−2.131	65.841	0.037	−0.584	0.274	−1.132	−0.037
C2	Equal Variances Assumed	0.230	0.633	−2.071	66	0.042	−0.587	0.283	−1.153	−0.021
	Inequal Variances Assumed	-	-	−2.075	65.993	0.042	−0.587	0.283	−1.152	−0.022
C3	Equal Variances Assumed	0.225	0.637	−2.446	66	0.017	−0.638	0.261	−1.159	−0.117
	Inequal Variances Assumed	-	-	−2.445	65.691	0.017	−0.638	0.261	−1.159	−0.117
C4	Equal Variances Assumed	0.003	0.957	−2.741	66	0.008	−0.614	0.224	−1.061	−0.167
	Inequal Variances Assumed	-	-	−2.733	64.379	0.008	−0.614	0.225	−1.063	−0.165
C5	Equal Variances Assumed	0.273	0.603	−0.891	66	0.376	−0.212	0.238	−0.687	0.263

	Inequal Variances Assumed	-	-	−0.891	65.555	0.376	−0.212	0.238	−0.688	0.264
C6	Equal Variance Assumed	1.254	0.267	−1.310	66	0.195	−0.208	0.159	−0.525	0.109
	Inequal Variances Assumed	-	-	−1.305	63.519	0.197	−0.208	0.159	−0.526	0.110
C7	Equal Variances Assumed	21.094	0.000	−2.330	66	0.023	−0.281	0.121	−0.522	−0.040
	Inequal Variances Assumed	-	-	−2.296	50.625	0.026	−0.281	0.123	−0.527	−0.035
C8	Equal Variances Assumed	12.365	0.001	−1.729	66	0.089	−0.217	0.126	−0.468	0.034
	Inequal Variances Assumed	-	-	−1.693	42.202	0.098	−0.217	0.128	−0.476	0.04

Table A3. Paired samples test

Pairs of Competency Samples		Paired Differences					*t*	*df*	Sig. (two-tailed)
		Mean	Standard Deviation	Mean Standard Error	95% CI of Diff				
					L	Upper			
Pair 1	C1	0.818	0.392	0.068	0.679	0.957	12.000	32	0.000
Pair 2	C2	1.030	0.394	0.069	0.891	1.170	15.019	32	0.000
Pair 3	C3	0.848	0.442	0.077	0.692	1.005	11.036	32	0.000
Pair 4	C4	0.727	0.517	0.090	0.544	0.911	8.085	32	0.000
Pair 5	C5	0.758	0.502	0.087	0.580	0.936	8.671	32	0.000
Pair 6	C6	0.455	0.506	0.088	0.275	0.634	5.164	32	0.000
Pair 7	C7	0.333	0.479	0.083	0.164	0.503	4.000	32	0.000
Pair 8	C8	0.242	0.561	0.098	0.044	0.441	2.484	32	0.018

*CI of Diff: Confidence Interval of the Difference.

CONFLICT OF INTEREST

The authors declare no conflict of interest.

AUTHOR CONTRIBUTIONS

H.E.M. conducted the research and performed the data analysis. Y.N. supervised the study and provided guidance throughout the research process. All authors had approved the final version.

REFERENCES

[1] J. Toste and S. Ciullo, "Reading and writing instruction in the upper elementary grades," *Interv. Sch. Clin.*, vol. 52, pp. 259–261, May 2017. https://doi.org/10.1177/1053451216676835

[2] A. Azennoud, K. Lamghari, and A. Guaad, "The impact of French as a medium of instruction on academic access and performance in Moroccan higher education," *Moroccan Journal of Quantitative and Qualitative Research*, vol. 7, no. 3, 2025.

[3] B. Chakrani, A. Ziad, and A. Lachkar, "Paradoxes of language policy in Morocco: Deconstructing the ideology of language alternation and the resurgence of French in STEM instruction," *Languages*, vol. 10, no. 6, p. 135, June 2025. https://doi.org/10.3390/languages10060135

[4] I. V. S. Mullis, M. von Davier, P. Foy, B. Fishbein, K. A. Reynolds, and E. Wry. (2023). PIRLS 2021 international results in reading. *TIMSS & PIRLS International Study Center, Boston College, Chestnut Hill*. [Online]. Available: https://pirls2021.org/results/

[5] F. Zhang, C. Jin, and C. Fan, "Factors influencing students' reading literacy in Morocco: A multilevel analysis," *Humanit. Soc. Sci. Commun.*, vol. 11, no. 1, 1056, Aug. 2024. https://doi.org/10.1057/s41599-024-03575-4

[6] H. Zeghli, "Challenge of learning French in Morocco: A study of reading skills," *Int. Uni-Sci. Res. J. Humanit. Soc. Sci.*, vol. 5, pp. 25–29, 2024. https://doi.org/10.59271/s45451.024.2233.5

[7] S. Boubih, M. B. Mesaoud, and Z. E. Atmani, "Optimizing alternate teaching with flipped classroom: Teachers' perspectives," *Multidisciplinary Science Journal*, 2025.

[8] P. B. Gough and W. E. Tunmer, "Decoding, reading, and reading disability," *Remedial Spec. Educ.*, vol. 7, no. 1, pp. 6–10, Jan. 1986. https://doi.org/10.1177/074193258600700104

[9] J. M. Clark and A. Paivio, "A dual coding perspective on encoding processes," in *Imagery and Related Mnemonic Processes*, M. A. McDaniel and M. Pressley, Eds., New York, NY: Springer New York, 1987, pp. 5–33. https://doi.org/10.1007/978-1-4612-4676-3_1

[10] P. Guo, J. J. Jeyaraj, and A. B. Razali, "A systematic review of Collaborative Mobile-Assisted Language Learning (C-MALL) practices using bibliometric, content, and scientometric analyses," *Humanit. Soc. Sci. Commun.*, vol. 11, no. 1, 1435, Oct. 2024. https://doi.org/10.1057/s41599-024-03940-3

[11] M. M. Neumann, "Young children's use of touch screen tablets for writing and reading at home: Relationships with emergent literacy," *Comput. Educ.*, vol. 97, pp. 61–68, 2016. https://doi.org/10.1016/j.compedu.2016.02.013

[12] T. Shanahan and C. J. Lonigan, "The national early literacy panel: A summary of the process and the report," *Educ. Res.*, vol. 39, no. 4, pp. 279–285, June 2010. https://doi.org/10.3102/0013189X10369172

[13] C. S. Brown and H. College, "Language and literacy development in the early years: Foundational skills that support emergent readers," *Lang. Lit. Spectr.*, vol. 24, pp. 35–49, 2014.

[14] C. M. Connor, F. J. Morrison, B. J. Fishman, C. Schatschneider, and P. Underwood, "Algorithm-guided individualized reading instruction," *Science*, vol. 315, no. 5811, pp. 464–465, Jan. 2007. https://doi.org/10.1126/science.1134513

[15] L. Fiester, "Early warning confirmed: A research update on third-grade reading," *The Annie E. Casey Foundation*, 2013.

[16] D. Gaonac'h and C. Golder, *Reading and Understanding: The Psychology of Reading*, Hachette éducation, 2015. (in French)

[17] L. C. Ehri, "Learning to read words: Theory, findings, and issues," *Sci. Stud. Read.*, vol. 9, no. 2, pp. 167–188, Apr. 2005. https://doi.org/10.1207/s1532799xssr0902_4

[18] E. Riquois, "Developing reading competence in Fresnch as a foreign and second language," in *Proc. 2nd World Congress of French Linguistics, La Nouvelle-Orléans, Etats-Unis: EDP Sciences*, 2010. (in French)

[19] N. K. Duke, A. E. Ward, and P. D. Pearson, "The science of reading comprehension instruction," *Read. Teach.*, vol. 74, no. 6, pp. 663–672, May 2021.

[20] M. R. Y. Huo, P. Koh, Y. Cheng, S. H. Marinova-Todd, and X. Chen, "The simple view of reading in French second language learners," *Learn. Individ. Differ.*, vol. 92, 102082, Dec. 2021.

[21] D. A. Kilpatrick, "The article that introduced the simple view of reading," *Read. Leag. J.*, vol. 1, no. 2, p. 13, 2020.

[22] N. S. Baron, "Reading in a digital age," *Phi Delta Kappan*, vol. 99, no. 2, pp. 15–20, Oct. 2017. https://doi.org/10.1177/0031721717734184

[23] J.-F. Eubanks, H.-T. Yeh, and H. Tseng, "Learning Chinese through a twenty-first century writing workshop with the integration of mobile technology in a language immersion elementary school," *Comput. Assist. Lang. Learn.*, vol. 31, no. 4, pp. 346–366, May 2018.

[24] B. Klimova and K. Zamborova, "Use of mobile applications in developing reading comprehension in second language acquisition—A review study," *Educ. Sci.*, vol. 10, no. 12, 391, Dec. 2020. https://doi.org/10.3390/educsci10120391

[25] A. T. Shofi and W. Jannah, "Developing mobile learning application as instructional media for reading comprehension," *Al-Lisan*, vol. 7, no. 2, pp. 198–224, Aug. 2022. https://doi.org/10.30603/al.v7i2.2739

[26] G. Schiavo, N. Mana, O. Mich, M. Zancanaro, and R. Job, "Attention-driven read-aloud technology increases reading comprehension in children with reading disabilities," *J. Comput. Assist. Learn.*, vol. 37, no. 3, pp. 875–886, June 2021. https://doi.org/10.1111/jcal.12530

[27] K. Chitthathur and S. Venugopal, "The use of mobile apps to enhance reading skills of language learners: A review," *J. Hum. Res. Rehabil.*, vol. 13, no. 1, pp. 31–37, Apr. 2023.

[28] L. Salmerón, C. Vargas, P. Delgado, and N. Baron, "Relation between digital tool practices in the language arts classroom and reading comprehension scores," *Read. Writ.*, vol. 36, no. 1, pp. 175–194, Jan. 2023. https://doi.org/10.1007/s11145-022-10295-1

[29] J. M. F. Batanero, M. M. Rueda, J. F. Cerero, and P. R. Gravan, "Impact of ICT on writing and reading skills: A systematic review (2010–2020)," *Texto Livre Ling. E Tecnol.*, vol. 14, no. 2, e34055, July 2021. https://doi.org/10.35699/1983-3652.2021.34055

[30] F. Mahini, Z. J.-A. Forushan, and F. Haghani, "The importance of teacher's role in technology-based education," *Procedia-Soc. Behav. Sci.*, vol. 46, pp. 1614–1618, 2012. https://doi.org/10.1016/j.sbspro.2012.05.348

[31] T. N. Fitria, "The use of Artificial Intelligence in Education (AIED): can AI replace the teacher's role?" *EPIGRAM E-J.*, vol. 20, no. 2, pp. 165–187, Oct. 2023. https://doi.org/10.32722/epi.v20i2.5711

[32] N. K. Duke, A. E. Ward, and P. D. Pearson, "The science of reading comprehension instruction," *Read. Teach.*, vol. 74, no. 6, pp. 663–672, May 2021. https://doi.org/10.1002/trtr.1993

[33] S. Vaughn and J. Fletcher, "Explicit instruction as the essential tool for executing the science of reading," *The Reading League Journal*, vol. 2, no. 2, p. 4, 2022.

[34] V. L. C. Angub *et al.*, "Multimodal reading program to aid san mateo national high school's Grade 7 students in improving reading competency," *J. Except. Multidiscip. Res.*, vol. 2, no. 2, pp. 1–7, July 2025. https://doi.org/10.69739/jemr.v2i2.710

[35] R. Gersten, L. S. Fuchs, J. P. Williams, and S. Baker, "Teaching reading comprehension strategies to students with learning disabilities: A review of research," *Rev. Educ. Res.*, vol. 71, no. 2, pp. 279–320, June 2001. https://doi.org/10.3102/00346543071002279

[36] S. M. Brookhart, *How to Create and Use Rubrics for Formative Assessment and Grading*, ASCD, 2013.

[37] T. V. Rasinski, D. R. Reutzel, D. Chard, and S. Linan-Thompson, "Reading fluency," *Handbook of Reading Research,* Volume IV, Routledge, p. 34, 2011.

[38] P. H. Grawe, "Applied mathematics in the humanities: Review of nonparametric statistics for the behavioral sciences by sidney siegel and N. John Castellan, Jr. (2nd ed., 1988)," *Numeracy*, vol. 9, no. 1, Jan. 2016. https://doi.org/10.5038/1936-4660.9.1.7

[39] A. Field, *Discovering Statistics Using IBM SPSS Statistics*, 6th ed., SAGE Publications, 2024.

[40] W. A. Hoover and P. B. Gough, "The simple view of reading," *Read. Writ.*, vol. 2, no. 2, pp. 127–160, June 1990. https://doi.org/10.1007/BF00401799

[41] L. Verhoeven and J. V. Leeuwe, "The simple view of second language reading throughout the primary grades," *Read. Writ.*, vol. 25, no. 8, pp. 1805–1818, Nov. 2011. https://doi.org/10.1007/s11145-011-9346-3

[42] J. Oakhill, K. Cain, and B. Nesi, "Understanding of idiomatic expressions in context in skilled and less skilled comprehenders: Online processing and interpretation," *Sci. Stud. Read.*, vol. 20, no. 2, pp. 124–139, Mar. 2016.

[43] Y. Laajan, S. Dehhane, and B. Nachit, "Impact of weak reading comprehension skills on language usage," *IJTPE*, vol. 16, no. 2, pp. 44–50, June 2024.

[44] B. Fernandez-Gauna, N. Rojo, and M. Graña, "Automatic feedback and assessment of team-coding assignments in a DevOps context," *Int. J. Educ. Technol. High. Educ.*, vol. 20, no. 1, p. 17, Mar. 2023. https://doi.org/10.1186/s41239-023-00386-6

[45] C.-M. Hung, I. Huang, and G.-J. Hwang, "Effects of digital game-based learning on students' self-efficacy, motivation, anxiety, and achievements in learning mathematics," *J. Comput. Educ.*, vol. 1, pp. 151–166, Nov. 2014. https://doi.org/10.1007/s40692-014-0008-8

[46] S. El Bakkali, M. Serghini, M. Barkatou, and H. Nebdi, "Gamification and mathematics: Playing for better learning," *IJTPE J.*, vol. 15, no. 4, pp. 189–197, Dec. 2023.

[47] O. Segal-Drori, O. Korat, A. Shamir, and P. S. Klein, "Reading electronic and printed books with and without adult instruction: effects on emergent reading," *Read. Writ.*, vol. 23, no. 8, pp. 913–930, Sep. 2010. https://doi.org/10.1007/s11145-009-9182-x

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