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RESEARCH ARTICLE

Enhancing Vocational Certification Learning through a Gamified Chatbot: Evidence from a Quasi-Experimental Study

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Abstract: Certification-based vocational education often emphasizes practical training, yet repetitive subject-based learning tasks place a heavy burden on teachers and reduce student motivation. To address this challenge, this study examined the integration of a gamified chatbot into cognitive content instruction for the Level B Computer Hardware Fabrication certification. A quasi-experimental design was implemented across three academic years, involving a control group (conventional instruction), an experimental group using a non-gamified chatbot, and another using a gamified chatbot. Over an eight-week intervention, participants completed pre- and post-tests to measure learning effectiveness, while learner satisfaction was assessed through a validated questionnaire. Results from ANCOVA revealed that the gamified chatbot group achieved learning outcomes equivalent to teacher-led instruction and significantly outperformed the non-gamified chatbot group. Post hoc tests confirmed large effect sizes favoring gamification. Learners also reported greater satisfaction, particularly in reduced boredom and improved alignment with learning preferences. These findings demonstrate that a gamified chatbot can effectively function as a mobile cognitive content instructor, sustaining motivation, enhancing learning outcomes, and alleviating teacher workload in certification-oriented education. The proposed model is scalable and holds global relevance, offering adaptability to other vocational certifications, STEM training, and content-intensive learning contexts.

Keywords: chatbot, gamification, mobile learning, drill-and-practice learning, improving classroom teaching, vocational education, teacher workload

1 Introduction

The 21st century, characterized by a knowledge-based economy and global competition, has heightened the importance of vocational and technical education. At different levels, senior vocational high schools cultivate entry-level personnel, junior colleges train intermediate technicians, and universities of science and technology prepare high-level professionals (Li & Lai, 2007). Within this system, professional certification functions as both a quality assurance mechanism and a recognized labor market credential; when effectively integrated, it strengthens industry–academia alignment, facilitates communication between labor supply and demand, and enhances students' employability—creating mutual benefits for schools, employers, and learners (Li et al., 2010). According to Article 10 of the Regulations for Technician Skills Certification and Issuance of Certificates, candidates qualify by passing both a written and a practical test (Skill Evaluation Center, Workforce Development Agency, Ministry of Labor, 2021), supported by official study guides and reference materials (Skill Evaluation Center, Workforce Development Agency, Ministry of Labor, 2023). In practice, vocational training emphasizes hands-on instruction requiring equipment, facilities, and sustained practice, but subject-based instruction remains constrained by fixed schedules and locations. Digital learning helps overcome these barriers, particularly for cognitive mastery that relies on drill-and-practice activities; however, such activities are often repetitive and monotonous, demanding teacher supervision to maintain motivation and engagement, thereby placing a heavy instructional burden on teachers.

Since the 1970s, behaviorist theory has been widely recognized for explaining knowledge acquisition and memory (Burke, 1982). Building on this foundation, Skinner (1968) emphasized that repeated stimuli and responses, reinforced by immediate feedback, strengthen cognitive development. Digital drill-and-practice learning, inspired by these principles, typically employs question bank-style formats in which problems serve as stimuli and answers as responses. Correct responses are rewarded and incorrect responses penalized, reflecting operant conditioning and the laws of effect, proximity, and exercise. By delivering immediate feedback, such systems accelerate the stimulus–response cycle and promote mastery through repetition. While effective for cognitive learning, their repetitive nature often leads to boredom and disengagement (Skinner, 1968), underscoring the need for additional pedagogical strategies to sustain motivation.

Mobile learning (M-learning), also referred to as ubiquitous learning, represents a context-aware educational paradigm in which learners engage through mobile devices and the Internet (Alrasheedi & Capretz, 2015; Crompton & Burke, 2018; Hobert & Berens, 2019; Li, 2019). M-learning environments comprise three core components: mobile devices, communication infrastructure, and learning activity modules (Chang et al., 2003). M-learning is characterized by features such as ubiquity, portability, personalization, interactivity, collaboration, and immediate information access. Any learning activity conducted via a mobile device, regardless of the learner's location or mobility, qualifies as m-learning (Ozdamli & Cavus, 2011). Beyond preserving the benefits of distance education, m-learning empowers learners to study anytime and anywhere (Huang et al., 2016). In recent years, chatbots have gained prominence across various domains. According to Insider Intelligence, 40% of global users prefer customer service interactions via chatbots (Yuen, 2023). Chatbots are intelligent conversational systems widely used in sectors such as customer support, education, and e-commerce. They can provide instant assistance, respond to user inquiries, and deliver personalized information—thus enhancing the overall user experience. Between 2010 and 2020, the proportion of people accessing the Internet via mobile devices in Taiwan surged from 1% to 82.1% (Taiwan Network Information Center, 2020), with individuals spending nearly a quarter of their day online (Business Next, 2023). Among mobile applications, LINE, Facebook, Instagram, and Messenger have penetration rates of 95.7%, 90.8%, 70.6%, and 68.5%, respectively, with LINE emerging as the most widely used platform (The News Lens, 2023). A LINE bot is a chatbot integrated into the LINE messaging platform. It delivers personalized services and responses based on user input. LINE bots can interact with users via various message types, including text and images, and are supported by a rich API framework for developers (Huang, 2023). In the field of education, chatbot-based instruction has demonstrated superior performance in enhancing students' learning achievement, motivation, and confidence compared to traditional methods. Students generally view chatbot-supported learning positively and show higher acceptance. When designed effectively, chatbots can deliver personalized support, making learning more engaging and responsive. Students using chatbots can study in a more relaxed and enjoyable manner, receiving timely feedback and guidance throughout the learning process (Lin & Ye, 2023).

Digital games have been shown to enhance learner motivation by making learning experiences more enjoyable (Gee, 2003). Integrating digital games into curricula can stimulate intrinsic motivation, encouraging learners to invest greater time and effort in their studies (Malone & Lepper, 1987). Although gamification and game-based learning share conceptual similarities, they differ in implementation. Gamification refers to the application of game-like design principles to non-game contexts, with an emphasis on sustaining user motivation. These human-focused designs draw on game mechanics—such as points, badges, and leaderboards—to increase user engagement in educational settings (Deterding et al., 2011; Xu et al., 2017). When applied effectively, gamification promotes competition and recognition, thereby boosting learner commitment. It can also be embedded in community-driven educational platforms where features like virtual coins and ranking systems reflect learning progress (Li, 2019). Gamified learning environments have been shown to increase cognitive engagement, reinforce learning intensity, and improve learning outcomes (Hamari & Koivisto, 2015; Simões et al., 2013). Such environments are particularly well-suited for enhancing immersion and motivation in repetitive learning contexts (Dondlinger, 2007).

Gamification has been shown to play a particularly beneficial role in boosting learner motivation (Kozub et al., 2025). Common game elements integrated into gamified learning environments include points, badges, leaderboards, virtual characters, rewards, missions, gifts, in-game currency, personal profiles, levels, challenges, achievements, stars, tokens, narratives, decision-making, experience points, goals, background music, countdown timers, progress bars, and forums (Al-Hafdi & Alhalafawy, 2024). Among these elements, points serve as quantitative indicators of learners' task completion and performance. Grounded in operant conditioning theory, gamification mechanisms such as awarding points and badges for task completion or accurate responses act as positive reinforcements, thereby promoting desired behaviors and learning habits (Landers et al., 2014). Recent studies have extended these concepts through adaptive gamification, which dynamically adjusts game elements based on learners' progress, preferences, and performance (Papadakis et al., 2024; Zourmpakis et al., 2023a, 2023b, 2024). As a result, educational institutions are increasingly encouraged to implement motivational learning platforms that incorporate these elements. Research has demonstrated that such platforms—especially those integrating points, badges, and leaderboards—can significantly enhance learner engagement and overall learning effectiveness (Al-Hafdi & Alhalafawy, 2024).

Recent scholarship has increasingly emphasized the role of chatbots, gamification, and generative AI in mobile and ubiquitous learning. In the mobile chatbot domain, recent studies highlight their potential to enhance engagement and self-directed learning by providing anytime, anywhere access and real-time support (Dahri et al., 2025). Research also shows that AI-powered chatbots have been effectively integrated into teacher training (Ahmad, 2025), course information support (Nasa-Ngium et al., 2023), and positive design interventions that improve learner motivation (Zaky, 2023). At the same time, systematic reviews confirm that chatbots have been widely studied in e-learning contexts between 2016 and 2022, but most applications have been limited to short-term or scripted interactions (El Azhari et al., 2023).

The rise of generative AI has further extended chatbot functionality, enabling adaptive support in higher education and teacher education contexts. Studies have compared student and faculty perspectives on generative AI in mobile learning (Liu, 2025), examined adoption through theoretical models such as UTAUT (Zhang & Wareewanich, 2024), and explored applications for language learning and multilingual classrooms (Athanassopoulos et al., 2023). These works underscore how generative AI tutors can provide personalized, scalable, and context-aware assistance in both K–12 and higher education (Hakiki et al., 2023; Vankúš, 2024).

Parallel to chatbot development, mobile gamification research has demonstrated that digital game-based learning can foster engagement, persistence, and reduced boredom across different educational contexts. Empirical evidence shows that gamification techniques improve student motivation in preschool science education (Xezonaki, 2022), maritime English courses (Diahyleva et al., 2024), and general K–12 classrooms (Lampropoulos, 2023). Gamification tools applied in the context of student teacher training for Musical Education and its Didactics have been shown to enhance participation, motivation, and the overall teaching–learning process in higher education (Carrión Candel & Colmenero, 2022).

To address the challenges of student disengagement and low motivation in repetitive subject-based learning tasks, this study proposes the integration of a gamified chatbot into classroom instruction to support mobile, drill-and-practice learning. The chatbot enables teachers to offload repetitive instructional tasks while providing students with real-time feedback and motivational reinforcement. As a mobile learning tool, the chatbot allows learners to access instructional content anytime and anywhere through their personal devices, thereby extending learning beyond the classroom. Developed specifically for the Level B Computer Hardware Fabrication certification, the chatbot functions as a mobile learning system infused with gamification elements to foster students' motivation, engagement, and cognitive learning outcomes.

Although recent studies have shown that chatbots, gamification, and generative AI can effectively enhance engagement and support mobile learning, most prior work has focused on general education or language learning contexts, often through short-term interventions. Few studies have examined how gamified chatbots can be applied in certification-based vocational training, where dense cognitive content and repetitive practice are critical for examination success. Moreover, even fewer have adopted multi-year quasi-experimental designs that provide longitudinal evidence of learning effectiveness and learner satisfaction.

In light of these gaps, this study aims to examine the impact of a gamified mobile chatbot on both students' learning effectiveness and self-directed learning satisfaction, while also exploring its potential to alleviate instructional burden on teachers.

2 Materials & Methods

The following section details the system design and implementation, experiment design, and questionnaire design.

2.1 System design & implementation

Conventional instruction is typically conducted in fixed physical classrooms, where teachers serve as the primary facilitators and students as passive recipients of knowledge. In such settings, the burden of lesson preparation and delivery falls entirely on the teacher, often resulting in substantial workload and stress.

This study reimagines traditional large-class instruction by transforming it into an individualized mobile learning (M-learning) scenario. The learning environment shifts from a centralized classroom to decentralized mobile devices, wherein a chatbot assumes the role of the cognitive content instructor. In this paradigm, entire classrooms are replaced by individual learners, and instruction becomes flexible, autonomous, and personalized—accessible anytime and anywhere.

The chatbot engages learners by continuously delivering subject-specific quiz questions from a certification-oriented question bank. Learners conduct self-assessments and participate in repetitive practice aimed at achieving content mastery. To mitigate the monotony typically associated with drill-and-practice learning, the chatbot incorporates gamification mechanisms such as point accumulation and speed-based answer competitions to sustain motivation and promote engagement.

The chatbot operates via a Google Apps Script (GAS) server, which manages script execution, data collection from mobile devices, and database storage. Learners' behavioral data—including interaction logs and performance metrics—are recorded on the GAS server and made available to teachers. These real-time analytics enable teachers to monitor learner progress and provide timely interventions and feedback.

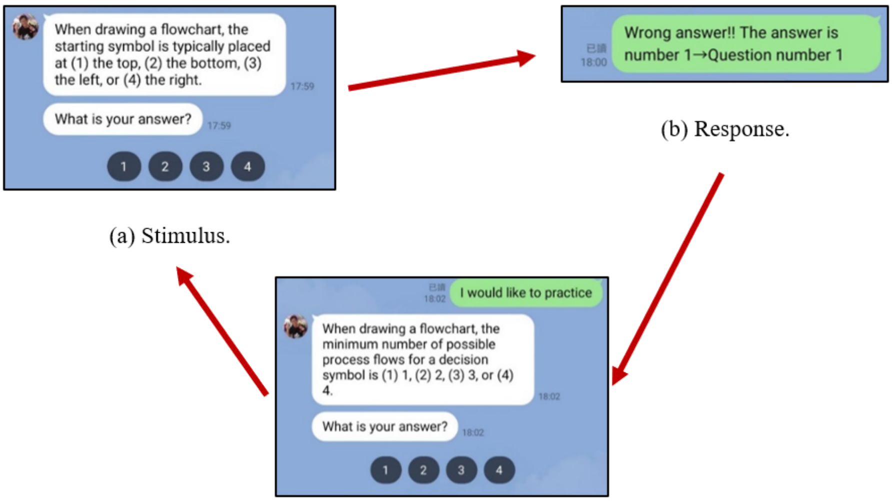
Based on the individualized m-learning context described above, this study designed a chatbot interface composed of three core components: the chatbot's identity and interface elements, learning-related interaction functions, and a command menu. The system was designed to address the instructional requirements of converting conventional teaching into an m-learning format, encompassing two primary functional modules: cognitive question bank learning and gamification mechanisms.

(1) Cognitive question bank learning mechanism

The cognitive question bank learning module is grounded in the drill-and-practice pedagogical approach and aligns with the principles of behaviorist learning theory. In this module, the chatbot systematically guides learners to read through each quiz item sequentially—from the first to the last entry in the question bank. Once all items have been reviewed, the system transitions into a randomized quiz mode, ensuring that students have been exposed to the full scope of content prior to assessment.

To reinforce cognitive processing and reduce reliance on guesswork, learners are permitted to attempt quiz questions only after reading them. This approach emphasizes understanding prior to self-assessment and encourages repeated practice for questions initially answered incorrectly. Learners continue practicing these items until mastery is achieved.

System functionality was verified through operational testing (see Figure 1(a)–(c)), confirming that the module meets the intended instructional requirements and adheres to the stimulus–response association model. This validation demonstrates the effectiveness of the chatbot in promoting structured cognitive engagement and learning retention through repeated exposure and feedback.



(a) Stimulus.

(b) Response.

(c) Strengthening the stimulus-response association through constant practice.

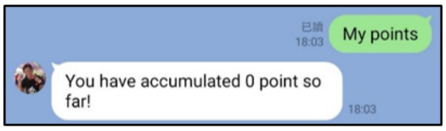
Figure 1 Testing the cognitive question bank learning mechanism

(2) Gamified learning mechanism

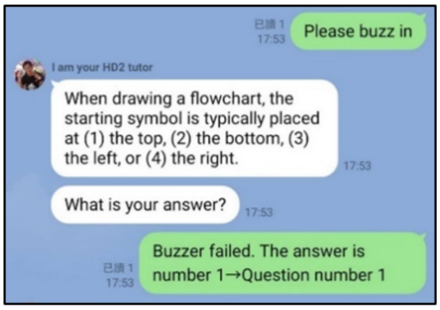
The gamified learning module incorporates both a point accumulation system and spontaneous rapid-answer competitions to enhance learner engagement and sustain motivation throughout the learning process. Points are awarded based on specific learning milestones: learners receive 1 point for every 100 quiz items read from the question bank, 1 point for every 35 questions correctly answered during self-assessment, and 1 additional point for every 35 previously incorrect questions that are subsequently answered correctly. Once learners accumulate 6 points, they are granted an extra bonus score, providing further incentive for continued participation.

To increase the dynamic and interactive nature of the learning experience, spontaneous rapid-answer competitions are periodically conducted. These real-time contests foster a sense of excitement and challenge, encouraging learners to actively engage with the content and their peers, thereby reinforcing self-directed learning motivation.

The functionality and effectiveness of this gamified mechanism were validated through empirical testing. As illustrated in Figure 2a, learners were able to successfully accumulate points according to the established criteria. Furthermore, the chatbot was shown to effectively integrate into group-based learning environments, enabling the execution of rapid-answer competitions and fostering collaborative learning dynamics (Figure 2b).



(a) Point accumulation.



(b) Rapid-answer competitions.

Figure 2 Testing the gamified learning mechanism

2.2 Experiment design

This study conducted a teaching experiment to investigate the impact of gamification on students' learning effectiveness and self-directed learning satisfaction when interacting with the chatbot in the context of a certification course. The research framework is illustrated in Figure 3.

As the experiment was embedded within standard classroom instruction and posed no more than minimal risk to participants, formal ethics committee approval was not required. Nonetheless, all participants were fully informed of the study's objectives, procedures, and data collection methods prior to participation. Informed consent was obtained from all students before any questionnaires or assessments were administered.

Random assignment within the same academic year was not feasible because mixing instructional conditions in the same class would have led to contamination (e.g., students sharing chatbot accounts or competition questions) and fairness concerns in a certification-oriented curriculum. Therefore, the study adopted a staggered cohort design across three consecutive years. Participants were divided into three groups over the span of three academic years:

(1) The control group (2022) received traditional teacher-led instruction.

(2) Experimental Group 1 (2023) engaged in self-directed learning via a non-gamified chatbot.

(3) Experimental Group 2 (2024) used a gamified chatbot, integrating point systems and rapid-answer competitions.

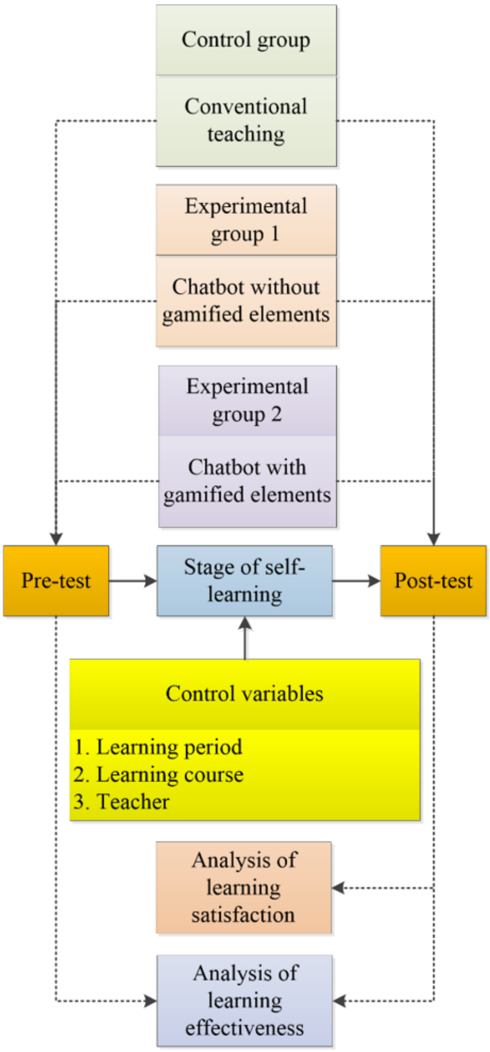


Figure 3 Research framework

To assess learning effectiveness, all participants completed a pre-test and post-test. These test scores were used to compare outcomes across the control group, Experimental Group 1, and Experimental Group 2.

In addition, learning satisfaction was assessed using a structured questionnaire. However, this measure was administered only to the experimental groups, as the control group did not interact with the chatbot system and was therefore excluded from the satisfaction analysis.

To ensure experimental rigor and control for potential confounding variables, all three groups were exposed to identical instructional content—namely, the Level B Computer Hardware Fabrication certification curriculum—taught by the same instructor, and delivered over equivalent time periods. This consistent instructional design allowed for a valid comparison of the effects of chatbot-based and gamified mobile learning environments on both learning effectiveness and student perceptions.

The experimental design was implemented as follows:

(1) Participants

A total of 63 students participated in the study. They were divided into three groups based on their academic year enrollment:

A. The control group comprised 25 students enrolled in the Computer Hardware Maintenance (Advanced) course during the 2022 academic year, who received conventional teacher-led instruction. The gender distribution was 22 males and 3 females, and 40% of the participants reported having no prior soldering experience.

B. Experimental Group 1 consisted of 18 students from the 2023 academic year, who engaged in self-directed learning through a non-gamified chatbot. The group included 15 males and 3 females, with 39% of the participants having no prior soldering experience.

C. Experimental Group 2 comprised 20 students from the 2024 academic year, who used a gamified chatbot incorporating point systems and rapid-answer competitions. The group consisted of 20 males and 3 females, with 30% of the participants lacking prior soldering experience.

All participants were drawn from the same vocational institute located in Taitung, Taiwan.

(2) Implementation Period

The experiment spanned three academic years, with each intervention lasting eight weeks:

A. Control Group (2022): September 5 – October 28, 2022 (conventional teacher-led instruction)

B. Experimental Group 1 (2023): September 18 – November 10, 2023 (chatbot-assisted learning without gamification)

C. Experimental Group 2 (2024): September 9 – November 1, 2024 (chatbot-assisted learning with gamification)

(3) Research Instrument

A self-developed learning satisfaction questionnaire was used to evaluate learners' perceptions of the chatbot-based learning experience. The instrument was designed specifically for the context of mobile, gamified learning within certification training.

(4) Analysis Tools

Data were analyzed using IBM SPSS Statistics version 21.0. Statistical techniques included descriptive analysis, ANCOVA for evaluating differences in learning effectiveness, and post hoc tests where applicable.

2.3 Questionnaire design

To assess students' perceptions of the chatbot-based learning experience, this study developed a learning satisfaction questionnaire (see Table 1) adapted from Yang's (2015) Assessment Scale for Perception Toward English Learning. The questionnaire comprised 12 items distributed across three dimensions: fondness, motivation, and adversity.

Table 1 Initial questionnaire draft

Dimension	No.	Item
Fondness	1	I enjoy studying with the chatbot.
	4	I like studying the subject with the chatbot.
	5	I became stressed and was unable to concentrate when studying with the chatbot. (reverse-worded)
	12	I can study the subject faster using the chatbot.
Motivation	2	I think using the chatbot for self-learning can help me prepare for the Level B Computer Hardware Fabrication certification test.
	3	Engaging in self-learning with the chatbot is a crucial learning method for me.
	7	Every time I study with the chatbot, I tend to work hard, because it arouses my interest in learning.
	8	Using the chatbot for self-learning does not align with my learning style. (reverse-worded)
	11	I enjoy using the chatbot for self-learning.
Adversity	6	I believe that using the chatbot for self-learning is directly beneficial to my learning for the subject's certification test.
	9	I think that using the chatbot for self-learning makes the learning process boring to me. (reverse-worded)
	10	I feel that using the chatbot for self-learning has triggered my interest and curiosity in my studies.

Each item was rated on a 5-point Likert scale, ranging from 1 (strongly disagree) to 5 (strongly agree). To minimize response bias, Items 5, 8, and 9 were reverse-coded, while the remaining items were positively worded. This structure ensured balanced assessment and facilitated more accurate interpretation of students' learning satisfaction in relation to the chatbot-enhanced learning environment.

Eighteen students enrolled in the Computer Hardware Maintenance (Advanced) course during the 2023 academic year participated in the development and pilot testing of the learning satisfaction questionnaire. All students completed the questionnaire in its entirety. An item analysis was conducted to determine the critical ratio (CR) value for each item. With the exception of Item 5, which was removed due to an inability to compute the t value—caused by a standard deviation of zero in both the high and low scoring groups—all other items met the statistical significance threshold and were retained for further analysis. The results of the item analysis are summarized in Table 2.

Table 2 Item analysis

Dimension	Number	t-test
Fondness	1	0.014*
	4	0.014*
	5	—
	12	0.006*
Motivation	2	0.015*
	3	0.014*
	7	0.035*
	8	0.003*
	11	0.014*
Adversity	6	0.014*
	9	0.006*
	10	0.014*

Note: — delete

Subsequently, a reliability analysis was performed to assess the internal consistency of the questionnaire. Cronbach's α coefficient is commonly used to evaluate the reliability of multi-item scales. According to Wu (2000), a Cronbach's α value above 0.70 is considered acceptable, while Guo (1997) suggests that items with α values below 0.65 should be excluded.

As shown in Table 3, the Cronbach's α values for the three dimensions were as follows: 1) Fondness: 0.938; 2) Motivation: 0.939; 3) Adversity: 0.857.

Table 3 Reliability analysis

Dimension	Number	α value for each dimension	Total α value
Fondness	1 4 12	0.938	0.911
Motivation	2 3 7 8 11	0.939	
Adversity	6 9 10	0.857	

The overall Cronbach's α value was 0.911, indicating a high level of internal consistency. Based on these results, the questionnaire was deemed to exhibit strong scale reliability, supporting its suitability for measuring students' satisfaction in chatbot-based learning environments.

3 Results & Discussion

3.1 Analysis of learning satisfaction

The learning satisfaction analysis included valid responses from a total of 38 participants, comprising students from Experimental Group 1 (non-gamified chatbot) and Experimental Group 2 (gamified chatbot). To compare students' perceived satisfaction across the three dimensions—fondness, motivation, and adversity—an independent samples t-test was performed.

The comparison focused on identifying whether the integration of gamification elements in the chatbot-based learning environment resulted in statistically significant differences in satisfaction levels. The results of the t-tests for each dimension are presented in Table 4.

The analysis of learning satisfaction showed that learners in the gamified group reported slightly higher scores in fondness and motivation compared to the non-gamified group, though these differences were not statistically significant. In contrast, a significant improvement was found in the adversity dimension, indicating that the gamified chatbot enabled learners to better cope with challenges in self-directed learning ($p = 0.011 < 0.05$).

Table 4 Results of independent samples t-tests

Dimension	Experimental Group	Mean	Std. Dev.	t-value	p-value (two-tailed)
Fondness	Group 1 Group 2	4.24 4.44	0.73 0.65	-1.265	0.210
Motivation	Group 1 Group 2	4.09 4.37	0.64 0.65	-1.882	0.064
Adversity	Group 1 Group 2	3.96 4.37	0.69 0.69	-2.618	0.011*

Note: * $p < 0.05$

At the item level, two significant differences emerged between the groups (see Table 5). Learners in the gamified group perceived the chatbot as more compatible with their individual learning styles (Item 8, $p = 0.001 < 0.05$) and reported reduced boredom during repetitive learning tasks (Item 9, $p = 0.001 < 0.05$). These results highlight the role of gamification in aligning learning experiences with students' preferences and sustaining their engagement.

Table 5 Results of independent samples t-tests for individual questionnaire items

Dimension	Item	Experimental Group	Mean	Std. Dev.	t-value	p-value (two-tailed)
Fondness	1	Group 1 Group 2	4.24 4.53	0.85 0.65	-1.668	0.100
	4	Group 1 Group 2	4.21 4.42	0.91 0.64	-1.169	0.246
	12	Group 1 Group 2	4.26 4.37	0.72 0.79	-0.608	0.545
Motivation	2	Group 1 Group 2	4.47 4.55	0.76 0.55	-0.516	0.607
	3	Group 1 Group 2	4.37 4.47	0.75 0.65	-0.655	0.515
	7	Group 1 Group 2	4.32 4.34	0.74 0.71	-0.158	0.875
	8	Group 1 Group 2	3.08 4.05	1.46 1.04	-3.352	0.001*
	11	Group 1 Group 2	4.21 4.42	0.78 0.64	-1.288	0.202
Adversity	6	Group 1 Group 2	4.32 4.42	0.81 0.64	-0.628	0.532
	9	Group 1 Group 2	3.24 4.26	1.46 0.95	-3.633	0.001*
	10	Group 1 Group 2	4.32 4.42	0.74 0.72	-0.628	0.532

Note: * $p < 0.05$

3.2 Analysis of learning effectiveness

This study employed a quasi-experimental design featuring a pre-test/post-test non-equivalent group structure to evaluate the impact of chatbot-based instruction—both with and without gamification—on students' learning effectiveness.

Participants were assigned to three distinct cohorts over three academic years. All groups followed the same eight-week intervention, covering the curriculum for the Level B Computer Hardware Fabrication certification. To ensure instructional consistency and control for extraneous variables, the same instructor, course schedule, and learning materials were used across all cohorts. Additionally, the chatbot deployed in both experimental groups delivered identical drill-and-practice content, with gamification elements applied exclusively in the 2024 cohort.

Descriptive statistics indicated that the control group and the gamified group achieved nearly identical post-test performance, both substantially outperforming the non-gamified group. The non-gamified group also showed the greatest variability in outcomes, suggesting inconsistent engagement or comprehension. Pre-test results confirmed that the three groups began with comparable baseline abilities, with only minor differences that were unlikely to confound post-test comparisons. Full descriptive statistics are provided in Table 6.

Table 6 Descriptive statistics

Experimental Group	N	Pre-test Mean	Pre-test SD	Post-test Mean	Post-test SD
Control (2022)	25	39.08	9.30	79.72	11.97
Group 1 (2023, no gamification)	18	33.33	9.42	55.83	23.38
Group 2 (2024, with gamification)	20	36.10	8.88	80.05	13.90

To determine whether the three groups demonstrated comparable baseline academic ability, independent samples t-tests were conducted on pre-test scores:

(1) The difference between the control group and Experimental Group 1 was marginally significant ($p = 0.054$), with the control group showing slightly higher performance.

(2) No significant difference was observed between the control group and Experimental Group 2 ($p = 0.282$).

Taken together, these results indicate no statistically significant differences in pre-test scores across the three groups, thereby supporting the assumption of baseline equivalence and justifying the use of analysis of covariance (ANCOVA) for further analysis.

An ANCOVA was subsequently conducted to examine differences in post-test performance among the three instructional conditions (conventional instruction, non-gamified chatbot, gamified chatbot), while controlling for pre-test scores as a covariate. This approach enabled the researchers to account for minor variations in prior academic ability and isolate the effect of the instructional intervention on learning outcomes.

Prior to conducting the ANCOVA, assumptions regarding normality, linearity, homogeneity of variance, and homogeneity of regression slopes were tested and confirmed to be met.

The ANCOVA results (see Table 7) revealed a statistically significant main effect of instructional group on post-test scores, $F(2, 59) = 18.34$, $p < 0.001$, partial $\eta^2 = 0.383$ (large effect), indicating that the type of instructional method had a substantial impact on students' learning effectiveness. Additionally, pre-test scores were identified as a significant covariate, $F(1, 59) = 21.97$, $p < 0.001$, partial $\eta^2 = 0.271$ (medium–large effect), suggesting that students' prior knowledge contributed meaningfully to their post-test performance. The use of ANCOVA therefore provided a more precise comparison of adjusted post-test means across the three groups, offering robust evidence that instructional modality—particularly the inclusion of gamified chatbot-based learning—played a critical role in shaping learning outcomes.

Table 7 Learning effectiveness analysis (ANCOVA)

Source	df	Sum of Squares	Mean Square	F-value	p-value
Group	2	7427.51	3713.76	18.34	< 0.001**
Pre-test (covariate)	1	4450.46	4450.46	21.97	< 0.001**
Residual	59	11950.03	202.54		

Note: ** $p < 0.001$

Following the ANCOVA, a post hoc Tukey Honestly Significant Difference (HSD) test was conducted to examine pairwise differences among the three groups' adjusted post-test scores (see Table 8).

Table 8 Post hoc analysis (Tukey HSD comparisons)

Comparison	Mean Diff	p-value
Control *vs.* Exp1 (2023)	+23.89	< 0.001**
Control *vs.* Exp2 (2024)	–0.33	0.984
Exp1 *vs.* Exp2	–24.22	< 0.001**

Note: ** $p < 0.001$

The results showed that Experimental Group 2 (gamified chatbot) performed significantly better than Experimental Group 1 (non-gamified chatbot), $p < 0.001$, Cohen's $d = 1.28$ (large effect). The control group also significantly outperformed Experimental Group 1, $p < 0.001$, $d = 1.36$ (large effect). In contrast, no statistically significant difference was found between the control group and Experimental Group 2, $p = 0.984$, $d = 0.03$ (negligible effect). These findings indicate that the gamified chatbot learning approach was equally effective as conventional teacher-led instruction in improving students' learning performance, and substantially more effective than the non-gamified chatbot-based approach. The results underscore the pivotal role of gamification elements—such as points and competitions—in enhancing learner engagement, reducing monotony, and ultimately improving learning effectiveness in mobile learning environments.

3.3 Summary

When digital drill-and-practice learning activities were delivered without gamification, students reported that the process felt repetitive, tedious, and poorly aligned with their learning preferences. This underscores a well-documented challenge in self-directed digital learning—namely, the tendency for repetitive tasks to diminish learner engagement and motivation.

This study examined whether integrating gamification elements into a chatbot-based learning system could enhance student satisfaction and learning effectiveness. Group comparisons of learning satisfaction revealed that the gamified chatbot significantly improved learners' ability to cope with challenges in autonomous learning (adversity dimension), while also reducing boredom and aligning better with individual learning styles. In contrast, learners using the non-gamified chatbot reported higher levels of monotony and weaker alignment with their preferred learning approaches. These results suggest that gamification elements play a vital role in sustaining motivation and engagement in repetitive learning contexts.

In terms of learning effectiveness, descriptive and inferential analyses consistently showed that the gamified group performed at a level comparable to traditional teacher-led instruction and significantly outperformed the non-gamified group. ANCOVA results confirmed that instructional modality had a strong effect on post-test performance (partial $\eta^2 = 0.383$, large), even after controlling for pre-test scores (partial $\eta^2 = 0.271$, medium–large). Post hoc analyses further indicated large effect sizes when comparing the gamified and non-gamified groups, underscoring the practical significance of gamification for learning outcomes.

Collectively, these findings contribute to the literature in three key ways. First, they demonstrate that a gamified chatbot-based mobile learning system can achieve learning outcomes equivalent to teacher-led instruction, validating its role as a cognitive content instructor in vocational education. Second, they show that gamification mitigates well-known problems of digital drill-and-practice learning—such as boredom and misalignment with learning styles—thereby enhancing motivation and satisfaction. Third, these results align with behaviorist principles of reinforcement and immediate feedback (Burke, 1982; Skinner, 1968), while demonstrating how gamification extends this framework by providing motivational affordances that address the limitations of purely behaviorist approaches. Furthermore, the ability of learners to sustain practice through the gamified chatbot highlights its contribution to self-directed learning in mobile environments.

In comparison with recent international studies—such as ChatGPT-assisted language learning in multilingual classrooms (Athanassopoulos et al., 2023), gamification in preschool science education (Xezonaki, 2022), and maritime English training (Diahyleva et al., 2024)—our findings extend the evidence base to certification-based vocational education. This indicates that gamified chatbots can be adapted across diverse educational contexts, from early childhood to professional training.

Finally, these findings have important implications for educational policy and practice. By showing that gamified chatbots can deliver cognitive instruction equivalent to teacher-led approaches while alleviating teacher workload, this study suggests a scalable model for vocational certification training. Such systems may be particularly valuable in regions with limited teaching resources, offering a globally relevant strategy to expand access to vocational education and support workforce development.

4 Conclusion

This study investigated the integration of a gamified chatbot into cognitive content instruction for the Level B Computer Hardware Fabrication certification, using a quasi-experimental design to evaluate both learning effectiveness and learner satisfaction. The findings yielded the following key conclusions:

(1) Gamified chatbots can serve as cognitive content instructors

The chatbot successfully delivered digital drill-and-practice learning content with learning outcomes comparable to those achieved through conventional teacher-led instruction. This affirms the chatbot's potential to function as a cognitive content instructor, thereby allowing human teachers to focus more on hands-on skill training and personalized instruction.

(2) Gamification enhances both learning effectiveness and learner motivation

Students using the gamified chatbot demonstrated significantly higher learning gains than those using the non-gamified version. Moreover, learners in the gamified group reported reduced boredom and a stronger alignment with their preferred learning styles, suggesting that gamification plays a vital role in increasing both engagement and motivation in self-directed learning environments.

(3) Chatbots help reduce teachers' instructional burden in content-heavy courses

By automating repetitive cognitive instruction, the chatbot system alleviated the instructional burden on teachers. This freed educators to provide more targeted feedback, monitor learning progress in real time, and support individualized learning needs.

(4) Gamified mobile learning systems are effective in vocational education settings

The integration of gamification and chatbot technologies into mobile learning platforms represents a practical and scalable solution for improving student engagement and learning outcomes in certification-based vocational education.

In summary, this study demonstrates that a gamified chatbot can effectively assume the role of a cognitive content instructor by delivering self-directed drill-and-practice learning with outcomes equivalent to those of traditional instruction. Furthermore, the inclusion of gamification elements not only improved learning effectiveness and motivation but also significantly reduced the instructional load on teachers. Beyond the specific case of the Level B Computer Hardware Fabrication certification, the model demonstrates strong scalability: it can be adapted to other vocational certifications, STEM training, and academic subjects where repetitive practice is essential. At the same time, potential equity issues must be acknowledged, as differences in digital access, device availability, and learner motivation may affect adoption; these challenges highlight the importance of institutional support, offline-compatible features, and teacher monitoring mechanisms to ensure equitable benefits for all learners. Importantly, these contributions carry global relevance, offering a cost-effective and adaptable model for vocational institutes, policymakers, and EdTech designers worldwide seeking to enhance learner engagement, sustain motivation, and alleviate teacher workload in content-heavy, certification-oriented education. Nevertheless, the relatively small group sizes in this study ($n = 18–25$) may limit the generalizability of the findings. While ANCOVA was applied to control for baseline differences, the modest sample sizes may reduce the stability of the estimates. Future research with larger and more diverse cohorts across institutions is warranted to validate and extend these results.

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Conflicts of Interest

The author declares no conflicts of interest.

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