

## Gamified digital exercises to enhance reading literacy in Kazakhstani primary schools

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### ABSTRACT

Recent national and international large-scale assessment results indicate persistent difficulties in higher-order reading comprehension among Kazakhstani primary school students. Although reading literacy (RL) is a strong predictor of academic success, existing instructional practices do not consistently support the development of advanced comprehension skills, and empirical evidence on technology-supported reading instruction in the Kazakh-language context remains limited. This study evaluated a technology-enhanced instructional framework integrating curriculum-aligned gamified digital exercises (GDE) into Grade 4 Kazakh language lessons. A quasi-experimental pre-test/post-test control group (CG) design was employed with 100 fourth-grade students. The experimental group (EG) participated in a six-week intervention implemented under typical classroom information and communication technologies (ICT) constraints, while the CG received traditional instruction. The results demonstrated significantly greater improvements in overall RL in the EG, with large effect sizes, particularly in higher-order comprehension tasks involving inference and information integration. A strong positive correlation was found between gains in RL and reading motivation. These findings suggest that curriculum-aligned gamified digital activities can effectively enhance both cognitive and motivational dimensions of reading development in resource-constrained primary education settings.

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## 1. INTRODUCTION

Modern reading literacy (RL) is a crucial component of functional literacy and a key outcome of modern education. Insufficient functional literacy in contemporary societies significantly limits individuals' educational, social, and professional opportunities [1]. Developing functional literacy early, starting in elementary school, is essential. Young students spend considerable time interacting with teachers and peers, which allows schools to provide meaningful learning experiences [2], [3]. Schools, through diverse instructional methods and organizational strategies, offer important opportunities to develop students' RL, including the pedagogically grounded integration of information and communication technologies (ICT) [4]. RL is widely recognized as a strong predictor of future academic success [5]–[7].

Evidence from the Progress in International Reading Literacy Study (PIRLS) shows that students who develop effective reading strategies in primary school achieve higher outcomes across language-related

domains [8], [9]. Kazakhstan participated in PIRLS for the first time in 2016. PIRLS 2021 results indicate that only 39% of students reached an intermediate proficiency level, and the national average declined by 32 points over the past five years [10], [11]. These results highlight persistent difficulties in higher-order processes such as inference, evaluation, and integration of information. This underscores the need for instructional approaches beyond basic decoding [12]–[14]. The performance gap relative to Organisation for Economic Co-operation and Development (OECD) peers points to systemic limitations in instructional practices and access to authentic Kazakh-language reading materials [15]. Analyses of PIRLS data reveal persistent difficulties with complex text comprehension, understanding implicit meaning, and interpretation. Limited vocabulary, challenges with polysemantic expressions, and underdeveloped metacognitive skills constrain independent reading abilities [16]–[18].

Research increasingly emphasizes instructional tools that combine gamification, instant feedback, and interactivity, such as Wordwall, LearningApps, and Quizizz [19], [20]. Meta-analyses indicate that these tools enhance learner motivation and support lexical and grammatical development [21]. However, most studies focus on students in East Asian and European contexts with high ICT availability [22]. Empirical research addressing reading instruction in Kazakh under constrained ICT conditions remains extremely limited [23]–[25]. Moreover, existing studies rarely examine both cognitive outcomes (RL) and affective outcomes (reading motivation) together [26]–[30].

In Kazakhstan, where Kazakh is taught from the early grades, there is little evidence on the effectiveness of interactive digital tasks as part of an instructional framework for early RL development. Classroom observations and prior reports, corroborated by PIRLS data, indicate that by the fourth grade, students' text comprehension in Kazakh remains insufficient, limiting their academic success and engagement with authentic texts. The effectiveness of short but frequent gamified digital exercises (GDE) under ICT constraints has not been established. It is also unknown how such interventions affect both cognitive and motivational outcomes. Addressing this gap, the present study proposes a structured instructional framework integrating GDE into primary school reading instruction under typical classroom ICT constraints, including limited infrastructure, restricted screen time, and the absence of custom educational software. Specifically, the study aims to answer the following research questions:

- To what extent does the integration of the framework with GDE improve primary school students' RL under typical classroom ICT constraints? (RQ1)
- To what extent does the framework enhance students' reading motivation compared with traditional instructional approaches among Grade 4 students? (RQ2)

The purpose of the study is to evaluate the effects of the instructional framework integrating GDE on RL and reading motivation among Kazakhstani primary school students, providing empirically grounded insights for educators on the use of gamified digital tools in resource-constrained classrooms. This study adopts an educational program evaluation perspective by examining the framework as a structured intervention implemented under authentic school conditions. The object of evaluation is the instructional framework integrating GDE into Grade 4 Kazakh language instruction. The evaluation is guided by two primary criteria: instructional effectiveness, assessed through measurable changes in RL and reading motivation, and implementation feasibility under typical classroom ICT constraints, including limited infrastructure, restricted screen time, and the absence of specialized software. The findings are intended to inform teachers, curriculum developers, and educational policymakers seeking evidence-based strategies for strengthening RL in resource-constrained educational systems.

## 2. THE COMPREHENSIVE THEORETICAL BASIS

RL plays a central role in primary education, underpinning learners' academic achievement, self-regulation, and engagement with learning processes [31]. RL encompasses decoding, vocabulary knowledge, and higher-order comprehension processes. These components enable learners to decode written symbols and map them onto semantic representations, which are closely interrelated during early literacy development [32]. Consequently, systematic development of reading skills in primary school is widely recognized as foundational for learners' cognitive, linguistic, and educational growth [33]. International attention to early reading instruction has been reinforced by large-scale assessments such as PIRLS, which underscore the importance of foundational reading skills for later academic success and lifelong learning [34]. Instructional models that emphasize gradual skill development, from decoding to higher-level comprehension, are particularly relevant for younger learners.

The simple view of reading (SVR) model conceptualizes reading comprehension as the interaction between decoding and language comprehension, and it has received substantial empirical support across diverse educational contexts [35]. Research further indicates that effective primary reading instruction should extend beyond phonetic skills to include explicit teaching of reading strategies, such as identifying main

ideas, making inferences, and monitoring comprehension [36]. Developmental theory suggests that children aged six to nine are typically in the concrete operational stage, which limits abstract reasoning and emphasizes the importance of visual supports, contextual cues, and scaffolded learning activities [37]. Instructional approaches incorporating multimodal input, structured tasks, and guided practice are therefore particularly well suited to this developmental stage. Prior research suggests that these activities are most effective when integrated into regular classroom instruction and aligned with curriculum objectives, rather than used as standalone technological solutions [38]. In reading instruction, GDE have been associated with improvements in vocabulary, text comprehension, and reading fluency. Gamification elements, including points, feedback, and task-based challenges, have been shown to foster positive attitudes toward reading and sustain engagement among young learners.

### 3. METHOD

#### 3.1. Study design

This study employed a quasi-experimental pre-test/post-test control group (CG) design to evaluate the effectiveness of a technology-enhanced instructional framework in improving RL and learner motivation among fourth-grade students [39]. The study was conducted under authentic school conditions to reflect routine instructional practice. Random assignment was not feasible due to administrative and organizational constraints within the school; therefore, intact classes were used. While this approach may introduce potential selection bias, baseline equivalence between the experimental group (EG) and the CG was examined using pre-test measures and demographic characteristics prior to the intervention. No statistically significant differences were identified at baseline, suggesting initial comparability between groups. This design preserved ecological validity while allowing for structured comparison and reasonable control of baseline equivalence.

#### 3.2. Collection of research samples

The study was conducted at School-Gymnasium No. 38 in Almaty, Kazakhstan. A total of 100 fourth-grade students participated in the study, including 50 students in the EG and 50 in the CG. The sample size of 100 was chosen based on class availability and to ensure sufficient statistical power (approximately 0.80) for detecting medium effect sizes (Cohen's  $d=0.5$ ). The participants' ages ranged from 9 to 10 years ( $M=9.8$ ,  $SD=0.3$ ), as shown in Table 1. Initial language proficiency was assessed using a school-based A1-level diagnostic aligned with Grade 4 curriculum standards. The test included 20 multiple-choice items and short writing tasks assessing vocabulary, reading comprehension, and basic grammar. Parental/guardian consent obtained.

Table 1. Participant characteristics

Characteristic	EG	CG	Total
Age (years, mean±SD)	9.8±0.3	9.8±0.3	9.8±0.3
Gender (M/F, %)	24/26 (48%/52%)	24/26 (48%/52%)	24/26 (48%/52%)
Weekly hours studying Kazakh (mean±SD)	4.2±0.5	4.2±0.5	4.2±0.5
Initial language proficiency (A1 scale, mean±SD)	15.2±3.1	15.0±2.9	15.1±3.0

#### 3.3. Procedure

The study was conducted over six weeks, from January 15 to March 1, 2024, following approval from the Directorate of Education in Almaty, Kazakhstan. Participants were assigned to the EG and CG based on existing class structures rather than randomization. All teachers involved in the study held the qualification category of teacher-moderator and had at least three years of experience teaching Kazakh in primary education. Prior to the intervention, they received a two-hour training session on the use of GDE to ensure consistent implementation across classes. Teachers followed the same curriculum guidelines and lesson plans approved at the school level. In line with school regulations and ICT constraints, screen time per lesson was limited to 20 minutes in accordance with primary school digital use recommendations to prevent cognitive overload. In the EG, GDE were integrated into regular Kazakh language lessons, primarily targeting RL. Each of the 12 thematic units included 2–3 digital tasks, designed to reinforce vocabulary, grammar, and comprehension. Tasks were implemented via widely accessible online platforms and included interactive formats such as matching, gap-fill, word search, and short quizzes. Completion was monitored by teachers through in-platform tracking and class discussion feedback. The CG followed the standard curriculum using traditional instructional methods.

### 3.4. Intervention

The intervention was implemented over a six-week period (12 sessions), with GDE integrated into regular Grade 4 Kazakh language lessons twice per week. The intervention aligned with Grade 4 Kazakh language curriculum objectives and targeted key components of RL through culturally and linguistically relevant gamified digital tasks. All activities followed a standardized structure across classes to ensure implementation consistency. The intervention structure is summarized in Table 2.

Table 2. Intervention design

Aspect	Details
Digital platforms and Exercise types	Wordwall, LearningApps, Quizizz, matching, gap-fill, word search, multiple-choice quizzes
Lesson integration	Activities embedded at introduction, main phase, and closure
Frequency and duration	2–3 exercises per lesson, delivered twice weekly (4–6 activities per week), with screen time limited to 20 minutes
Grouping	Individual, pairs, small groups

### 3.5. Instruments

Two instruments were used to assess the outcomes of the intervention: a reading literacy assessment (RLA) and an adapted motivation for reading questionnaire (MRQ). Both instruments demonstrated satisfactory reliability and validity. Details, including constructs, format, adaptation, and psychometric properties, are summarized in Table 3.

Table 3. Assessment instruments

Instrument	Framework	Constructs/categories	Items	Scale	Reliability/validity	Adaptation/context
RLA	PIRLS; SVR	BU—literal comprehension (Pictures and T/F) WU—vocabulary recognition (Match words ↔ pictures) DRC—inference, main ideas, integration (Gap-fill and multiple-choice)	30	Correctness (1=correct, 0=incorrect)	KR-20=0.82; construct validity evidenced by theoretically consistent subscale structure	Adapted to Kazakh; expert-reviewed; age-appropriate; curriculum-aligned and transfer tasks
MRQ	Wigfield and Guthrie (1997)	Interest, confidence, and engagement in reading activities	12	4-point Likert scale	Cronbach's $\alpha=0.91$ ; construct validity grounded in established theoretical framework and prior validation studies	Linguistically and contextually adapted to Kazakh classrooms and GDE activities

Note: basic understanding (BU), word understanding (WU), and deep reading comprehension (DRC).

In this evaluation, the RLA served as the primary cognitive outcome measure because it was aligned with PIRLS frameworks and the SVR model, reflecting internationally recognized constructs of RL. Its alignment with curriculum objectives and higher-order comprehension processes made it appropriate for assessing intervention-related changes in students' reading performance. The MRQ functioned as the primary affective outcome measure, enabling the evaluation of changes in students' interest, confidence, and engagement in reading. Given the established relationship between reading motivation and comprehension development, inclusion of the MRQ allowed the study to assess both cognitive and motivational dimensions of the instructional framework. Both instruments were used strictly as summative outcome measures administered at pre-test and post-test. They were not employed for formative classroom assessment during the intervention, ensuring that observed changes reflect overall program impact rather than formative measurement influences.

### 3.6. Data analysis

Table 4 summarizes the data analysis methods applied at various stages of the study. These methods were selected to ensure both the accuracy and reliability of the results. Additionally, appropriate statistical tests were applied to identify significant patterns and relationships within the data.

Table 4. Data analysis methods

Analysis component	Statistical method	Notes/Metrics
Pre- and post-test Comparison	Paired-sample t-test	Mean $\pm$ SD, t-value, p-value; within-group changes (EG and CG)
Between-group comparison	Independent-samples t-test on post-test scores	Cohen's d for effect size; compares EG vs CG post-test means
RLA analysis (part-wise)	Paired and independent t-tests per category	Categories: BU, WU, DRC; Mean $\pm$ SD, t-value, p-value, Cohen's d; post-test scores used for between-group comparison
Reading motivation	Descriptive statistics and t-tests (paired and independent)	Mean $\pm$ SD per subscale and total score; statistical tests performed
Correlation between RL and motivation	Pearson or Spearman correlation	r-value, p-value; correlation for total scores and subscales; Spearman used if normality assumptions not met
Assumptions and reliability	Shapiro–Wilk (normality), Levene's test (homogeneity), KR-20, and Cronbach's $\alpha$	Normality, variance equality, internal consistency coefficients
Significance level	–	$\alpha=0.05$

#### 4. RESULTS

As shown in Table 5, the EG showed substantial improvement in overall RL, while gains in the CG were minimal. The observed effect sizes indicate that the instructional intervention had a very large practical impact on the EG's RL. In contrast, the CG exhibited only modest gains, reflecting minimal natural improvement. The between-group comparison further suggests that the experimental intervention provided a substantial advantage over standard teaching practices. Similar patterns were observed for part-wise RL and motivational outcomes, with the EG showing notable improvements across subdomains and affective measures, whereas the CG's gains remained limited.

Table 5. Overall RL scores

Group	Pre-test (M $\pm$ SD)	Post-test (M $\pm$ SD)	t	p	Cohen's d
EG	17.4 $\pm$ 3.2	25.1 $\pm$ 2.8	16.5	<0.001	2.1
CG	17.6 $\pm$ 3.1	18.9 $\pm$ 3.0	3.1	0.004	0.4
Between-group (post-test)	–	–	10.7	<0.001	2.1

Table 6 shows that the EG outperformed the CG across all RL components at post-test. The largest effects were observed in the gap-fill and multiple-choice tasks, which reflect higher-order comprehension processes, whereas gains in the CG remained minimal across all test parts. Across subcomponents, the observed effect sizes indicate consistently large to very large practical improvements, particularly in tasks requiring deeper comprehension. Overall, the pattern of results suggests that the intervention was especially effective in promoting higher-order comprehension processes, rather than only surface-level decoding skills, highlighting its practical significance in enhancing students' RL.

Table 6. Part-wise RL scores

Test part	EG Pre-test (M $\pm$ SD)	EG Post-test (M $\pm$ SD)	CG Pre-test (M $\pm$ SD)	CG Post-test (M $\pm$ SD)	t	p	Cohen's d
1. Pictures and T/F (5)	3.1 $\pm$ 1.0	4.4 $\pm$ 0.6	3.2 $\pm$ 1.1	3.4 $\pm$ 1.0	6.0	<0.001	1.2
2. Match words $\leftrightarrow$ pictures (5)	3.5 $\pm$ 0.9	4.6 $\pm$ 0.5	3.6 $\pm$ 1.0	3.8 $\pm$ 0.9	5.5	<0.001	1.1
3. Gap-fill (10)	5.6 $\pm$ 2.1	8.2 $\pm$ 1.4	5.7 $\pm$ 2.0	6.1 $\pm$ 1.8	6.5	<0.001	1.3
4. Multiple-choice (10)	5.2 $\pm$ 1.9	7.9 $\pm$ 1.3	5.1 $\pm$ 2.0	5.5 $\pm$ 1.9	7.3	<0.001	1.5

Note: Parts 1–2 assess BU and WU; Parts 3–4 assess DRC.  $\Delta$ =Post-test–Pre-test.

As shown in Table 7, students in the EG demonstrated substantially higher post-test reading motivation compared with the CG. The magnitude of the observed difference suggests a strong practical effect, indicating that the intervention contributed not only to cognitive improvements but also to enhanced affective engagement with reading. As illustrated in Figure 1, motivation levels increased consistently in the EG following the intervention, whereas changes in the CG remained limited. These findings suggest that the instructional framework effectively supports both motivational development and reading achievement, reinforcing the overall effectiveness of the program. The results highlight the practical significance of the affective gains, demonstrating meaningful improvements in learners' engagement and attitudes toward reading.

Table 7. Reading motivation (MRQ) scores

Group	Pre-test (M±SD)	Post-test (M±SD)
EG	3.2±0.4	4.1±0.3
CG	3.3±0.5	3.5±0.4

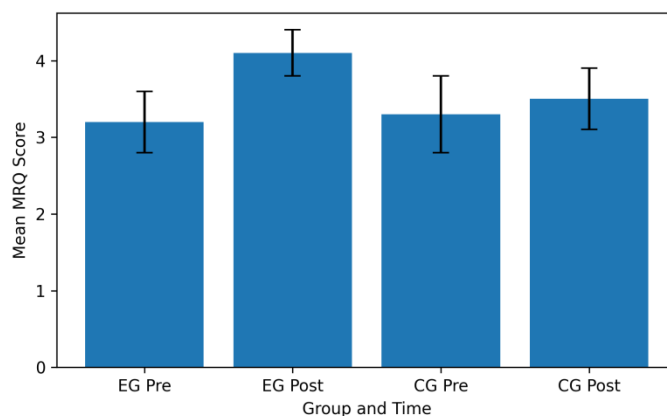


Figure 1. MRQ scores for the EG and the CG at pre- and post-test

## 5. DISCUSSION

The present study explored how the instructional framework with GDE influenced RL and reading motivation among Grade 4 students, highlighting practical improvements achieved through the intervention. Students who participated in the GDE-based intervention demonstrated significantly greater improvements in both RL and motivation compared with peers receiving traditional instruction. Gains were most pronounced in higher-order comprehension tasks, such as inference-making and integration of information. These results suggest that interactive digital activities with immediate feedback effectively support complex reading processes that are often challenging for young learners.

These findings align with prior research showing that gamified and interactive digital instruction enhances reading comprehension and learner engagement [40]–[43], while extending this evidence to the underexplored Kazakh language context [44]–[49]. The results contribute to the limited empirical evidence on technology-supported reading instruction in Kazakh, demonstrating that GDE can enhance both cognitive and motivational outcomes. In addition to cognitive gains, the EG exhibited increased motivation across interest, confidence, and engagement dimensions, highlighting the potential for structured digital activities to foster positive affective responses to reading. The parallel improvements observed in RL and motivation suggest that cognitive and affective outcomes may develop together within well-designed digital learning environments.

While causal conclusions are limited by the quasi-experimental design, the findings indicate a meaningful association between structured digital practices and improved reading outcomes. Several limitations should be acknowledged. First, the quasi-experimental design without random assignment introduces potential threats to internal validity, including possible selection bias and uncontrolled contextual influences, despite baseline equivalence between groups. Second, the study was conducted in a single school with a modest sample size, which constrains external validity and limits generalizability to broader educational contexts. Third, the relatively short duration of the intervention restricts conclusions about the long-term sustainability of observed gains. Finally, although the instruments demonstrated satisfactory reliability, they were administered only at pre- and post-test, limiting the ability to capture dynamic changes in learning trajectories over time.

From a broader evaluation and policy perspective, the findings have implications for curriculum monitoring and resource allocation in primary education. The demonstrated improvements in higher-order comprehension suggest that structured digital supplementation may serve as an effective evaluative indicator of curriculum responsiveness to contemporary literacy demands. For ICT investment decisions, the results indicate that meaningful learning gains can be achieved using widely accessible, low-cost digital platforms rather than requiring advanced technological infrastructure. This is particularly relevant for resource-constrained educational systems seeking cost-effective strategies to enhance literacy outcomes. Furthermore, the framework was implemented by regular classroom teachers following brief orientation, suggesting that large-scale adoption would not require extensive professional retraining. Instead, targeted professional

development focused on pedagogically grounded digital integration may be sufficient. Collectively, these considerations position the instructional framework not only as an effective classroom strategy but also as a feasible and scalable intervention model within constrained educational contexts.

## 6. CONCLUSION

This study provides evidence that the instructional framework integrating GDE can effectively enhance RL and motivation among Grade 4 students in a Kazakhstani primary school, demonstrating the potential for structured digital practices in routine classroom settings. The findings provide evidence that measurable improvements in both RL and motivation were observed using accessible, curriculum-aligned digital tools implemented within routine classroom practice. Beyond documenting instructional gains, the study highlights the value of integrating cognitive and affective outcome measures in program evaluation, thereby supporting more comprehensive evidence-based decision-making in primary education. The observed large practical effects suggest that even modest pedagogically structured enhancements, such as GDE, can yield meaningful educational benefits without requiring extensive infrastructural investment. Although the results should be interpreted within the limitations of a single-site quasi-experimental design, the framework demonstrates potential transferability to similar resource-constrained contexts where scalable, low-cost literacy interventions are needed. Future research should examine long-term sustainability and broader implementation across diverse educational settings.

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## AUTHOR CONTRIBUTIONS STATEMENT

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C : **C**onceptualization

M : **M**ethodology

So : **S**oftware

Va : **V**alidation

Fo : **F**ormal analysis

I : **I**nvestigation

R : **R**esources

D : **D**ata Curation

O : **O**riting - **O**riginal Draft

E : **E**riting - **R**eview & **E**ditting

Vi : **V**isualization

Su : **S**upervision

P : **P**roject administration

Fu : **F**unding acquisition

## CONFLICT OF INTEREST STATEMENT

Authors state no conflict of interest.

## DATA AVAILABILITY

The corresponding author may provide study data upon reasonable request.

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