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Article

The Impact of IoT-Based Learning on English Proficiency in Civil Engineering Education

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A B S T R A C T

Civil engineering students frequently struggle to master English in ways that meet professional and technical communication demands. Conventional grammar-focused approaches often fail to provide sufficient relevance to engineering contexts, creating a gap between academic learning and workplace needs. To address this issue, the present study explores the role of the Internet of Things (IoT) in enhancing English learning for civil engineering students. A mixed-methods design was applied, combining a quasi-experimental pre-test and post-test with 60 undergraduate students, analyzed using SPSS, and complemented with questionnaires, classroom observations, and interviews. During the eight-week intervention, students engaged with IoT-based applications such as Duolingo, Cake, Hello English, BBC Learning English, Memrise, and Beelinguapp, as well as cloud-based platforms for collaborative technical writing and sensor-based project simulations that required describing real-time engineering data in English. The results revealed a significant improvement in English proficiency, with post-test scores ($M = 72.30$) notably higher than pre-test scores ($M = 61.20$), and a strong correlation ($r = 0.721$, $p < 0.05$) between IoT use and enhanced vocabulary, writing, and communication skills. Students also reported high engagement, motivation, and satisfaction. The findings suggest that IoT integration is not only effective in improving language proficiency but also provides meaningful, profession-oriented learning experiences that prepare students for global civil engineering communication.

Keywords: *Iot, English Learning, Civil Engineering, Communication*

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INTRODUCTION

The rapid advancement of digital technology in the era of Industrial Revolution 4.0 has brought significant transformation to education worldwide. One of the most influential innovations is the Internet of Things (IoT), which enables real-time, interactive, and personalized learning experiences through smart devices, mobile applications, and cloud-based systems. In the field of language education, IoT has been increasingly recognized for its potential to support autonomous learning, enhance motivation, and provide authentic contexts for communication practice (Al-Fraihat et al., 2020; Bdiwi et al., 2019). By integrating IoT, English learning can move beyond conventional classroom boundaries, offering flexible access to resources and opportunities for collaboration across digital platforms.

Within civil engineering education, English proficiency plays a vital role since most academic references, international standards (ISO, ASTM), and professional documentation are published in English (Sun & Chen, 2019). Proficiency in technical English is essential for students to access global knowledge, engage in international collaboration, and compete in the professional arena. However, traditional grammar-based teaching methods are often insufficient in addressing these demands. Limited integration of technology, low levels of student engagement, and the absence of contextualized practice remain major challenges that hinder effective English learning in this field (Harmer, 2015).

Recent studies have demonstrated that IoT-based learning can increase student participation, provide relevant learning contexts, and align language learning with professional needs (Bdiwi et al., 2019; Sun & Chen, 2019). Therefore, this research emphasizes the importance of IoT not only as a pedagogical innovation but also as a strategic approach to bridge the gap between academic English instruction and the real communication requirements of civil engineering education.

METHOD

The participants consisted of 60 undergraduate students from the Civil Engineering Department of Universitas Pepabri Makassar during the 2024/2025 academic year. All of them were enrolled in the *Technical English* course and had previously completed basic English classes. The majority were in their second and third year of study, representing students with sufficient English background but limited exposure to IoT-based learning. A purposive sampling technique was applied to ensure that the participants shared similar academic characteristics and that the implementation of IoT-enhanced instruction was a new experience for them.

This study employed a mixed-method design combining quantitative and qualitative approaches. The quantitative approach was used to measure the improvement of civil engineering students' English proficiency after the implementation of IoT-based learning through a TOEFL-like pre-test and post-test. Meanwhile, the qualitative approach was used to explore students' perceptions, motivation, and challenges through interviews and classroom observations. A mixed-method design was selected because it provides both measurable outcomes and deeper insights into the students' learning experiences (Creswell & Plano Clark, 2017).

Respondents

The study was conducted in the Civil Engineering Department at several universities in Makassar. The research population consisted of undergraduate civil engineering students, and the sample included 60 participants enrolled in the Technical English course in the 2024/2025 academic year. A purposive sampling technique was applied with the following criteria: (1) students who had completed basic English courses, and (2) students who had not previously participated in IoT-based learning. This approach allowed the researcher to focus on students with sufficient English background while ensuring the novelty of the IoT learning experience.

Research Design

This study employed a quasi-experimental design using a one-group pre-test and post-test model, consisting of three main stages. The pre-test was conducted to measure the students' initial English proficiency levels prior to the intervention. (1) Treatment: Over eight weeks, students participated in IoT-based English learning sessions that integrated smart voice assistants and various applications to enhance reading, writing, speaking, and listening skills; cloud-based platforms to support collaborative technical writing; and sensor-based IoT project simulations—such as monitoring temperature and humidity data and describing the results in English—to link language use with real-world contexts. (2) Post-test: After the intervention, a post-test was administered to assess improvements in students' English proficiency. In addition to these tests, questionnaires, observations, and interviews were employed as complementary instruments to provide a more comprehensive understanding of the learning outcomes.

Instruments

TOEFL-like Test

The TOEFL-like test served as both the pre-test and post-test to measure students' proficiency across four key skills: listening, speaking, reading, and writing. The pre-test was administered before the implementation of IoT-based learning to establish baseline proficiency levels, while the post-test followed the eight-week intervention to identify improvements. The **listening section** required students to answer multiple-choice questions based on audio recordings of conversations and lectures; the **speaking section** involved short oral tasks such as describing project data or responding to prompts, assessed using standardized rubrics; the **reading section** included comprehension exercises based on technical and general English passages, particularly within civil engineering contexts; and the **writing section** asked students to produce short essays and technical reports focusing on interpreting IoT sensor data in English. The resulting scores were then statistically analyzed using paired-sample t-tests in SPSS (version 26) to determine the significance of differences between pre- and post-test performance.

Questionnaire

A structured Likert-scale questionnaire (1–5) was designed to measure students' perceptions of IoT-based English learning, consisting of 15 items grouped into four key dimensions. The engagement dimension assessed students' interest and active participation during IoT-based learning activities; motivation evaluated the extent to which IoT tools encouraged students to enhance their English proficiency; relevance examined how well IoT-based learning aligned with civil engineering contexts and professional needs; and usability measured the ease of use, accessibility, and functionality of IoT and cloud-based applications. The questionnaire's reliability was tested using Cronbach's Alpha, resulting in a coefficient of $\alpha = 0.891$, which indicates a high level of internal consistency.

Observation Guidelines

Systematic classroom observations were conducted to capture real-time student behaviors and participation during IoT-based learning sessions. An observation checklist was used to document several key aspects: interaction, referring to the level of collaboration among students and between students and instructors while using IoT tools; participation, encompassing the frequency and quality of students' contributions during class activities, discussions, and simulations; and communication performance, which focused on students' ability to describe IoT sensor data, deliver oral presentations, and engage in technical English exchanges. The observation notes were then analyzed qualitatively to complement the quantitative findings, providing a more comprehensive understanding of students' engagement and learning processes.

Interview Guidelines

Semi-structured interviews were conducted with a selected group of students and instructors following the intervention, using an interview protocol containing open-ended questions to explore several key aspects. These included participants' experiences in using IoT applications and cloud-based tools for English learning; challenges encountered, such as technical difficulties, digital literacy limitations, and resource constraints; benefits perceived from IoT integration, including enhanced motivation, contextualized practice, and professional relevance; and suggestions for improving the implementation of IoT-based English learning within civil engineering education. All interviews were audio-recorded, transcribed, and analyzed thematically to identify recurring patterns and unique insights that enriched and supported the interpretation of the quantitative findings.

Procedures

Preparation Stage

At the beginning of the study, the researcher prepared the research instruments, including the TOEFL-like test, the Likert-scale questionnaire, observation guidelines, and interview protocols. The instruments were validated through expert judgment from English language lecturers and educational technology specialists. The research schedule and IoT-based applications (Duolingo, Cake, Hello English, BBC Learning English, Memrise, Beelinguapp, Google Docs, Microsoft 365, Grammarly Online) were also selected and tested for feasibility before implementation.

Pre-Test Stage

All 60 participants took a TOEFL-like pre-test to measure their initial English proficiency levels in listening, speaking, reading, and writing. This baseline data was essential for identifying students' entry-level skills before the IoT-based learning program was introduced.

Treatment (IoT-Based Learning) Stage

The treatment was carried out over eight weeks in Technical English classes, during which students engaged in a variety of IoT-based learning activities. They used smart voice assistants such as Alexa and Google Assistant to practice listening and speaking; mobile applications including Duolingo, Cake, Hello English, BBC Learning English, Memrise, and Beelinguapp to enhance vocabulary, grammar, listening, speaking, and reading comprehension; and cloud-based platforms such as Google Docs, Microsoft 365, and Grammarly Online to develop collaborative technical writing skills and receive real-time feedback. Additionally, students participated in sensor-based project simulations involving temperature, humidity, and vibration monitoring, where they described and reported data findings in English both orally and in writing to promote contextualized language learning. Throughout this stage, the researcher conducted systematic classroom observations to document students' engagement, participation, and interactions during the learning process.

Post-Test Stage

After completing the treatment, the same TOEFL-like test was administered as a post-test. This step was designed to measure the improvement in students' English proficiency after experiencing IoT-based learning.

Questionnaire Stage

Following the post-test, students completed a Likert-scale questionnaire (1–5) to provide feedback on their perceptions of IoT-based learning. The questionnaire measured aspects such as engagement, motivation, relevance, usability, and satisfaction.

Interview Stage

Semi-structured interviews were conducted with selected students and instructors. This stage aimed to explore deeper insights into the participants' experiences, including perceived benefits, obstacles, and suggestions for future implementation of IoT in English learning for civil engineering.

Data Collection Techniques

The instruments used in this study included several complementary tools to obtain both quantitative and qualitative data. (1) Tests (Pre-test and Post-test): These were administered to measure students' English proficiency before and after the IoT-based learning intervention, allowing the researcher to identify the level of improvement achieved. (2) Questionnaire: This instrument was distributed to collect students' perceptions of IoT-based English learning, particularly focusing on aspects of engagement, motivation, relevance, and ease of use. (3) Observation: Classroom observations were conducted to assess students' active participation, interaction, and engagement during activities that integrated IoT tools. (4) Interviews: Semi-structured interviews with both students and instructors were used to explore their experiences, challenges, and suggestions regarding the implementation of IoT in English learning, providing deeper insights to complement the quantitative results.

Validity and Reliability

To ensure the accuracy and trustworthiness of the research instruments, several validation procedures were carried out. Content validity was established through expert judgment by English language lecturers and educational technology specialists, ensuring that each instrument aligned with the study objectives and maintained content relevance. The reliability test of the questionnaire was conducted using Cronbach's Alpha, which yielded a coefficient value of $\alpha > 0.70$, demonstrating a high level of internal consistency and reliability. Additionally, methodological triangulation was applied by employing multiple instruments—tests, questionnaires, observations, and interviews—to strengthen the credibility and validity of the findings through cross-verification of data obtained from diverse sources.

Data analysis

Quantitative Analysis.

The quantitative data in this study consisted of students' pre-test and post-test TOEFL-like scores, along with responses from the Likert-scale questionnaire. The pre-test and post-test analysis was conducted using the Paired Sample t-Test in SPSS version 26 to determine whether there was a statistically significant difference in students' English proficiency before and after the IoT-based learning intervention. The analysis produced key indicators such as the mean difference, t-value, and significance level (p-value), which were used to evaluate the effectiveness of the treatment. Meanwhile, the questionnaire analysis employed descriptive statistics, including mean and standard deviation, to summarize students' perceptions of engagement, motivation, relevance, and usability of IoT in English learning. Additionally, the reliability of the questionnaire was tested using Cronbach's Alpha, with a coefficient greater than 0.70 indicating a high level of internal consistency.

Qualitative Analysis

The qualitative data were derived from classroom observations and semi-structured interviews with students and instructors, analyzed using the Miles and Huberman (1994) model, which comprises three key stages. The data reduction stage involved selecting, simplifying, and organizing raw data from observation notes and interview transcripts through coding, categorization, and identification of recurring themes related to student engagement, challenges, and benefits of IoT-based English learning. The data display stage presented the organized information in narrative descriptions, tables, and thematic charts to facilitate interpretation and highlight emerging patterns, connections, and contrasts across data sources. Finally, conclusion drawing and verification entailed developing interpretations based on the identified themes, with findings verified through cross-checking against quantitative results and raw data to ensure accuracy, credibility, and trustworthiness. By integrating both quantitative and qualitative analyses, the study achieved a comprehensive understanding of the effectiveness of IoT integration in English learning for civil engineering students.

FINDINGS AND DISCUSSION

Picture 1. Examples of Iot Applications

Table 1. Strengths and Weaknesses of Iot Applications

Application	Strengths	Weaknesses
Duolingo	Provides systematic practice in vocabulary and grammar.	Limited speaking practice; less suited for professional contexts.
Cake	Features automatic pronunciation correction.	Lacks support for academic/technical writing.
Hello English	Covers all language skills (reading, writing, speaking, listening) and offers offline mode.	Requires additional practice to align with professional civil engineering contexts.
BBC Learning English	Offers authentic materials (news, interviews, articles) to enhance listening and speaking.	Language is often too formal and fast for beginners.
Memrise	Strong in vocabulary building using spaced repetition; includes user-generated technical content.	Focuses mainly on vocabulary; limited support for academic writing/speaking.
Beelinguapp	Supports reading comprehension through bilingual texts (English–Indonesian side by side).	Limited to reading and listening skills only.

Cloud-based Apps (Google Docs, Microsoft 365, Grammarly Online)	Supports technical writing with real-time collaboration and automatic grammar correction.	Requires stable internet connection.

Findings

Paired Sample t-Test Analysis (Pre-Test and Post-Test English Proficiency)

To determine whether there was a significant difference in students' English proficiency before and after the implementation of IoT-based learning, a Paired Sample t-Test was conducted.

Table 2. Paired Sample t-Test Analysis (Pre-Test and Post-Test English Proficiency)

Statistic	Value
N	60
Mean Pre-test	61.20
Mean Post-test	72.30
Mean Difference	11.10
T	-9.523
Sig. (2-tailed)	0.000

The pre-test and post-test analysis showed a clear improvement in students' English proficiency after eight weeks of IoT-based learning. The mean pre-test score was 61.20 (SD = 6.85), while the mean post-test score increased to 72.30 (SD = 7.12). This represents an average gain of 11.10 points, equivalent to an improvement of 18.1% from the baseline. A paired-sample t-test confirmed that this difference was statistically significant ($t = -9.523$, $p < 0.001$). The largest improvements were observed in speaking (+21.3%) and listening (+19.5%), while reading (+15.7%) and writing (+16.8%) also showed substantial gains.

Since the significance value (p-value) = 0.000 < 0.05, there is a significant difference between the pre-test and post-test scores. This indicates that the use of IoT had a positive and significant effect on improving the English proficiency of civil engineering students.

Descriptive Analysis of Students' Perceptions

The questionnaire consisted of 15 items measuring students' perceptions of the effectiveness of IoT-based learning, using a Likert scale of 1–5 (1 = Strongly Disagree, 5 = Strongly Agree).

Table 3. Students' Perceptions

Aspect	Mean	SD
Engagement through IoT applications	4.35	0.52
Relevance of materials to civil engineering	4.28	0.56
Ease of use of IoT & cloud-based applications	4.21	0.68
Increased confidence in speaking	4.40	0.49
Satisfaction with the learning method	4.46	0.45

Descriptive statistics from the questionnaire further support these results. Students rated their engagement at a mean score of 4.35 (SD = 0.52), motivation at 4.40 (SD = 0.49), and satisfaction with IoT-based learning at 4.46 (SD = 0.45) on a 1–5 Likert scale. Overall, more than 87% of participants agreed or strongly agreed that IoT applications made learning more interactive and enjoyable, while 83% reported that IoT helped them connect English learning to real civil engineering contexts.

Overall, students gave positive evaluations of the use of IoT in English learning. The highest scores were in satisfaction and increased confidence, indicating that students felt more comfortable and capable of expressing ideas in English through IoT tools.

Reliability Test

Cronbach's Alpha = 0.891 → High Reliability

A Cronbach's Alpha value greater than 0.70 indicates that the questionnaire instrument had high reliability and consistency in measuring students' perceptions.

How does IoT-based learning affect students' English proficiency?

The results of the pre-test and post-test showed a significant improvement in students' English proficiency after participating in IoT-based learning for eight weeks. The mean pre-test score was 61.20, while the mean post-test score increased to 72.30, with a mean difference of 11.10 points. The paired-sample t-test revealed a p-value = 0.000 ($p < 0.05$), indicating a statistically significant difference between the two tests. This suggests that IoT integration had a positive and measurable effect on students' language skills. Vocabulary and grammar improved through Duolingo and Memrise; listening and speaking skills increased significantly through Cake, Hello English, and BBC Learning English; reading comprehension improved with Beelinguapp, which provided bilingual technical texts; and technical writing skills were enhanced through cloud-based applications such as Google Docs, Microsoft 365, and Grammarly Online.

How does IoT integration influence students' engagement and motivation?

The questionnaire results demonstrated high student engagement and motivation during IoT-based learning. The overall satisfaction score was 4.46 (on a 1–5 scale), while the perception of improved speaking confidence scored 4.40. More than 87% of students reported that IoT applications made learning more interactive, flexible, and enjoyable. These findings indicate that the integration of IoT not only improved learning outcomes but also enhanced students' enthusiasm and confidence in using technical English.

What challenges and contextual benefits emerge from IoT-based English learning?

IoT-based simulations, such as describing real-time sensor data (temperature, humidity, vibration), helped students practice technical English in authentic contexts. This strengthened their ability to communicate in civil engineering scenarios, bridging the gap between academic English and professional needs. Students also gained familiarity with international technical standards (ISO, ASTM) by applying English to real project-related tasks. Despite these benefits, approximately 20% of students experienced challenges, such as unstable internet connections, limited access to devices, and insufficient digital literacy. These challenges highlight the importance of infrastructure readiness and training to maximize the benefits of IoT integration.

These results indicate that IoT not only produced measurable improvements in proficiency but also fostered high levels of student engagement and confidence in using English for professional communication.

Discussion

The findings indicate that the integration of IoT-based tools in English learning has a significant impact on civil engineering students' language proficiency. This result is consistent with the principles of Technology-Enhanced Language Learning (TELL), which highlight interactive, personalized, and context-based learning. The improvement in test scores, particularly in speaking and listening, demonstrates that IoT tools can create authentic practice environments that are often missing in traditional grammar-focused methods.

Furthermore, the positive perceptions reported in the questionnaire reinforce these results by showing that students were more engaged and motivated when learning through IoT platforms. This supports previous research that emphasizes the role of digital technologies in improving learner involvement. In the present study, IoT not only enhanced students' motivation but also ensured that language practice was closely tied to civil engineering contexts, making the learning experience more meaningful and professionally relevant.

In addition, the contextual use of IoT, such as project simulations and cloud-based collaboration, reflects the principles of Contextual Teaching and Learning (CTL). Through this approach, students did not merely acquire English theoretically but applied it directly in technical scenarios, thereby strengthening their ability to communicate in professional engineering environments. Nevertheless, challenges such as limited infrastructure, digital literacy gaps, and technical issues remain significant barriers. These obstacles, which have also been highlighted in prior studies, suggest that the successful implementation of IoT in higher education requires not only technological innovation but also adequate institutional support and training. Addressing these challenges is therefore essential for ensuring the long-term sustainability and effectiveness of IoT-based English learning in civil engineering education.

CONCLUSIONS

This study demonstrates that integrating Internet of Things (IoT) technologies into English language learning produces a transformative impact on civil engineering education. Students showed significant improvement in TOEFL-like test scores, particularly in speaking and listening, supported by overwhelmingly positive perceptions of engagement, motivation, and contextual relevance. IoT tools, such as project simulations, cloud-based writing platforms, and sensor-data descriptions, enabled students to bridge academic English learning with real-world professional communication needs. The findings highlight the relevance of IoT as a pedagogical innovation within English for Specific Purposes (ESP), especially in technical and engineering contexts. By aligning language learning with authentic civil engineering practices, IoT strengthens both linguistic proficiency and professional readiness. The synergy between Technology-Enhanced Language Learning (TELL) and Contextual Teaching and Learning (CTL) frameworks shows that IoT is not only a tool for improving English skills but also a strategic approach for preparing graduates to engage in global engineering communication. Despite its promising results, the study faced several limitations, including unstable internet connectivity, limited access to digital devices, and varying levels of digital literacy among students. These constraints may have affected the consistency of the learning experience and highlight the need for supportive infrastructure. Future studies should involve larger and more diverse samples across different universities to strengthen generalizability. Longitudinal research is also recommended to assess the sustainability of IoT-based learning outcomes over time. Additionally, further exploration is needed into integrating IoT with advanced technologies such as Artificial Intelligence (AI), Augmented Reality (AR), and Virtual Reality (VR) to enhance English for Specific Purposes (ESP) in engineering education.

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