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A GAMIFIED ESP-CALL FRAMEWORK FOR TECHNICAL VOCABULARY LEARNING IN VOCATIONAL COMPUTER NETWORK ENGINEERING: A QUASI-EXPERIMENTAL STUDY

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Abstract: This quasi-experimental study examined the effectiveness of a gamified English for Specific Purposes (ESP) Computer-Assisted Language Learning (CALL) framework for teaching technical vocabulary to vocational students in Computer Network Engineering. The study addressed two research questions: (1) To what extent does the gamified ESP-CALL framework improve students' technical vocabulary mastery? (2) What patterns of classroom engagement are observed during implementation? Forty eleventh-grade students from SMK Abdul Aziz Balung Jember, Indonesia, were assigned to experimental (n=20) and control (n=20) groups. The experimental group received four sessions of gamified instruction using Quizizz, Kahoot!, and simulation tasks with points, badges, timed missions, and team challenges. The control group received conventional textbook-based instruction. Pre-test and post-test vocabulary scores were analyzed using t-tests, ANCOVA, and Cohen's d effect size. Observation checklists measured visible engagement. Results showed the experimental group significantly outperformed the control group on post-test scores (M=77.70 vs 72.40; t(38)=2.80, p=.008). The effect size was large (Cohen's d=0.89). ANCOVA confirmed a significant group effect after controlling for pre-test scores ($F(1,37)=28.91$, $p<.001$, partial $\eta^2=.439$). Observation data indicated higher visible engagement in the experimental group (average 3.66 vs 2.73). The findings suggest that integrating contextualized ESP content, multimodal CALL tools, and gamification elements can improve technical vocabulary learning in vocational EFL contexts. Limitations include short intervention duration (two weeks), single-site sampling, and imbalanced gender composition between groups.
Keywords: *Gamification; ESP; CALL; technical vocabulary; vocational education; Computer Network Engineering*

INTRODUCTION

In vocational education, particularly in Computer Network Engineering (CNE), students are expected to understand specialized terminology related to manuals, network configuration, troubleshooting, and professional communication. However, many vocational students still struggle to acquire and apply technical terminology effectively because vocabulary instruction is often decontextualized, memorization-based, and weakly connected to authentic technical practices. This challenge is pedagogically important because technical expressions functions not only as lexical knowledge but also as a tool for understanding procedures, diagnosing problems, and communicating technical information in workplace-oriented contexts.

English for Specific Purposes (ESP) emphasizes alignment between language instruction and learners' professional communication needs. Dewi and Sari (2025) argue that vocational ESP classrooms in Indonesia still face challenges in integrating authentic technical communication into classroom instruction, particularly in technology-oriented departments. Similarly, Yulianti and Sumekto (2024) highlight that ESP needs analysis is essential for aligning instructional materials with vocational students' future professional tasks and communication practices.

Recent studies similarly indicate that contextualized ESP instruction supports vocational learners in disciplinary lexical knowledge developing workplace-related technical vocabulary (Belcher, 2021; Sari & Wirza, 2021). Hyland (2022) further emphasizes that ESP classrooms should prioritize disciplinary discourse and practical communication relevant to learners' future professions.

Computer-Assisted Language Learning (CALL) has transformed language learning by providing interactive and multimodal learning environments. Early CALL theory highlighted the importance of interaction and technological mediation in language learning processes (Chapelle, 2001). Technology-supported learning environments may facilitate vocabulary acquisition through increased exposure, feedback, learner autonomy, and interaction (Shadiev & Yang, 2020). Interactive applications such as Wordwall and Quizizz may additionally improve vocabulary mastery because students perceive learning activities as enjoyable and motivating (Az Zahrah & Anwar, 2023; Tiana et al., 2022). CALL-based instruction may also create more authentic and student-centered learning experiences through quizzes, multimedia materials, and collaborative digital tasks (Anwar & Husniah, 2016). In vocational education, CALL activities may help students connect technical terminology with visual demonstrations and procedural practices (Çakmak et al., 2021). Mobile-assisted applications have also become increasingly relevant because they allow repeated vocabulary practice beyond the classroom setting (Kacetl & Klímová, 2021).

Gamification has been associated with increased learner participation and task persistence in language learning environments. Kapp (2021) argues that game-based activities normalize failure as part of learning. Meta-analytic evidence further suggests that game-based learning elements positively influences motivation and learning performance across educational contexts (Sailer & Homner, 2020). Recent meta-analytic research further demonstrates that gamified vocabulary learning environments positively influence vocabulary retention, learner motivation, and classroom participation across language learning contexts (Chen & Hwang, 2024). More recent studies have shown that gamified environments can support vocabulary learning and learner engagement in digital language classrooms (Avila & Fonseca, 2021). Previous studies show that gamified vocabulary learning improves retention and engagement, particularly through digital platforms such as Kahoot, Quizizz, and Wordwall (Wang & Tahir, 2020; Zhang & Hasim, 2023). Pratiwi et al. (2024) further reported that combining gamified technology with structured instructional methods supported vocabulary retention and classroom participation. Game-based learning elements may therefore provide meaningful support for specialized terminology instruction because learners interact actively with digital tasks, quizzes, and collaborative challenges in more motivating learning environments.

Research on gamification in language learning has developed along three trajectories relevant to this study. First, studies on gamified vocabulary learning consistently report positive effects on retention and engagement. Wang and Tahir (2020) found that Kahoot! enhanced classroom participation, while Zhang and Hasim (2023) reported positive impacts of game-based learning elements on vocabulary learning across EFL contexts. However, most studies focused on general English rather than ESP contexts.

Second, research on CALL in vocational education demonstrates that multimodal input supports technical vocabulary acquisition. Lai et al. (2022) found that technology-enhanced environments increased learner autonomy and vocabulary exposure. Phuong and Khuong (2023) further reported that gamified mobile-assisted learning supported vocabulary retention through repeated interaction. Gamification has increasingly been recognized as an effective strategy in technology-enhanced language learning and vocational education settings (Dahalan et al., 2023).

Third, studies on gamification in vocational education remain limited. Omar et al. (2024) and Mahmud et al. (2025) found that gamified collaborative tasks supported practical task completion. However, these studies did not employ quasi-experimental designs or focus specifically on technical vocabulary development.

Despite these positive findings, contradictory evidence also exists. Hanus and Fox (2015) found that competitive gamification elements sometimes produced anxiety and reduced intrinsic motivation. This indicates that game-based learning elements effectiveness may depend on instructional design and classroom context. Almeida et al. (2023) found that excessive competition, cognitive overload, and poorly designed reward systems may reduce intrinsic motivation and increase learner anxiety. These findings suggest that the effectiveness of gamification depends heavily on instructional design quality and contextual implementation.

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Overall, four patterns emerge: (1) gamification generally supports vocabulary learning; (2) CALL environments support vocabulary acquisition; (3) vocational ESP contexts remain under-researched; and (4) quasi-experimental evidence integrating ESP, CALL, and gamification is still limited.

Despite extensive research on gamification, ESP, and CALL separately, four specific gaps remain. First, few studies have integrated ESP content, multimodal CALL environments, and gamification into a single instructional framework (Feng et al., 2026). More recent research has also begun to explore AI-supported and immersive learning environments in vocational education (Dewantara et al., 2024; Yusuf et al., 2026). Second, evidence from Computer Network Engineering classrooms is virtually absent. Third, most existing studies rely on perception-based designs rather than quasi-experimental investigation of vocabulary outcomes (Huang & Hew, 2025). Fourth, vocational education contexts in Indonesia remain under-represented in the game-based learning elements literature.

This study offers three novel contributions. First, it proposes an integrated digital learning framework combining contextualized ESP content, multimodal CALL tools, and gamification elements. Second, it applies the framework in a Computer Network Engineering classroom, an underexplored vocational context. Third, it employs a quasi-experimental design with ANCOVA to provide stronger empirical evidence than perception-based studies.

This study is significant for three constituencies. For vocational EFL teachers, it provides an evidence-based instructional model for teaching technical expressions. For curriculum developers, it demonstrates how ESP, CALL, and gamification can be integrated coherently. For researchers, it contributes quasi-experimental evidence on gamified ESP-CALL from an under-researched vocational context in Indonesia.

This study is significant for vocational English teachers, curriculum developers, and ESP researchers because it provides evidence-based insight into integrating ESP, CALL, and gamification in vocational vocabulary learning. Using a quasi-experimental pre-test-post-test control group design, the study addresses the following research questions: (1) To what extent does a gamified ESP-CALL framework improve vocational students' technical vocabulary mastery in Computer Network Engineering? (2) What patterns of visible classroom engagement are observed during the implementation of the gamified ESP-CALL framework?

ESP is a learner-centered approach that aligns language instruction with learners' disciplinary and occupational communication needs. Hutchinson and Waters (1987) emphasize that ESP instruction should reflect authentic communication contexts rather than generalized language teaching goals. More recent scholarship similarly highlights the importance of contextualized communication practices in vocational education (Hyland, 2022; Anthony, 2021). In Indonesian vocational contexts, ESP needs analysis is considered essential for aligning instructional materials with workplace communication demands and disciplinary practices (Yulianti & Sumekto, 2024; Dewi & Sari, 2025).

Disciplinary lexical knowledge plays a central role in vocational learning because students are required to understand specialized terminology used in workplace communication and procedural tasks. Bancroft-Billings (2020) explains that specialized terminology supports disciplinary discourse comprehension, while Nation (2022) argues that disciplinary lexical knowledge acquisition is closely related to disciplinary literacy and conceptual understanding. In Computer Network Engineering contexts, students need opportunities to apply terminology while interpreting manuals, diagnosing problems, and explaining technical procedures. Technology-supported ESP instruction additionally enables students to interact with authentic engineering-related materials and simulations, which may strengthen vocabulary retention and communicative confidence simultaneously (Aini et al., 2023).

CALL enables learners to interact with multimodal input such as text, visuals, audio, quizzes, and simulations within technology-supported learning environments. CALL integration may strengthen vocabulary acquisition, learner interaction, and classroom engagement through authentic task-based activities and collaborative digital learning (Anwar, 2021; Anwar & Husniah, 2016; Nurhayati & Widiati, 2025). Technology-enhanced environments may additionally support learner autonomy and vocabulary exposure (Lai et al., 2022; Rahimi & Fathi, 2022). Al-Emran and Granić (2024) argue that perceived usefulness, accessibility, and ease of use significantly affect students' engagement in digital learning environments. This perspective is relevant to the present study because gamified ESP-CALL activities require active learner

interaction with technology-supported instructional platforms.

In vocational ESP contexts, multimodal CALL activities help students associate technical terminology with visual interfaces, procedural actions, and troubleshooting practices (Luo et al., 2024; Lee, 2025). Multimedia Learning Theory further explains that learners process information more effectively when verbal and visual representations are integrated meaningfully (Mayer, 2021). However, technology alone does not automatically improve learning outcomes. Tang and Hew (2022) note that digital environments may produce superficial interaction if instructional tasks are not pedagogically aligned. Therefore, CALL implementation should involve meaningful task design and contextualized disciplinary objectives.

Technology-supported collaborative learning environments may strengthen learner interaction and participation during English learning activities (Anwar, 2021). Nursi et al. (2025) also argue that specialized mobile applications may help engineering students learn technical terminology through contextualized and interactive practice activities. However, technology alone does not automatically improve learning outcomes. Tang and Hew (2022) note that digital environments may produce superficial interaction if instructional tasks are not pedagogically aligned. Therefore, CALL implementation should involve meaningful task design and contextualized disciplinary objectives. Learners' acceptance of educational technology also influences the effectiveness of technology-supported instruction. Al-Emran and Granić (2024) argue that perceived usefulness, accessibility, and ease of use significantly affect students' engagement in digital learning environments. This perspective is relevant to the present study because gamified ESP-CALL activities require active learner interaction with technology-supported instructional platforms.

Gamified learning environments commonly incorporate points, badges, progress indicators, timed challenges, and collaborative missions. These elements may strengthen learner engagement when meaningfully integrated into instructional activities (Toda et al., 2020). Recent studies indicate that gamified learning environments positively influence vocabulary learning, behavioral engagement, and classroom participation (Zhang & Hasim, 2023; Huang & Hew, 2025). In vocational contexts, gamified collaborative tasks may additionally support practical task completion and peer interaction (Omar et al., 2024; Mahmud et al., 2025). In educational settings, learner engagement is also influenced by contextual and instructional factors rather than motivation alone (Fredricks et al., 2021).

The motivational foundation of gamification is associated with Self-Determination Theory, which emphasizes autonomy, competence, and relatedness as important psychological needs (Ryan & Deci, 2023). Previous studies conducted by Khoirul Anwar and colleagues similarly reported that gamified online learning environments improved vocabulary achievement and learner participation. Tiana et al. (2022) found that Kahoot and Quizizz enhanced vocabulary mastery and engagement, while Az Zahrah and Anwar (2023) reported that Wordwall improved vocabulary acquisition and learning enthusiasm. However, some researchers argue that gamification does not always guarantee positive learning outcomes because excessive competition may increase learner anxiety and reduce intrinsic motivation (Hanus & Fox, 2015).

The present study conceptualizes a gamified ESP-CALL framework as an integrated instructional design combining contextualized technical content, multimodal digital tools, and game-based engagement strategies. ESP provides domain-specific vocabulary and authentic vocational tasks, CALL provides interactive digital environments through quizzes and simulations, and gamification supports active participation through points, badges, timed missions, and collaborative challenges.

Recent vocational ESP studies in Indonesia indicate that technology-supported and context-oriented instruction is increasingly necessary for preparing students for workplace communication demands (Dewi & Sari, 2025; Yulianti & Sumekto, 2024). Recent evidence also suggests that gamified multimodal environments may facilitate technical vocabulary acquisition by increasing learner interaction and repeated exposure to discipline-specific terms (Mokwa-Tarnowska & Tarnowska, 2024). Despite growing interest in gamification, ESP, and CALL, few studies have integrated these three components within vocational Computer Network Engineering classrooms using quasi-experimental designs. Therefore, this study attempts to address this gap by examining the implementation of a gamified ESP-CALL framework in vocational technical English learning.

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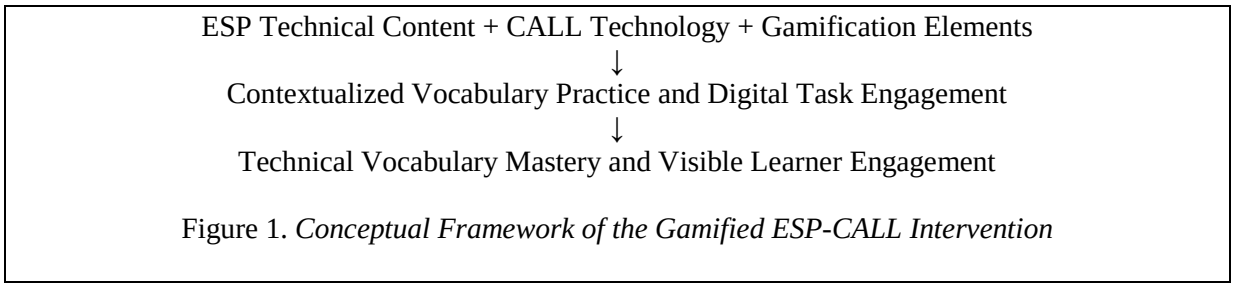


Figure 1. *Conceptual Framework of the Gamified ESP-CALL Intervention*

This study is grounded in three complementary theories. Self-Determination Theory (Ryan & Deci, 2023) explains that intrinsic motivation is supported when learners experience autonomy, competence, and relatedness. Gamification elements (points, badges, progress indicators) may support the competence need, while team challenges support relatedness. Multimedia Learning Theory (Mayer, 2024) explains that learners process information more effectively when verbal and visual representations are integrated. CALL environments provide such multimodal input. ESP Theory (Hyland, 2022) emphasizes that language instruction should align with learners' disciplinary communication needs, justifying the use of vocational terminology from Computer Network Engineering.

METHOD

This study employed a quasi-experimental pre-test-post-test control group design. Random assignment was not feasible because students were organized in intact classrooms. Therefore, baseline equivalence was examined through pre-test comparison, and ANCOVA was conducted to control for potential initial differences between groups. This design enabled the researcher to compare vocabulary development between students who received the gamified ESP-CALL intervention and students who received conventional instruction.

The participants were 40 eleventh-grade students of Computer Network Engineering at SMK Abdul Aziz Curahlele Balung Jember, East Java, Indonesia. One intact class was assigned as the experimental group (n = 20), while another intact class was assigned as the control group (n = 20). Both groups studied the same disciplinary lexical knowledgetopics and followed the same instructional duration. The experimental group consisted of 16 male and 4 female students, whereas the control group consisted of 20 female students. Because this gender imbalance was a characteristic of the intact classroom grouping, it was not manipulated by the researcher and is acknowledged as a limitation when interpreting the findings.

Table 1. *Participant characteristics*

Variable	Experimental Group	Control Group
N	20	20
Grade	XI	XI
Major	Computer Network Engineering	Computer Network Engineering
Age	17 years old	17 years old
Gender	16 male and 4 female	20 female
School	SMK Abdul Aziz Balung Jember	SMK Abdul Aziz Balung Jember
Pre-test M (SD)	64.85 (5.21)	65.20 (5.34)
Instruction	Gamified ESP-CALL instruction	Conventional instruction

An a priori power analysis using G*Power 3.1 (Faul et al., 2009) for an independent-samples t-test, assuming a medium effect size (d=0.50), α=.05, and power=.80, indicated a minimum required sample of 26 participants per group. The obtained sample (n=20 per group) is below this threshold, which limits statistical power. Therefore, significant findings should be interpreted cautiously, and non-significant findings may reflect insufficient power rather than absence of effect. The gender imbalance (experimental: 16 male, 4 female; control: 20 female) may have influenced engagement patterns and vocabulary outcomes. The observation checklist was pilot-tested with one non-participating class, yielding inter-rater agreement of 85%."

Two instruments were used: a technical vocabulary test and an observation checklist. The vocabulary test measured students' mastery

learning process. It included participation in of specialized terminology in Computer Network Engineering. It consisted of 30 items: 15 multiple-

choice items, 10 matching items, and 5 sentence completion items. Multiple-choice and matching items assessed recognition and understanding of technical terms, while sentence completion items required students to apply vocabulary in context. The maximum score was 100, and the test was administered in 90 minutes. An example of a multiple-choice item is: 'Which device is used to forward data packets between networks?' (a) Switch, (b) Router, (c) Hub, (d) Firewall.

The observation checklist was used to assess visible learner engagement during the activities, peer interaction, responsiveness to feedback, attention to tasks, use of digital tools, and task completion. The checklist used a 4-point scale from 1 (very low engagement) to 4 (very high engagement). Because this instrument produced numerical ratings supported by observation notes, the engagement data were treated as observational quantitative data supported by qualitative field notes rather than as a standardized psychometric measure of engagement.

Table 2. *Vocabulary test blueprint*

Section	No. Items	Purpose	Scoring
Multiple choice	15	To assess recognition and conceptual understanding of CNE technical terms	Objective scoring
Matching	10	To match technical terms with definitions or functions	Objective scoring
Sentence completion	5	To assess contextual application of vocabulary in technical sentences	Rubric-based scoring
Total	30	To measure technical vocabulary mastery	Converted to 0-100 scale

Table 3. *Engagement observation rubric*

Dimension	1 - Beginning	2 - Developing	3 - Competent	4 – Exemplary
Participation	Rarely participates and avoids tasks.	Participates only when prompted.	Participates actively in most tasks.	Takes initiative and shows high enthusiasm.
Attention	Frequently distracted and off task.	Needs repeated redirection.	Generally focused with minor distractions.	Sustains attention throughout activities.
Interaction	Rarely interacts or contributes.	Interacts minimally with peers.	Collaborates and contributes constructively.	Actively builds on peers' ideas.
Task responsiveness	Does not complete tasks or follow instructions.	Completes tasks inconsistently.	Completes tasks accurately and on time.	Produces high-quality responses and follows complex instructions.

Content validity was established through expert judgment involving specialists in English Language Teaching, ESP, and educational technology or Computer Network Engineering. The experts evaluated the relevance, clarity, and contextual appropriateness of the test items and observation indicators. Their feedback was used to revise unclear items and improve alignment between the instruments, learning objectives, and domain-specific vocabulary.

The vocabulary test reliability was estimated using the Kuder-Richardson Formula 20 (KR-20), which is appropriate for objectively scored items, and the coefficient was .82, indicating high internal consistency. For the sentence completion section and observation checklist, inter-rater reliability was calculated using the interclass correlation coefficient (ICC), yielding a coefficient of .82. This indicates strong agreement between the two raters. The multiple-choice and matching sections were scored objectively and therefore did not require inter-rater scoring.

The treatment was conducted in four instructional sessions over two weeks, with two sessions administered per week. Each session lasted approximately 90 minutes and followed the same pedagogical sequence: vocabulary introduction, guided digital practice, gamified task completion, and reflective feedback. The experimental group received gamified ESP-CALL instruction, while the control group received conventional textbook-based explanation, vocabulary memorization, and teacher-led exercises without digital gamification.

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The four sessions were designed to integrate ESP content, CALL-based multimodal learning, and gamification elements within authentic vocational tasks. Vocabulary was not presented as isolated word lists but embedded in activities such as interpreting manuals, identifying network devices, explaining firewall functions, and solving troubleshooting scenarios. The teacher served as a facilitator who guided students through digital tasks and provided corrective feedback.

Table 4. *Treatment sessions of the gamified ESP-CALL intervention*

Session	Technical Vocabulary Focus	CALL Tools Used	Gamification Elements	ESP-Based Task
1	Basic network devices (router, switch, hub)	Quizizz	Points and badges	Identify and classify network devices
2	Manual and instruction vocabulary	Google Forms and digital worksheet	Timed mission	Interpret a technical manual
3	Network security (firewall, encryption)	Kahoot! and simulation	Progress bar	Explain firewall functions
4	Integrated project and troubleshooting vocabulary	Quizizz and simulation task	Team challenge	Solve a real-case network scenario

To strengthen treatment fidelity, both groups were taught the same specialized terminology topics, received the same number of sessions, and followed the same instructional duration. A treatment checklist was used in every session to verify that the experimental group received the planned ESP-CALL gamified activities and that the control group received conventional instruction without digital gamification. Classroom observations were conducted during all four sessions to monitor adherence to the intervention procedure. Because the study used intact classes in a natural school setting, teacher-related or class-related effects could not be completely eliminated; therefore, this issue is acknowledged as a limitation rather than overstated as fully controlled.

Data collection consisted of pre-test administration, treatment implementation, post-test administration, and classroom observation. Both groups completed the vocabulary pre-test before the intervention and the vocabulary post-test after the intervention. During the treatment, two raters observed students' visible engagement using the observation checklist and field notes.

Data were analyzed using descriptive statistics, Shapiro-Wilk tests for normality, Levene's tests for homogeneity of variance, paired-samples t-tests for within-group improvement, independent-samples t-tests for between-group comparison, gain-score comparison, Cohen's d for effect size, and ANCOVA to control for pre-test scores. The significance level was set at alpha = .05. Engagement scores were reported descriptively because no standardized engagement instrument or inferential engagement test was used. Observation notes and written task responses were analyzed using qualitative content analysis focusing on vocabulary accuracy, technical specificity, and contextual appropriateness.

This study followed institutional ethical procedures for research involving students. Formal permission was obtained from the school principal, and approval was granted by the English teacher responsible for the participating classes. Participation was voluntary, and parental or legal guardian consent was obtained because the participants were under 18 years old. Students were assured that their identities would remain confidential, the data would be used only for academic purposes, and test results would not be included in official school grades. All data were securely stored and used only for research analysis.

RESULT AND DISCUSSION

RQ#1: To what extent does a gamified ESP-CALL framework improve vocational students' technical vocabulary mastery in Computer Network Engineering?

Descriptive statistics and baseline equivalence

Descriptive statistics showed that both groups had relatively comparable domain-specific terms proficiency before the intervention. The experimental group obtained a pre-test mean score of 64.85, while the control group obtained a mean score of 65.20. After the intervention, the experimental group achieved a post-test mean score of 77.70, whereas the control group achieved a mean score of 72.40. The experimental group also showed a larger gain score than the control group.

The independent-samples t-test on pre-test scores showed no statistically significant difference between the experimental and control groups, $t(38) = -0.21$, $p = .835$. This indicates that the two groups had comparable initial levels of

disciplinary lexical knowledge before the intervention.

Table 5. *Descriptive statistics of vocabulary scores*

Group	N	Pre-test M	Pre-test SD	Post-test M	Post-test SD	Gain M	Gain SD	Post Min-Max
Experimental	20	64.85	5.21	77.70	5.87	12.85	4.12	68-88
Control	20	65.20	5.34	72.40	6.11	7.20	3.95	60-82

Table 6. *Baseline equivalence based on pre-test scores*

Group	N	Pre-test M	SD	t	df	p	Interpretation
Experimental	20	64.85	5.21	-0.21	38	.835	No significant baseline difference
Control	20	65.20	5.34				

Assumption testing

All Shapiro-Wilk p-values were greater than .05, indicating that the data were normally distributed. Therefore, parametric analyses were considered appropriate. Levene's test also showed that the variance of both pre-test and post-test scores was homogeneous across groups because all p-values were greater than .05.

Table 7. *Test of Nnormality (Shapiro-Wilk)*

Group	Variable	Statistic	p	Interpretation
Experimental	Pre-test	0.962	.312	Normal
Experimental	Post-test	0.971	.421	Normal
Control	Pre-test	0.958	.287	Normal
Control	Post-test	0.965	.356	Normal

Table 8. *Test of homogeneity (Levene's Test)*

Variable	Statistic	p	Interpretation
Pre-test	0.284	.597	Homogeneous
Post-test	0.412	.524	Homogeneous

Within-group and between-group vocabulary improvement

The paired-samples t-test indicated that both groups showed improvement from pre-test to post-test. However, the experimental group showed a larger mean improvement than the control group.

The independent-samples t-test indicated that the experimental group significantly outperformed the control group on the post-test, $t(38) = 2.80$, $p = .008$. The effect size was large, Cohen's $d = 0.89$, suggesting practical significance beyond statistical significance. However, this effect should be interpreted cautiously because the sample size was limited and the treatment duration was relatively short.

The gain-score comparison also showed that the experimental group was associated with improvement significantly more than the control group, $t(38) = 4.43$, $p < .001$, $d = 1.40$. This finding supports the interpretation that the gamified ESP-CALL intervention was associated with greater technical vocabulary development than conventional instruction.

Table 9. *Paired-samples t- m test Results*

Group	Pre-test M (SD)	Post-test M (SD)	Mean Difference	95% CI for Cohen's d	t	df	p
Experimental	64.85 (5.21)	77.70 (5.87)	12.85	[8.52, 17.18]	6.21	19	< .001
Control	65.20 (5.34)	72.40 (6.11)	7.20	[0.68, 13.72]	2.31	19	.032

Table 10. *Independent-samples t-test on post-test scores*

Group	N	Post-test M	SD	Mean Difference	95% CI for Cohen's d	t	df	P	Cohen's d
Experimental	20	77.70	5.87	5.30	[1.46, 9.14]	2.80	38	.008	0.89
Control	20	72.40	6.11						

Table 11. *Independent-samples t-test on gain scores*

Group	N	Gain M	SD	Mean Difference	95% CI for Cohen's d	t	df	P	Cohen's d
Experimental	20	12.85	4.12	5.65	[3.07, 8.23]	4.43	38	< .001	1.40
Control	20	7.20	3.95						

ANCOVA results

ANCOVA was conducted to control for potential baseline differences between groups. The results showed a significant group effect after controlling for pre-test scores, $F(1, 37) = 28.91$, $p < .001$, partial eta squared = .439. The adjusted post-test mean for the experimental group was 77.52, while the adjusted post-test mean for the control group was 72.58. These results strengthen the evidence that the observed difference was associated with the intervention rather than initial proficiency differences.

Table 12. ANCOVA results with post-test as dependent variable

Source	SS	df	MS	F	P	partial η^2
Pre-test (covariate)	142.45	1	142.45	4.87	.033	.116
Group	845.72	1	845.72	28.91	< .001	.439
Error	1082.25	37	29.25			

RQ#2: What patterns of visible classroom engagement are observed during the implementation of the gamified ESP-CALL framework?

Observation-based engagement

Observation data indicated higher visible engagement among students in the experimental group across all indicators. The average of the six engagement indicators was 3.66 for the experimental group and 2.73 for the control group. Because the engagement data were based on observation checklist ratings rather than a standardized psychometric engagement scale, these findings should be interpreted as descriptive observational evidence rather than definitive proof of statistically significant engagement differences. The strongest visible differences appeared in students' use of digital tools, responsiveness to feedback, and participation in learning activities. These are descriptive observation ratings, not standardized engagement scores. Inferential statistics were not applied.

Table 13. Observation-based engagement scores

Engagement Indicator	Experimental Group M	Control Group M	Interpretation
Participation in activities	3.65	2.75	Higher visible participation in the experimental group
Peer interaction	3.55	2.60	More collaborative behavior in the experimental group
Responsiveness to feedback	3.70	2.80	More frequent response to feedback
Attention to tasks	3.60	2.85	More sustained attention
Use of digital tools	3.75	2.50	Higher engagement with digital tools
Task completion	3.68	2.90	More consistent task completion
Average across indicators	3.66	2.73	Descriptively higher visible engagement in the experimental group

Note. These scores represent descriptive observation ratings rather than standardized engagement measures. Differences between groups are reported for descriptive purposes only; inferential statistical tests were not applied to engagement data.

Qualitative observational evidence

Observation notes and written task responses were analyzed using qualitative content analysis. The analysis focused on three indicators: vocabulary accuracy, technical specificity, and contextual appropriateness. The examples below illustrate how students' use of technical vocabulary became more specific and contextually appropriate during the intervention. Yu (2023) found that gamified English vocabulary instruction positively influenced students' learning outcomes, satisfaction, and engagement..

These examples suggest that the intervention supported not only vocabulary recognition but also more precise and contextually appropriate use of technical terminology in vocational tasks. However, because the qualitative evidence was

limited to classroom observation notes and selected task responses, it should be interpreted as illustrative support for the quantitative vocabulary findings rather than as a separate comprehensive qualitative strand.

The findings directly address both research questions of the study. Regarding RQ1, the gamified ESP-CALL framework was associated with greater technical vocabulary improvement than conventional instruction, as reflected in the higher post-test scores, larger gain scores, and significant ANCOVA results. Regarding RQ2, the experimental group demonstrated descriptively higher visible classroom engagement across participation, peer interaction, responsiveness to feedback, and use of digital tools. However, because engagement data were observational and descriptive only, these findings should be interpreted cautiously.

The findings of this study suggest that the gamified ESP-CALL framework was associated with greater improvement in vocational students' disciplinary lexical knowledge than conventional instruction. The present findings also support Tiana et al. (2022), who found that gamified online learning platforms such as Kahoot and Quizizz were associated with improvements in students' vocabulary mastery and classroom participation. Similar findings were reported by Az Zahrah and Anwar (2023), who indicated that Wordwall-based learning increased students' vocabulary achievement and classroom enthusiasm through interactive game-based activities. Syarifah and Fediyanto (2025) reported that Wordwall-based gamification supported vocabulary mastery among vocational ESP learners by increasing learner interaction and contextual vocabulary exposure.More recent studies also indicate that gamified mobile-assisted learning can support vocabulary retention through repeated interaction and immediate feedback (Phuong & Khuong, 2023). In vocational contexts, gamified instruction may additionally strengthen collaborative participation and practical task engagement (Raziana & Wibawanto, 2025).

Students in the experimental group achieved a higher post-test mean score, indicated larger gain scores, and maintained a significant advantage after pre-test scores were controlled through ANCOVA. This result is generally consistent with previous studies reporting positive relationships between gamified learning environments and vocabulary development in language education contexts (Wang & Tahir, 2020). This result suggests that the observed learning advantage may have emerged from the pedagogical alignment of contextualized ESP content, multimodal CALL activities, and gamified learning elements.

First, the results support the relevance mechanism of ESP instruction. Students did not learn vocabulary as isolated lexical items; instead, they encountered terms within authentic CNE-related activities such as identifying network devices, interpreting manuals, explaining firewall functions, and solving troubleshooting scenarios. This contextualization may have helped students connect vocabulary with technical functions and workplace-like procedures, thereby supporting deeper semantic processing (Basturkmen, 2010; Hyland, 2022).

Second, the findings suggest that CALL-supported multimodal input may have facilitated vocabulary processing. Recent studies indicate that technology-supported and multimodal learning environments may facilitate vocabulary retention and contextual understanding by combining visual input, interaction, and immediate feedback (Lai et al., 2022; Lin & Lan, 2023). Similar findings were reported by Gao and Pan (2023), who emphasized that gamified vocabulary applications support contextual vocabulary learning through interactive design, learner autonomy, and repeated exposure to vocabulary tasks. In line with multimedia learning theory, such multimodal exposure may support vocabulary processing by linking technical terms with visual and procedural contexts (Mayer, 2024). However, the study did not measure cognitive load directly; therefore, claims about reduced cognitive load should be avoided.

Third, the observation data suggest that gamification may have contributed to visible learner engagement. This interpretation is consistent with Self-Determination Theory, which explains that learners may become more engaged when instructional activities support competence, autonomy, and relatedness (Ryan & Deci, 2023). Recent empirical studies similarly report that gamified learning environments may strengthen behavioral and emotional engagement when game elements are connected to meaningful instructional objectives rather than purely competitive activities (Kohnke et al., 2023; Huang & Hew, 2025). As a result, the engagement findings should be interpreted cautiously as descriptive indicators of visible classroom participation rather than definitive measurements of motivational change. Similar methodological limitations have also been noted in recent gamification research within vocational education settings (Alghamdi & Ali, 2024; Feng et al., 2026).

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The findings of this study are also consistent with Chan and Lo (2024), who concluded that gamification in EFL and ESL instruction may positively influence learner engagement, vocabulary retention, and learning motivation when integrated with pedagogically meaningful classroom activities.

The findings are consistent with the interpretation that gamification Technology-supported vocabulary learning in this context. The experimental group showed descriptively higher visible engagement, which mirrors previous claims by Zhang and Hasim (2023) regarding gamification's capacity to facilitate active environments.

Table 14. Qualitative examples

Data Source	Initial Response	Later Response	Interpretation
Student task response	"Router is for internet."	"A router forwards data packets between different networks using IP addresses."	Increased technical specificity
Troubleshooting task	"Check the cable."	"Verify the IP configuration, check the Ethernet connection, and diagnose network failure."	More contextualized technical vocabulary use

Illustrative qualitative evidence

Classroom observation notes and written task responses additionally illustrated how students used domain-specific terms more precisely during the intervention. For example, one student initially defined a router as "for internet," but later explained that "a router forwards data packets between different networks using IP addresses." Similarly, troubleshooting responses became more contextually appropriate and technically specific over time. These examples provide illustrative support for the quantitative findings by showing that students increasingly applied technical terminology within authentic vocational contexts rather than using isolated lexical definitions.

However, researchers argue that gamification designs do not universally assure positive learning trajectories. Our findings contrast slightly with contradictory studies that found no significant gamification effect (e.g., Hanus & Fox, 2015), where competitive ranking charts induced unexpected competition anxiety and diminished classroom performance. The inclusion of collaborative team challenges within our gamified framework may have mitigated this anxiety by emphasizing shared relatedness over individual ranking pressures.

Theoretically, the study contributes to ESP-CALL research by proposing an integrated view of vocabulary learning in vocational education. The framework suggests that domain-specific terms development may be supported when contextual relevance, technological mediation, and motivational design work together within authentic problem-solving tasks. The findings may also reflect the relevance of gamification in technical and vocational education contexts. Previous studies suggest that gamified instructional approaches can support procedural understanding and active participation in technology-oriented learning environments (Kehdy, 2026).

In vocational classrooms, digital game-based activities may help learners engage more actively with problem-solving tasks and technical terminology. Despite these promising findings, several cautions are necessary. The study involved a relatively small sample from one school and a short intervention consisting of four sessions over two weeks. Students' engagement may also have been influenced by novelty effects associated with unfamiliar digital tools. In addition, the gender composition of the two intact classes was imbalanced, and class-related or teacher-related effects could not be fully ruled out. Therefore, the findings provide preliminary classroom-based quasi-experimental evidence rather than conclusive proof of long-term effectiveness.

Furthermore, the integration of CALL and technology-supported learning environments enabled students to interact with multimodal instructional materials such as visual representations, quizzes, simulations, collaborative discussion, and contextualized technical tasks. This finding supports Anwar and Husniah (2016), who state that CALL-based instruction may create more interactive and authentic English learning experiences through task-based digital activities. Huang et al. (2021) report that XR-supported environments may enhance contextual learning experiences through multimodal interaction. Similar trends are visible in vocational education, where virtual learning environments are increasingly used to support practical and technical instruction (Zolezzi et al., 2024). Hmoud et al.

(2025) further suggest that extended reality technologies may strengthen learner engagement and experiential understanding in technology-oriented classrooms.

Theoretical implications

This study contributes to three theoretical frameworks. First, it extends Self-Determination Theory by showing that gamification elements (points, badges, progress indicators) Technology-supported the competence need, while team challenges may support relatedness. Second, it provides empirical support for Multimedia Learning Theory (Mayer, 2024) by demonstrating that multimodal CALL input (text, visuals, simulations) was associated with better vocabulary outcomes than text-only instruction. Third, it supports ESP Theory (Hyland, 2022) by showing that contextualized technical vocabulary instruction aligned with disciplinary communication needs produces better learning outcomes than decontextualized instruction.

CONCLUSION

This study demonstrates that a gamified ESP-CALL framework integrating specialized terminology, multimodal digital tools, and gamification elements was associated with greater improvement in vocational students' disciplinary lexical knowledge compared to conventional instruction. The large effect size (d=0.89) and significant ANCOVA result suggest that the integrated framework has practical educational value. However, the short intervention duration and single-site sampling limit generalizability. Future research should investigate long-term retention, compare individual gamification elements, and examine emerging technologies such as virtual reality and AI-supported instruction in vocational ESP contexts.

The improvement may be attributed to the integration of three complementary components. The ESP component aligned vocabulary learning with students' disciplinary needs, the CALL component provided multimodal and interactive input, and the gamification component supported visible participation and sustained task engagement. Together, these elements created a contextualized learning environment that supported both domain-specific terms understanding and application. The findings suggest that contextualized ESP-CALL instruction may support both vocabulary development and meaningful vocational learning. Recent scholarship has emphasized the importance of accessible and engaging learning environments for vocational students, particularly through gamified and technology-supported approaches (Rahman et al., 2026).

This study contributes to vocational English education by offering a practical instructional model for teaching technical expressionsin technology-oriented classrooms. It shows how ESP, CALL, and gamification can be integrated in a coherent and context-sensitive manner rather than implemented as separate pedagogical tools.

Several limitations should be acknowledged. First, the study was conducted within a short intervention period consisting of four instructional sessions over two weeks, so it could not examine long-term retention. Second, the study involved a single vocational institution and a relatively small sample size, limiting generalizability. Third, the gender composition of the intact classes was imbalanced, which may have influenced classroom interaction and engagement patterns. Fourth, engagement was measured primarily through observational data rather than validated psychometric instruments or inferential engagement analysis. Fifth, the study focused on vocabulary outcomes and did not comprehensively examine broader communicative skills such as technical speaking, workplace communication, or collaborative problem-solving. Sixth, the study did not measure long-term retention (delayed post-test). Seventh, the engagement data were observational and descriptive only, lacking validated psychometric measures. Eighth, the novelty effect of digital tools may have influenced student engagement beyond the gamification elements themselves. Ninth, the teacher was not blinded to group assignment, introducing potential bias.

Future research may further investigate how emerging technologies can support vocational ESP learning environments. Recent studies have explored the use of immersive learning systems, virtual reality, and AI-supported instruction in language education (Kojić et al., 2026). Personalized mobile learning systems may also contribute to vocabulary development through adaptive feedback and individualized practice (Chen & Hsu, 2022). Chiu (2024) investigates long-term vocabulary retention, learner motivation, collaborative interaction, and the integration of emerging technologies such as artificial intelligence and immersive learning environments in vocational ESP instruction. Therefore, future research should employ longitudinal designs, larger multi-site samples,

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stahanndardized engagement measures, and broader language-performance outcomes.

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