Constructivist approaches for knowledge construction in gamified reading environments

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This study developed a game called iRead by integrating the principles of constructivist learning theory with Högberg et al.'s (2019) gamification dimensions to enhance reading comprehension and knowledge construction among higher education students. It investigated how learners' interactive and contextual experience factors contribute to knowledge construction and explored students' perceptions of the features of iRead in this process. This study used a mixed methods design, collecting quantitative and qualitative data from 90 university students. The quantitative data were collected through pretests and post-tests and subjected to regression analyses; the qualitative data were obtained through semi-structured interviews. The results indicated that iRead significantly improved the students' reading performance. Regression analysis results indicated that interactive and contextual experience variables significantly affected knowledge construction, with collaborative learning having the strongest influence. Three key themes were identified through thematic analysis of the interview data: active engagement through interactivity, cognitive development through critical thinking and problem-solving and autonomy in self-regulated learning. These findings highlight the potential of gamified environments based on constructivist learning theory to promote self-directed and collaborative knowledge construction. This study provides practical implications for educators and instructional designers and recommends future research directions.

Implications for practice or policy:

- Educators can enhance student engagement and reading comprehension by using gamified tools that integrate collaboration, authentic contexts and reflection.
- Policymakers and administrators should prioritise digital infrastructure and training to enable scalable adoption of gamified, constructivist learning environments.

Keywords: constructivist learning theory (CLT) model, interactive learning environment, contextual experiences, gamification, reading comprehension, gamified reading environment

Introduction

Reading comprehension is a fundamental ability that supports knowledge construction and meaningful learning. It involves complex cognitive processes that enable readers to form coherent mental representations of textual information (Butterfuss et al., 2020). Reading is not only a cognitive process but also a multisensory and affective experience that contributes to deeper knowledge creation (Aldana Hernández, 2025). Moreover, as a fundamental skill for academic success, reading comprehension promotes higher-order thinking, strengthens communication abilities and contributes to professional development and personal growth (Bektosheva, 2024). Effective reading comprehension relies on strategic approaches, including cognitive and metacognitive strategies such as predicting, questioning,

summarising, inferring, visualising and monitoring, as well as contextual factors such as learning styles, motivation, teaching methods and teacher support (Suhaila et al., 2025). However, insufficient reading strategies (Holandyah et al., 2024), limited background knowledge (Silaban et al., 2025) and inadequate teacher training (Rezaee et al., 2025) have been consistently reported as major obstacles to the development of reading comprehension skills. To address these challenges and enhance long-term reading comprehension, educators need to adopt adaptive and differentiated instructional approaches that actively engage learners and support effective knowledge construction across diverse texts and disciplinary contexts (Apiles, 2025).

Technological advancements and evolving pedagogical theories have contributed to a shift from teacher-centred models to student-centred paradigms in contemporary education (Bhardwaj et al., 2025; Shehata et al., 2024). Active learning strategies (Gamo, 2022), such as group discussions and collaborative problem-solving, have been shown to enhance engagement and learning outcomes across disciplines such as language learning, anatomy and information literacy, even in brief sessions (Dogani, 2023; Quadir et al., 2024). Student-centred learning (SCL) fosters a critical–reflective understanding and facilitates personalised instruction, helping learners achieve higher-order mastery. This pedagogical evolution serves as a foundation for detailed theoretical frameworks, such as constructivist learning theory (CLT; O'Connor, 2022), which further support the shift towards active student-centred learning approaches.

CLT provides a robust framework for fostering active engagement, inquiry and reflection, positioning learners as active participants who construct meaning through exploration and interaction (Nurhuda et al., 2023). In CLT-driven classrooms, teachers facilitate inquiry-based learning, guiding students to connect new knowledge with prior understanding (Chand, 2025). On the basis of this pedagogical foundation, game-based learning (GBL) complements CLT by translating its principles into immersive, interactive learning experiences. Aligned with CLT, GBL has emerged as a powerful approach for improving interactivity and learning efficiency (Wang et al., 2023). Both CLT and GBL emphasise learner autonomy, authentic contexts and collaborative tasks that promote knowledge construction (Marougkas et al., 2023).

Although studies have confirmed the effectiveness of game-based reading interventions (Kavlu, 2015; Ronimus et al., 2014) and the value of CLT in educational games (Yew & O'Kearney, 2017), they have not integrated CLT into gamification frameworks for knowledge construction. Careful attention to game design elements is crucial for ensuring pedagogical coherence (Casañ Pitarch, 2017). In particular, the application of Högberg et al.'s (2019) seven dimensions of gamification (accomplishment, challenge, competition, immersion, guidance, playfulness and social experience) within reading comprehension contexts remains under-explored. To address this gap, the present study developed iRead, a gamified reading application based on CLT and Högberg et al.'s gamification dimensions. The iRead game supports students' comprehension of course-related content – such as visual storytelling concepts, methods and portfolio development in Digital Media Art – through interactive game-based questions that assess disciplinary understanding. This study investigated the effect of iRead on reading performance, examined how interactive learning factors and contextual experiences facilitate knowledge construction and explored students' perceptions of the features of iRead during knowledge construction.

The research questions examined in this study are outlined as follows:

1. To what extent does iRead improve students' reading performance?
2. How do interactive learning factors within iRead predict students' knowledge construction?
3. How does the contextual experience of iRead predict students' knowledge construction?
4. What are students' perceptions of how gamified features in iRead influence their motivation to construct knowledge through reading comprehension?

Literature review

CLT

CLT, which is based on cognitive psychology, sociocultural theory and educational philosophy, was developed in the 1970s (Chuang, 2021; Muhajirah, 2020). Piaget (1954/2013) emphasised the role of active engagement in fostering learners' cognitive development, and Vygotsky (1978) focused on the sociocultural context of learning, introducing the concept of the zone of proximal development. The theoretical insights provided by these researchers repositioned educators as facilitators who support students in constructing knowledge through reflective, meaningful engagement (Nurhuda et al., 2023).

According to CLT, learning is an active, subjective process influenced by prior knowledge and experience (Shehata et al., 2024). It emphasises a shift from teacher-centred to student-centred education (Bhardwaj et al., 2025), where learners construct knowledge through engagement, social interaction and real-world tasks (Nurhuda et al., 2023). This approach supports evolving educational models such as problem-based and collaborative learning, fostering peer-driven cognitive development (Zajda, 2021, Chapter 3). CLT promotes autonomy, critical thinking, creativity and problem-solving in real and simulated settings (Nurhuda et al., 2023).

CLT can provide a theoretical foundation for analysinghow gamified tools, such as iRead, promote knowledge construction. The next section describes how active learning, which is central to constructivist pedagogy, enhances engagement, collaboration and contextual understanding, thus directly informing the research questions.

Enhancing knowledge construction through active and contextual learning in constructivist education

CLT sees students as active learners who build their own understanding (Matriano, 2020). Instead of just receiving information from the teacher, students learn through participation, interaction and reflection. Active learning operationalises CLT through interactive learning, which emphasises active engagement, diversity of experiences, access to varied learning resources and collaborative learning. Activities such as group discussions, role-plays, case studies and simulations embed meaningful interaction into the learning process, promoting engagement, collaboration cooperation and improved learning outcomes (Kiesler, 2025). Supported by both traditional and digital tools, these strategies enhance learner autonomy, critical thinking and collaborative competence (Marougkas et al., 2023). Empirical evidence consistently associates active engagement with deeper knowledge construction, as learners co-construct understanding through social interaction with peers and instructors within inclusive learning environments (Chuang, 2021). Moreover, interactive learning extends beyond participation to encompass diverse experiences and resource-rich environments. Engagement in varied activities and reflective practices strengthens motivation, autonomy, teamwork and experimentation (Lombardi et al., 2021). Exposure to diverse learning resources broadens perspectives and stimulates intellectual curiosity, while collaborative learning further develops problem-solving abilities, communication skills and emotional growth (Xu et al., 2024).

Contextual experience, encompassing authentic contexts and reflection, constitutes a central dimension of CLT, linking theoretical knowledge to meaningful real-world application. Authentic contexts enhance knowledge construction by connecting abstract concepts to learners' lived experiences, thereby strengthening comprehension and retention (Chen & Hwang, 2022; Marougkas et al., 2023). Learning situated in real-life or simulated scenarios promotes practical competence, collaborative problem-solving and sustained engagement (Purba et al., 2024), while fostering holistic cognitive, emotional and behavioural involvement (Purba et al., 2024). Accordingly, instructional strategies should align academic content with learners' realities to support deeper and more durable understanding (Hwang & Nurtantyana, 2022). Reflection complements contextual learning by enabling critical examination of experiences, identification of knowledge gaps and refinement of learning strategies. Through reflective

processes, learners transform experience into meaningful understanding, thereby reinforcing autonomy and self-regulated learning (Mohammed & Kinyo, 2020).

Together, active engagement, contextual experience and reflection operationalise the core principles of CLT, facilitating the transition from abstract knowledge to practical application. These principles provide a strong pedagogical foundation for integrating authentic, context-rich learning environments into gamified systems that aim to support sustained knowledge construction.

Gamified learning tools, GBL and effectiveness

Recent studies have shown that gamified learning tools can enhance student engagement and learning outcomes through motivational and feedback mechanisms (Quadir et al., 2027). For example, Khalid et al. (2026) found that students using the gamified tool Anatomy Cluedo achieved significantly higher cognitive learning gains, with engagement strongly correlated with learning outcomes. Similarly, Bruggink et al. (2025) reported that students who voluntarily used a gamified e-learning platform achieved higher exam scores, indicating that gamification can encourage productive learning behaviours. At the system level, Li and Wang (2025) analysed 22 gamified learning monitoring systems and found a moderate positive relationship among gamification, student engagement and academic achievement. In addition, Sari (2025) examined gamified tools such as Quizizz, Kahoot, Pear Deck and Nearpod and reported improvements in English reading comprehension among first-year university students. Consistently, Doria et al. (2025) found that gamification significantly improves reading comprehension.

Developments in information technology have led to the increasing use of digital games for entertainment and educational purposes (Kaimara et al., 2021). GBL integrates educational content into interactive experiences, enhancing student interest, participation and understanding (Dahalan et al., 2024).

Early educational games were limited and often disconnected from real-life contexts (Wasserman & Banks, 2017). However, advancements in technology and pedagogy have resulted in GBL evolving into a powerful pedagogical strategy that offers authentic contexts and immediate feedback, thereby enhancing intrinsic learning motivation (Asmawati, 2023). Contemporary GBL promotes interactive settings that support knowledge retention and performance (Dahalan et al., 2024). Consequently, educators are increasingly adopting GBL to enhance teaching effectiveness (Karakoç et al., 2022). For example, GBL supports the learning of vocabulary and spelling through engaging repetition, sparking curiosity and meaningful learning (Camacho-Sánchez et al., 2024). In reading education, GBL improves learning motivation, task completion and comprehension (Bjørner et al., 2022). GBL tools such as Kahoot and GraphoLearn enhance reading skills, especially for struggling learners (Ronimus et al., 2019; Sari, 2025). Moreover, GBL offers innovative approaches for enhancing critical reading skills in contexts where traditional methods are less effective (Joaquin & Imbat, 2024). It moderately improves fluency and comprehension but substantially enhances cognitive and emotional engagement (Ronimus et al., 2019). Overall, GBL effectively combines interactivity, motivation and contextual learning to support diverse educational outcomes.

Relationship between CLT and GBL

With rapid advancements in information technology, education is shifting from teacher-centred to student-centred models, representing both conceptual and practical transformations (Bhardwaj et al., 2025; Shehata et al., 2024). CLT underpins this shift, emphasising knowledge construction through active and contextual learning. Furthermore, GBL has become an interactive, engaging learning strategy aligned with CLT principles (Wang et al., 2023). Both GBL and CLT emphasise learner agency, with CLT considering learning as active meaning-making (Zajda, 2021, Chapter 3) and GBL promoting participation through motivating gameplay (Martín-Hernández et al., 2021). They also underscore the importance of contextualised learning, with CLT advocating real-world relevance (Chuang, 2021) and GBL offering authentic, challenge-based scenarios (Chukusol et al., 2024)

Research has confirmed the strong relationship between CLT and GBL. CLT fosters interactive, student-centred experiences that align with the principles of GBL (Li & Zhang, 2025), and GBL offers collaborative, constructivist learning platforms (Camacho-Sánchez et al., 2024). Studies have demonstrated that GBL enhances skills such as computational thinking through problem-solving and project-based methods and that it is effective in various contexts, including museums, where it boosts learning engagement and outcomes (Dahalan et al., 2024; Li & Zhang, 2025). Meta-analyses have revealed that constructivism has been increasingly used as a theoretical basis for designing GBL (Wu et al., 2012).

Both CLT and GBL emphasise collaboration; CLT focuses on peer interaction and cognitive growth (Dada et al., 2023), and GBL highlights teamwork, competition and social dynamics, which foster interpersonal skills (Fonseca et al., 2023; Marougkas et al., 2023). Thus, CLT and GBL form a synergistic educational framework that blends theory and practice to promote adaptive, inclusive and meaningful learning.

Gameplay architecture and mechanics of iRead

The game developed in this study, namely iRead, integrates Högberg et al.'s (2019) seven dimensions of gamification (i.e., accomplishment, challenge, competition, guidance, immersion, playfulness and social experience) in a manner that closely aligns with the core principles of CLT. CLT emphasises active, contextualised, social and reflective learning, where learners actively construct knowledge through meaningful engagement, social interaction and self-reflection (Hein, 1991). iRead aims to improve reading performance and support knowledge construction through interactive learning, contextual reading tasks and gamified features that enhance engagement, motivation and deeper cognitive processing.

The accomplishment dimension supports knowledge construction by providing progressive levels and clear goals or milestones that foster self-regulated learning and a sense of accomplishment (Erhel & Jamet, 2013). These achievement markers encourage learners to reflect on their progress and consolidate their understanding (Figure 1). The challenge dimension, which is implemented through time-limited and content-specific tasks, contributes to authentic contexts by engaging learners in problem-solving activities that mirror real-world cognitive demands, thus promoting knowledge transfer (Marougkas et al., 2023) (Figure 2).



Figure 1. Levels and goals in iRead

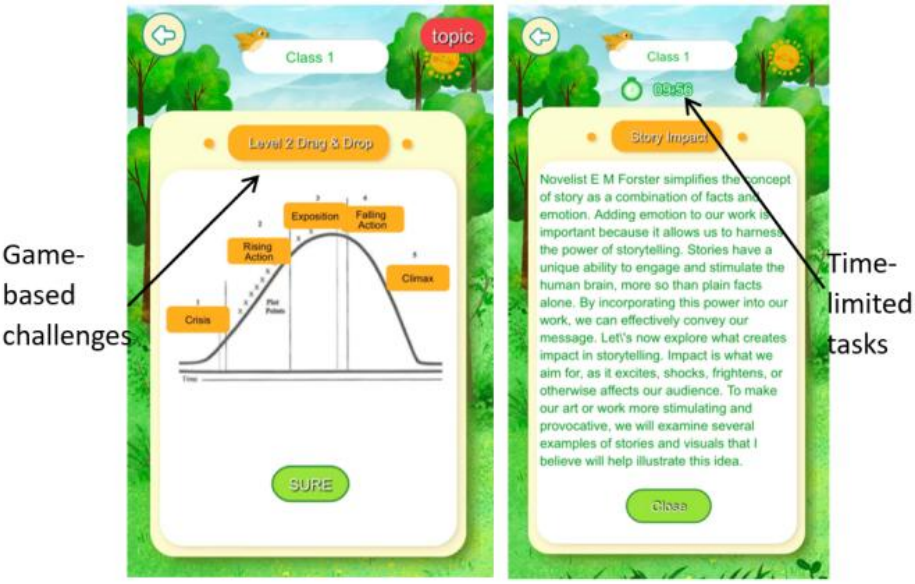


Figure 2. Reading comprehension task with a time constraint

The competition dimension, which is implemented through leaderboards, fosters social interaction and collaborative engagement by motivating learners through progress benchmarking and healthy rivalry (Nebel et al., 2017). Research has revealed that competitive and group-based activities can enhance engagement (Alghamdi & Holland, 2017) (Figure 3). The developed game offers online competitive quizzes that promote mastery of relevant knowledge. The guidance dimension is implemented through colour-coded indicators and level-based prompts, which act as scaffolding tools. These tools support knowledge construction and help learners regulate their progress, thus aligning with CLT's emphasis on guided discovery (Hmelo-Silver, 2004) (Figure 4).



Figure 3. Students' rankings in each class

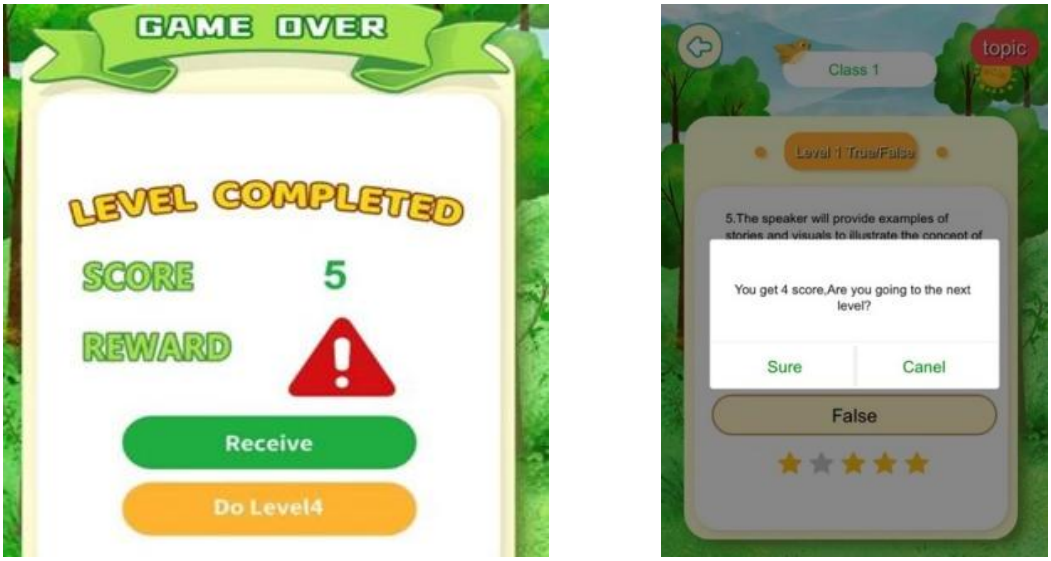


Figure 4. Level completion and score feedback

The immersion dimension deepens cognitive engagement by creating rich, interactive learning environments (Figure 5), thereby aligning with CLT's focus on contextualised, meaningful learning (Hamari et al., 2016). The playfulness dimension, which is implemented through rewards, stars and narrative elements, promotes active engagement and experimentation (Figure 6), fostering creativity, enjoyment and intrinsic motivation (Kalyani & Rajasekaran, 2018). Finally, the social experience dimension, which is implemented through discussion boards, messaging and peer interactions, aligns with CLT's conceptualisation of learning as a socially mediated process, supporting collaborative knowledge construction, critical dialogue and co-construction of understanding (Chen & Hwang, 2022; Vygotsky, 1978) (Figure 7). By integrating the aforementioned seven dimensions, iRead not only incorporates gamified elements but also operationalises CLT's core constructs, namely active engagement, contextual experience, guided learning and social interaction, to create an immersive environment for knowledge construction. This synergy enhances cognitive processing, fosters reflective learning and supports sustainable academic development (Hmelo-Silver, 2004).

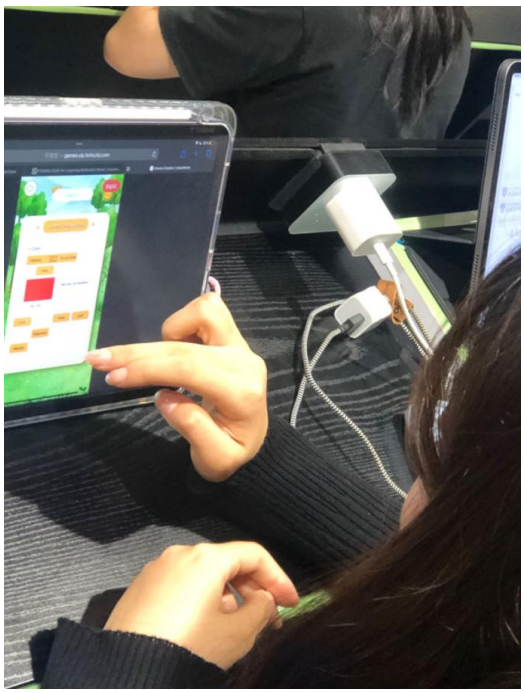


Figure 5. Immersive environment with iRead



Figure 6. Playfulness in the reward system of iRead

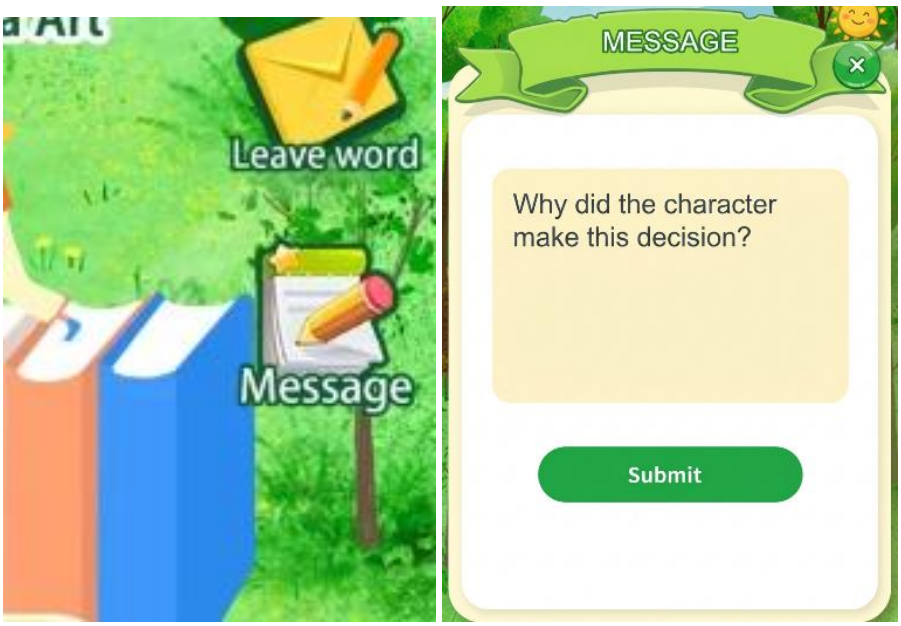


Figure 7. Social experience in iRead

Table 1 presents the iRead game features related to the CLT model.

Table 1
Operational definitions of types of interactive learning and contextual experience

Element	Operational definitions	iRead game features related with CLT model
Interactive learning	A digitally enabled, reciprocal process between teacher or designer and learner, involving access to content, tasks and problems (Reeves, 2012).	Real-time feedback, learning activities, scenario-based tasks and leaderboard rankings create a dynamic learning loop between system and learner.
Active engagement	Active engagement refers to students' behavioural, emotional and cognitive involvement in learning, where they actively participate, interact, make decisions and contribute to the learning process (Raharjo et al., 2024).	Time-limited tasks, reward, and storylines foster behavioural, emotional and cognitive involvement.
Diversity	The inclusion of varied concepts in learning to increase information relevance and cover multiple intentions (Calumby et al., 2017).	Multiple task types (true-false, mulitple-choice questions, drag-and-drop, scenario-based challenges), progress levels and adaptive content promote diverse learning experiences.
Learning resources	Tools or materials used to present and deliver educational content (Bušljeta, 2013).	Integrated hints, visual cues, vocabulary tools, level-based content and instructional scaffolds (e.g., colour-coded prompts) support learning and comprehension.
Collaborative learning	A learning approach where students, or students and teachers, work together on shared intellectual tasks (Major, 2020).	Peer feedback, class leaderboard comparisons, chat box, message and potential integration with discussion boards foster social interaction and co-learning.
Contextual experience	Instructional strategies that connect learning content to real-world applications meaningful to the learner (Lago & Ortega-Dela Cruz, 2021).	Real-world scenarios and content-based challenges situate learning in meaningful, authentic contexts.
Authentic context	The full set of conditions shaping how discourse is produced, shared and understood (Abusaada & Elshater, 2024).	Narrative-driven tasks and decision-making simulate realistic reading environments and discourse situations.
Reflection	The critical examination of one's thoughts and actions with the aim of change and improvement (Nguyen et al., 2014).	Replay options, feedback review and progress tracking promote self-assessment and metacognitive development.

Methods

Research design and participants

This study employed a mixed methods design to investigate the effects of the iRead gamified learning app on students' knowledge construction through reading comprehension. A quantitative analysis was conducted in an authentic classroom setting with 90 first-year undergraduate students (42 males, 48 females; aged 18–20) enrolled in the Digital Media Art module (FT003) at a university in China. All students had met the university's English language entry requirement, including a minimum score of 75 out of 150 in the Gaokao English Examination, formally known as the National Matriculation English Test (Shi, 2025), prior to admission. This requirement was used by the institution as evidence that students possessed an

appropriate level of English proficiency for participation in the English-medium instructional environment. Additionally, six students – four male and two female – from the same class were purposively selected for qualitative interviews based on their willingness to participate, ability to communicate their experiences and level of engagement with iRead. Leaderboard performance and classroom participation indicated that four were highly engaged, frequently answering questions and actively joining discussions and activities, while two participated occasionally but less consistently. Each student completed a 30–45-minute interview conducted in English and provided informed consent for anonymous recording and quotation.

Experimental procedure

This 7-week study consisted of five phases, delivered through weekly two-hour sessions (Figure 8). Phase1 (Weeks 1–3) established baseline comprehension through general testing. Phase 2 (Week 4) introduced the iRead game via instructions and demonstrations, allowing participants to familiarise themselves with its features. Phase 3 (Week 5) implemented the intervention by integrating the iRead game into classroom instruction, where students completed interactive tasks on visual storytelling concepts, methods and portfolio preparation through gamified quizzes with instant feedback, while the instructor facilitated and guided the activities. In Phase 4 (Week 6), a 30-minute questionnaire evaluated perceptions of interactive learning factors, contextual experience and knowledge construction. Phase 5 (Week 7) involved semi-structured interviews (30–45 minutes), conducted in English, recorded with consent and transcribed for thematic analysis.



Figure 8. Research procedure

Research instruments

This research adopted a mixed methods strategy, combining both quantitative and qualitative analyses through reading comprehension tests, self-reported questionnaires and interviews. The reading comprehension tests consist of pre- and post-tests with five reading passages and 25 questions, each scored at 4 points, summing up to a total of 100 points. The questionnaires assess factors based on the CLT theory, examining interactive learning (20 items), contextual experience (20 items), knowledge construction (10 items) through 50 items adapted from previous studies (Ho, 2024; Ugalde et al., 2021; Wahono et al., 2020; Xu et al., 2024). Each questionnaire utilises a five-point Likert scale (1 = *strongly disagree*; 5 = *strongly agree*). Cronbach's alpha reliability was used in this study ,and the results showed that Cronbach's alpha value of each variable was greater than 0.9, as shown in Appendix A. Therefore, the scale used in this study has good reliability. The data was also tested to determine the validity of its structure; no entries were deleted. For qualitative analysis, an interview was conducted to explore students' perceptions of the iRead game. The interview questions are provided in Appendix B.

Data analysis

This study used SPSS and NVivo for data analysis. SPSS processed quantitative data, employing descriptive analysis, paired-samples *t* test, and multiple regression analysis to explore differences between the pre- and post-scores of reading comprehension, predictions of interactive learning factors and contextual experience on knowledge construction. Separate regression models were used to examine distinct theoretical constructs and research questions, while future studies may apply hierarchical or simultaneous regression to assess their combined effects. NVivo was used for qualitative analysis of semi-structured interviews with six students. Interview data were coded inductively, ensuring consistency through collaborative discussion and analysis. The final themes were summarised in Table 2, with 98% inter-rater reliability achieved through participant code discussions.

Table 2
Developed themes and definitions

Coding schema of CLT factors	Subcategory	Theme definition
1. Active engagement through interactive design	Interactive prompts and feedback, real-world tasks and scenarios, multimodal storytelling and visuals and learner-content and learner-system interaction	Involves active learner participation through immersive design elements – such as interactive tasks, realistic scenarios and storytelling – that foster behavioural, emotional and cognitive engagement, enhancing curiosity, understanding, and knowledge retention (Wang et al., 2025).
2. Cognitive development through critical thinking and problem-solving	Analytical thinking, Decision-making in authentic contexts, Reflective problem-solving, and Knowledge transfer from game to real-life	Involves learners' ability to critically analyse, evaluate, and synthesise information to solve complex, real-world problems through contextual tasks that promote reflection, logical reasoning and deeper learning (Sholihah & Lastariwati, 2020).
3. Autonomy and motivation in self-regulated learning	Intrinsic motivation and enjoyment, Goal-setting and persistence, Planning and self-monitoring, and Sense of ownership and learning control	Reflects learners' intrinsic motivation and self-directed behaviours, including goal setting, progress monitoring and strategy management, which foster personal responsibility and sustained engagement (Zhu et al., 2025).

Results

Reading performance

A paired-samples *t* test was conducted to examine differences in students' reading performance before and after the intervention using iRead, as shown in Table 3. The reading scores of the students before and after the intervention exhibited significant differences [$t(89) = -3.92$, $p < .001$], with the mean difference being −8.277 (standard deviation = 19.988). Thus, the intervention had a significantly positive effect on the students' reading comprehension scores.

Table 3
Paired sample t test results comparing pre- and post-iRead reading comprehension scores

	Mean (difference)	*SD*	*t*	*df*	Sig. (2-tailed)
Pair 1 Pre & Post	-8.277	19.988	-3.92	89	<.001

Effects of interactive learning factors on knowledge construction in iRead

A multiple regression analysis was conducted by using the students' perceived interactive learning factors (active engagement, diversity, learning resources and collaborative learning) as independent variables and their perceived knowledge construction in the iRead game as the dependent variable. The regression results (Table 4) indicated that the overall model was statistically significant [$F(4, 85) = 26.892$, $p < .001$]. The set of interactive learning factors explained 55% of the variance in knowledge construction ($R^2 = .55$), emphasising the crucial roles of interactive learning factors in knowledge construction during gamified reading interventions. Moreover, as presented in Table 5, active engagement (β = .154, $p < .05$), diversity (β = .172, $p < .05$), learning resources (β = .247, $p < .01$) and collaborative learning (β = .446, $p < .001$) had significant positive effects on knowledge construction, with collaborative learning having the strongest effect.

Table 4
Regression results for effects of interactive learning factors on perceived knowledge construction

Model	Sum of squares	*df*	Mean square	*F*	*p*
Regression	24.279	4	6.070	26.892	<.001
Residual	19.185	85	.226		
Total	43.465	89			

Table 5
Regression coefficients and collinearity diagnostics

Model	Unstandardised coefficients		Standardised coefficients	*t*	Sig.	Collinearity statistics	
	B	SE	(β)			Tolerance	Variance inflation factor
(Constant)	.268	.403		.665	.508		
AE	.122	.061	.154	2.019	.047	.889	1.113
D	.153	.073	.172	2.101	.039	.772	1.295
LR	.233	.081	.247	2.863	.005	.695	1.439
CL	.421	.082	.446	5.113	<.001	.682	1.465

Note. AE: active engagement, D: diversity, LR: learning resources, CL: collaborative learning

Effect of contextual experience on knowledge construction in iRead

A multiple regression analysis was also conducted to examine the effects of two perceived contextual experience factors, namely authentic context and reflection, on perceived knowledge construction within iRead. As presented in Table 6, the overall model was statistically significant [$F(2, 87) = 44.213$, $p < .001$]. The two contextual experience factors explained 50% of the variance ($R^2 = .50$) in knowledge construction, highlighting the critical role of contextual learning experiences in shaping knowledge construction during gamified reading interventions. Authentic context (β = .356, $p < .05$) and reflection (β = .375, $p < .05$) also had significant individual effects on knowledge construction (Table 7).

Table 6
Regression results for effects of contextual experience factors on perceived knowledge construction

Model	SS	*df*	MS	*F*	*p*
Regression	21.909	2	10.995	44.213	<.001
Residual	11.556	87	.248		
Total	43.465	89			

Table 7
Regression coefficients and collinearity diagnostics

Model	Unstandardised coefficients		Standardised coefficients	*t*	Sig.	Collinearity statistics	
	B	SE	(β)			Tolerance	Variance inflation factor
(Constant)	1.575	.291		5.411	.001		
AC	.311	.144	.356	2.157	.034	.210	4.766
R	.343	.151	.375	2.275	.025	.210	4.766

Note. AC: authentic context, R: reflection

Learners' perceptions of iRead

Theme 1: Active engagement through interactive design

The six students (S1–S6) recruited in this study expressed that the interactive features of iRead, such as instant feedback, visual prompts, drag-and-drop tasks and real-world scenarios, substantially enhanced their engagement. S1 noted that the immediate feedback provided by iRead helped him identify mistakes and maintain focus. He stated, "It felt more like a game than a test". Moreover, S2 and S3 highlighted that leaderboard rankings increased their learning motivation and sustained their attention throughout the game. S1, S2 and S4 mentioned guidance feedback as a key element that helped them remain focused while reading. S5 found the game's structure intuitive and easy to follow, and S6 appreciated the personalised nature of the feedback. S2 stated that the drag-and-drop tasks helped him connect concepts to practical examples, and S4 emphasised that the real-world scenarios made the learning experience more immersive and relatable. Additionally, S1 and S3 stated that visual prompts helped clarify the learning content, making it easier to follow and understand.

Theme 2: Cognitive development through critical thinking and problem-solving

The students consistently described moments in which iRead challenged their thinking and promoted metacognitive reflection. S1 and S2 found the true-false questions particularly demanding because they required analysis of subtle textual cues and implied meanings. S1 shared that he often re-examined incorrect answers to understand the rationale behind them. S3 and S4 discussed how they adapted their strategies to improve their performance in subsequent tasks. S5 remarked that sequencing activities required considerable logical reasoning, whereas S6 explained that inferring meaning from contextual clues was essential during scenario-based challenges. S4 reflected on being more aware of which reading strategies worked best for her understanding, and S3 described engaging with multiple-choice questions that pushed him to evaluate and interpret main ideas beyond surface-level comprehension.

Theme 3: Autonomy and motivation in self-regulated learning

All students reported that iRead supported their ability to learn independently and at their own pace. S1 appreciated the option to revisit earlier levels to strengthen his understanding, and S2 and S5 valued the ability to repeat tasks until they felt confident. S1, S2 and S3 highlighted the replay function as an effective tool for monitoring progress and taking ownership of learning. S4 and S6 expressed that freedom in topic selection increased their sense of autonomy. S5 stated, "Controlling my pace let me focus on what I needed the most". S6 suggested incorporating adaptive difficulty levels to better tailor the learning process to individual needs. The students also identified different sources of motivation. S1, S3 and S5 were driven by earning star rewards; S2 was motivated to improve her leaderboard ranking; S3 was incentivised by the engaging storyline; and S4 and S5 were encouraged by the sense of progress and unlocking new stages. S6 proposed adding teacher interaction or peer feedback to further enhance collaboration and engagement.

Discussion

This study investigated the effect of iRead on students' reading comprehension by using a pre–post intervention design. The findings of the study are consistent with those of prior research, suggesting that gamified learning environments are associated with improved reading outcomes. For example, mobile and tablet-based games that integrate phonics and word reading tasks can enhance the reading skills of children with dyslexia and early readers (Bigueras et al., 2020).

In line with these results, the present study found that four interactive learning factors, namely active engagement, diversity, collaborative learning and learning resources, were significantly associated with knowledge construction during iRead gameplay, with collaborative learning showing the strongest association. These results are also consistent with those of Zabolotna et al. (2025), who revealed that co-regulation and socially shared regulation effectively support knowledge construction in computer-supported collaborative learning, echoing earlier insights by Rosen and Rimor (2009). The positive influence of learning resources on knowledge construction during iRead gameplay aligns with the results of Zenios and Goodyear (2008), who emphasised the benefits of collaborative and individual engagement in digital environments. The present study also indicated that diversity and active engagement were positively associated with knowledge construction, which is consistent with the findings of Lee et al. (2024), who demonstrated the effects of interactional diversity and curricular design. Similarly, Koohang and Paliszkiewicz (2013) proposed an e-learning model with three stages, namely underpinning, ownership and engagement, highlighting active engagement as key to knowledge construction. Erhel and Jamet (2013) determined that learner-centred strategies, timely feedback, intrinsic motivation, competition and collaboration also support the knowledge construction process (Alghamdi & Holland, 2017; Erhel & Jamet, 2013). The iRead game integrates these elements in the form of clear instructions, visual feedback and gamified features, thereby fostering engagement and promoting knowledge construction.

The present study found that contextual experience, specifically authentic context and reflection, was significantly associated with knowledge construction during iRead gameplay. This finding is consistent with the framework proposed by Mthembu and Mtshali (2013), who indicated that authentic problems, discourse and reflection enhance knowledge construction in nursing education. Similarly, Zenios and Goodyear (2008) emphasise the roles of contextualisation and epistemic activity in shaping knowledge within social and networked environments. Moreover, Daher (2010) demonstrated how mobile technologies support authentic, collaborative knowledge construction, and Tillema (2006) found that authenticity fosters knowledge productivity in professional learning. The results related to reflection are supported by the findings of Radović et al. (2022), who showed that guided and collaborative reflection enhances knowledge construction by facilitating deeper understanding and cognitive engagement.

Finally, the qualitative findings of this study suggest that interactive design features, such as feedback, prompts and realistic scenarios, significantly enhance learner engagement, aligning with CLT, which emphasises emotionally engaging, goal-driven learning (Alghamdi & Holland, 2017). The leaderboard and visual feedback mechanisms supported self-monitoring and motivation, consistent with the results of Bondaug (2021), who highlighted the positive effect of GBL on comprehension. The iRead game also fostered cognitive development through activities requiring critical thinking and problem-solving skills. The students' reflections revealed that iRead promoted active metacognitive engagement, which facilitated the identification of effective strategies, analysis of errors and inference-making. These results support Chang's (2019) assertion that reflective digital tasks deepen understanding. Furthermore, iRead effectively promoted autonomy and self-regulated learning. The ability to choose tasks, repeat levels, and track progress fostered learner independence, echoing the findings of Li et al. (2021) on the link between self-directed learning and motivation. Additionally, motivational features such as rewards, competition and progress tracking contributed to sustained engagement. The students suggested that the incorporation of adaptive difficulty levels and peer or teacher feedback into iRead can further improve personalised and collaborative learning experiences. These findings are in agreement with those of Baxter and Hainey (2024).

The findings of this study have crucial pedagogical implications. They suggest that well-designed gamified learning environments can cultivate immersive, reflective and collaborative learning experiences, thereby strengthening learners' cognitive and metacognitive abilities. Gamified systems such as iRead can stimulate interest and motivation among students who may be disengaged from traditional reading activities. Parents can also use such educational games as a constructive alternative to non-educational gameplay, encouraging children to develop reading habits through interactive learning. Beyond these pedagogical implications, the findings offer practical guidance for designing and implementing gamified learning tools in real classroom contexts. Effective systems should integrate meaningful content with scaffolding, immediate feedback, and adaptive support to sustain engagement and comprehension. Such tools can serve as formative learning supports, enabling active interaction with course materials while allowing instructors to monitor progress and guide learning. However, potential risks should also be considered. Overemphasis on competitive features such as leaderboards may increase anxiety among lower-performing students, and excessive reliance on rewards may weaken intrinsic motivation. Therefore, balanced and pedagogically grounded gamification design is essential to ensure meaningful learning outcomes.

Conclusion

This study contributes to the expanding field of GBL by integrating CLT with Högberg et al.'s (2019) gamification dimensions in a game called iRead to examine how interactive and contextual features affect knowledge construction and reading comprehension. The research findings offer empirical evidence for the pedagogical value of educational games based on constructivist and gamification principles, particularly in higher education settings.

Quantitative analysis results reveal that a teaching intervention involving the iRead game significantly improved students' reading comprehension. Regression analysis results indicate that four interactive learning factors, namely collaborative learning, learning resources, diversity and active engagement, as well as two contextual experience factors, namely authentic context and reflection, had significantly positive effects on knowledge construction during the iRead intervention. The game's design elements (i.e., real-world scenarios, guided reflection and peer collaboration) align with core CLT principles, thus fostering deeper engagement, self-regulated learning, critical thinking, and enhanced knowledge construction.

Although this study obtained crucial findings, it has certain limitations. The study sample contained students from only a single university, which might have affected the generalisability of the findings. Moreover, the short intervention duration and the limited number of qualitative responses constrained the research scope. Future research should employ longitudinal designs; recruit larger, more diverse samples; and focus on different educational contexts to validate and extend the findings of this study. Furthermore, the effectiveness of gamified interventions can be enhanced by integrating artificial-intelligence-driven personalisation within developed platforms, expanding the platforms to different domains, and incorporating teacher-guided reflection sessions. Future studies should examine how instructional support can optimise students' use of learning resources, particularly for those who struggle with reading comprehension. As neurodiverse learners were not included in the present study, future research should also explore how iRead can be adapted to support their diverse learning needs through qualitative investigation. Finally, another limitation of this study is the absence of a comparison group, as the evaluation relied solely on pre- and post-reading comprehension scores. This limits strong causal conclusions about iRead's effectiveness. Future research could adopt a randomised controlled design with a comparison group to provide stronger evidence of its impact.

Author contributions

Benazir Quadir: Supervision, Conceptualisation, Game design, Methodology, Investigation, Formal analysis, Writing – original draft, Writing – review and editing; **Kazi Mostafa:** Data collection, Validation, Writing – review and editing; **Jie-Chi Yang:** Validation, Writing – review and editing.

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Appendix A

Name of the constructs and items (*N* = 90)	Mean	SD	Factor loading
Interactive learning (Cronbach's alpha= .980)			
AE1: I can choose my learning way based on hints.	4.02	.936	.800
AE2: I actively learn and grow my knowledge through short passages.	4.19	.777	.910
AE3: iRead game encourages me to try and learn from mistakes.	4.08	.974	.883
AE4: Learning levels let me feel in charge of my learning pace.	4.06	.952	.902
D1: The true-false questions in iRead game helped me better understand the content.	4.19	.820	.911
D2: iRead offers various learning activities to meet my needs.	4.12	.934	.850
D3: Read's diverse learning environment encourages open thinking.	4.16	.898	.939
D4: Different class types help me improve problem-solving skills.	4.06	.940	.898
LR1: iRead's learning resources help me understand topics more clearly.	4.11	.867	.908
LR2: iRead provides resources that enhance both the quantity and quality of my learning.	4.04	.970	.941
LR3: iRead's simulations improve my conceptual understanding.	4.21	.757	.930
LR4: iRead offers personalised resources tailored to my learning needs.	4.08	.902	.911
CL1: Teamwork in iRead enhances my collaboration skills.	4.06	.891	.921
CL2: Cooperative learning helps me develop leadership abilities.	3.98	.971	.930
CL3: Group discussions improve my listening comprehension.	4.12	.897	.910
CL4: Working in teams makes learning more enjoyable and meaningful.	4.17	.824	.799
Contextual Experience (Cronbach's alpha= .981)			
AC1: Game knowledge is applicable to real-life situations.	3.96	1.027	.798
AC2: Solving real-world problems in the game improves my problem-solving skills.	4.04	.923	.849
AC3: Realistic scenarios enhance my critical thinking.	4.04	.860	.833
AC4: Case studies strengthen my subject knowledge.	4.03	.942	.817
AC5: Simulations resemble real-world challenges.	3.97	.965	.827
AC6: Short texts help me grasp real-world issues.	4.04	.898	.876
AC7: Game content links academic learning to daily life.	3.96	1.005	.871
AC8: Simulations reflect real-world complexity.	3.94	.891	.891
AC9: Real-life tasks improve my adaptability.	3.99	.906	.883
AC10: Hands-on learning shows practical relevance.	4.04	.873	.893
R1: The game prompts reflection on my learning progress.	4.04	.860	.827
R2: I assess my learning outcomes through gameplay.	4.07	.832	.862
R3: It encourages reflection on learning strategies.	4.03	.867	.899
R4: I reflect on how to overcome learning challenges.	3.98	.861	.891
R5: Reflection improves my study habits.	4.03	.917	.870
R6: It clarifies my understanding.	4.07	.845	.877
R7: It shapes my learning routines.	3.97	.917	.902
R8: It sharpens my thinking.	4.06	.853	.899
R9: It enhances my writing.	3.90	.949	.862
R10: It improves my ability to express ideas clearly.	4.00	.874	.847
Knowledge Construction (Cronbach's alpha= .966)			
KC1: Interactive learning enhances my engagement in constructing knowledge.	4.18	.869	.872
KC2: It helps me integrate diverse perspectives more effectively.	4.09	.802	.912

KC3: Contextual experiences improve my understanding of complex concepts.	4.14	.801	.868
KC4: Interactive settings promote critical thinking in knowledge construction.	4.14	.829	.908
KC5: I can connect theory and practice to enhance knowledge construction.	4.10	.900	.821
KC6: It enables me to express my views confidently.	4.14	.787	.917
KC7: Contextual experiences enrich my learning strategies.	4.16	.806	.867
KC8: Group collaboration deepens my understanding of knowledge construction.	4.13	.837	.806
KC9: I explore and apply new approaches to constructing knowledge.	4.18	.815	.870
KC10: Interactive learning sharpens my analytical skills as I construct knowledge.	4.14	.842	.861

Appendix B

1. Which iRead features (e.g., prompts, visuals or scenarios) made you feel more involved in the learning process?
2. How did interacting with the system (like clicking, matching or getting immediate feedback) influence your learning?
3. Can you describe a moment during gameplay when you had to really think critically to solve a problem?
4. Did you find yourself reflecting on your answers or strategies while playing the iRead game?
5. What improvements or features would you suggest to make the iRead game more effective for learning?
6. How did the game support your ability to learn independently or set your own learning pace?
7. What kept you motivated to continue using the iRead game?