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DOES E-LEARNING IMPROVE LEARNING OUTCOMES IN ICT-BASED COURSES? AN EXPERIMENTAL APPROACH

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A B S T R A C T

The integration of digital technologies in higher education has accelerated the adoption of e-learning, particularly in Information and Communication Technology (ICT)-based courses. However, evidence regarding its effectiveness in improving student learning outcomes remains inconclusive. This study aimed to examine the effect of e-learning on learning outcomes in ICT-based courses using an experimental approach. This research employed a quantitative experimental method with a one-group pretest–posttest design. The participants were 43 undergraduate students from the Information Technology Study Program selected through purposive sampling. Data were collected using pretest and posttest achievement tests and analyzed through descriptive statistics, Shapiro–Wilk normality testing, paired sample t-test, N-Gain analysis, and Cohen's d effect size. The results revealed a significant improvement in students' learning outcomes after the implementation of e-learning. Statistical analysis indicated a significant difference between pretest and posttest scores, supported by a moderate N-Gain score and a large effect size. These findings suggest that e-learning effectively improves students' learning outcomes in ICT-based courses and offers both academic and practical benefits in technology-oriented learning environments. Therefore, well-designed e-learning systems should be further integrated into higher education, particularly in digitally aligned disciplines.

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INTRODUCTION

The rapid advancement of digital technologies has significantly transformed educational practices across the globe, particularly in higher education. Among these transformations, e-learning has emerged as a prominent instructional approach, enabling flexible access to educational resources, interactive learning environments, and student-centered pedagogical models (Ellis et al. 2009; Martins et al. 2025; Teo et al. 2020). The integration of e-learning became even more accelerated following the global disruptions caused by the COVID-19 pandemic, which compelled educational institutions to adopt online and blended learning systems on an unprecedented scale (Budiman et al. 2024). As a result, e-learning is no longer viewed merely as an alternative mode of instruction but as an essential component of modern education systems (Encarnacion et al. 2025; Teferi et al. 2026).

In the context of Information and Communication Technology (ICT)-based courses, e-learning offers unique advantages. ICT-related subjects inherently involve digital literacy, software utilization, online collaboration, and technology-mediated problem-solving, making them particularly compatible with digital learning environments (Anthony, et al. 2019; Mustaqim et al. 2025; Tham, et al. 2005). Features such as learning management systems, multimedia content, virtual simulations, discussion forums, and automated assessments may enhance students' engagement and facilitate deeper understanding of course materials. Consequently, many institutions have invested substantial resources in implementing e-learning platforms for ICT instruction (Panyajamorn et al. 2028; Halomoan et al. 2026; Kenan 2016).

Despite its growing adoption, the effectiveness of e-learning in improving student learning outcomes remains inconclusive. Previous studies have reported mixed findings regarding the impact of e-learning on academic achievement. Several studies suggest that e-learning improves students' motivation, autonomy, and performance by promoting self-paced learning and increased access to learning materials. Conversely, other studies highlight challenges such as limited student interaction, technological barriers, reduced learning discipline, and unequal digital access, which may hinder learning effectiveness (Siritongthaworn, et al. 2006; Trisnawati et al. 2025). These inconsistent findings indicate that the success of e-learning may depend on contextual factors, course characteristics, instructional design, and learner readiness Encarnacion et al. 2021; Halomaon et al. 2024; Hakiki et al. 2024; Rais et al. 2025).

Furthermore, much of the existing literature relies on descriptive surveys, correlational analyses, or student perception studies, with relatively limited use of experimental methods to rigorously evaluate causal relationships between e-learning interventions and learning outcomes. This methodological limitation is particularly evident in studies focusing on ICT-based courses, where experimental evidence is still insufficient despite the strong theoretical alignment between digital learning environments and ICT competencies.

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To address this gap, the present study adopts an experimental approach to examine whether e-learning significantly improves learning outcomes in ICT-based courses. By comparing the academic performance of students exposed to e-learning interventions with those receiving conventional instructional methods, this study aims to provide empirical evidence regarding the effectiveness of e-learning in a controlled educational setting (Sulčič, V., & Lesjak, D. 2009).

This study contributes to the literature in three important ways. First, it provides experimental evidence on the causal impact of e-learning on student learning outcomes, addressing the methodological limitations of prior studies. Second, it specifically focuses on ICT-based courses, a domain in which e-learning is expected to demonstrate relevance and effectiveness. Third, the findings may offer practical implications for educators, curriculum designers, and policymakers in optimizing digital instructional strategies for technology-oriented disciplines.

METHOD

A. Research Design

This study employed a quantitative experimental approach to examine the effect of e-learning implementation on students' learning outcomes in ICT-based courses. Experimental research was selected because it enables the investigation of causal relationships between independent and dependent variables through the administration of a structured instructional intervention. The study adopted a one-group pretest–posttest design, in which participants were assessed before and after the implementation of e-learning as the treatment. This design was considered appropriate for measuring changes in student learning outcomes resulting from the intervention within the same participant group. The research design is illustrated as follows:

$$O_1 \; X \; O_2$$

Where:
O_1 = pretest score (before treatment)
X = e-learning intervention
O_2 = posttest score (after treatment).

In this design, students completed a pretest to assess their initial knowledge and competencies prior to the intervention. Following the implementation of e-learning in ICT-based instruction, students completed a posttest using equivalent assessment criteria. The comparison between pretest and posttest results enabled the researcher to evaluate changes in learning outcomes after exposure to the e-learning environment. Although this design does not include a control group, it is effective for preliminary

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evaluation of instructional interventions by measuring within-group changes over time.

B. Sample

The population of this study consisted of undergraduate students enrolled in the Information Technology Study Program. The sample included 43 students who were actively taking ICT-based courses during the research period. The sampling technique used was purposive sampling, in which participants were selected based on specific criteria relevant to the study objectives. The criteria included: (1) students enrolled in ICT-based courses, (2) students with access to the institutional e-learning platform, and (3) students who participated in both pretest and posttest sessions. Purposive sampling was considered appropriate because the study specifically targeted students with direct experience in technology-oriented learning environments.

C. Data Analysis Technique

The collected data were analyzed using descriptive and inferential statistical methods to evaluate the effectiveness of e-learning in improving students' learning outcomes in ICT-based courses. Data analysis was conducted using IBM SPSS Statistics.

D. Descriptive Statistics

Descriptive statistics were used to summarize students' pretest and posttest scores, including mean, standard deviation, minimum score, and maximum score. The mean score was calculated using:

$$\bar{X} = \frac{\sum X}{N}$$

where:
$\bar{X}$= mean score, $\sum X$= total score
N= number of participants.
The standard deviation formula is:

$$SD = \sqrt{\frac{\sum (X - \bar{X})^2}{N - 1}}$$

where:
SD= standard deviation
X= individual score.

E. Normality Test

A normality test was conducted before hypothesis testing using the Shapiro–Wilk test, as the sample size was below 50. Decision criteria: If $p > 0.05$, data are normally distributed. If $p < 0.05$, data are not normally distributed.

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F. Hypothesis Testing

To determine whether e-learning significantly improved learning outcomes, a paired sample t-test was used to compare pretest and posttest scores. The paired t-test formula is:

$$t = \frac{\bar{D}}{S_D/\sqrt{n}}$$

where:
t= t-value
$\bar{D}$= mean difference between pretest and posttest scores
S_D= standard deviation of differences
n= sample size.

The hypotheses were: H_0: E-learning does not significantly improve students' learning outcomes. H_1 : E-learning significantly improves students' learning outcomes.

G. Normalized Gain (N-Gain)

To measure learning improvement, the normalized gain score was calculated using:

$$N\text{-}Gain = \frac{Posttest - Pretest}{Maximum\ Score - Pretest}$$

Table 1. Presents the N-Gain criteria

N-Gain Score	Category
$g \geq 0.70$	High
$0.30 \leq g < 0.70$	Medium
$g < 0.30$	Low

Source: Adapted from Hake (1999).

H. Effect Size Analysis

To determine the magnitude of the treatment effect, Cohen's d was calculated as follows:

$$d = \frac{M_2 - M_1}{SD_{pooled}}$$

where:
d= effect size,
M_1= pretest mean,
M_2= posttest mean.

Interpretation: 0.20 = small effect, 0.50 = medium effect, and 0.80 or above = large effect. Thus, the combination of statistical significance, N-

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Gain, and effect size analysis provided a comprehensive evaluation of the impact of e-learning on students' learning outcomes.

RESULTS AND DISCUSSION

This study examined the effect of e-learning implementation on students' learning outcomes in ICT-based courses using a one-group pretest–posttest experimental design involving 43 students from the Information Technology Study Program.

A. Descriptive Statistics of Pretest and Posttest Scores

Descriptive statistics were calculated to compare students' academic performance before and after the implementation of e-learning.

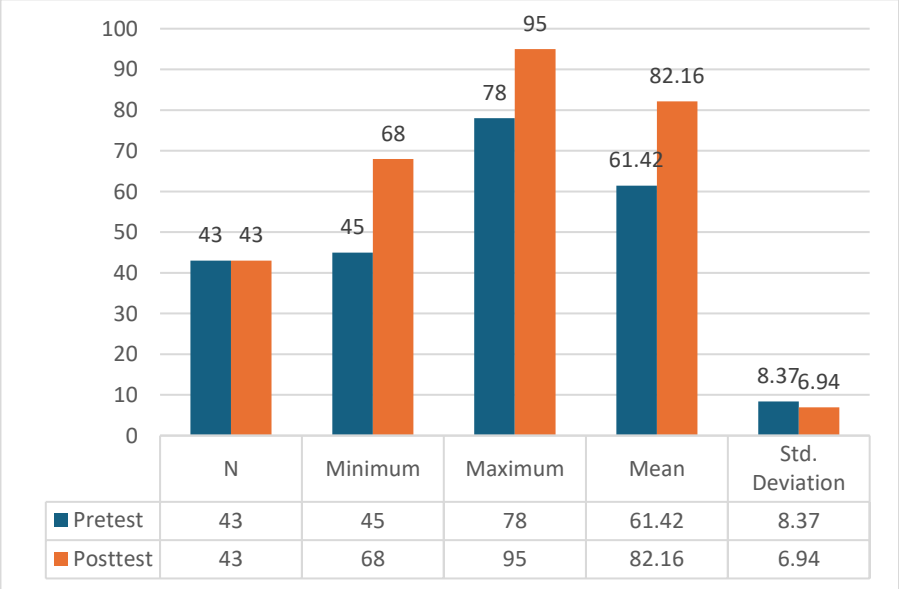

Figure 1. Descriptive Statistics of Students' Learning Outcomes

Figure 1 shows that the mean pretest score was 61.42, indicating a moderate level of initial knowledge in ICT-based courses. After the e-learning intervention, the mean posttest score increased to 82.16. The improvement of 20.74 points suggests a substantial increase in students' learning achievement following the implementation of e-learning. In addition, the posttest standard deviation (6.94) was lower than the pretest standard deviation (8.37), indicating that students' performance became more consistent after participating in e-learning activities.

B. Normality Test

Before hypothesis testing, a normality test was conducted using the Shapiro–Wilk test.

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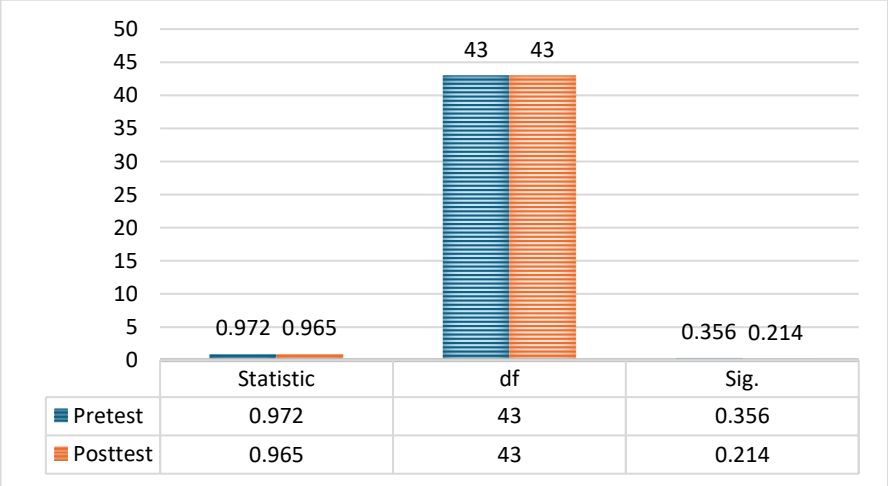

Figure 2. Normality Test Results

Based on Figure 2, the significance values for both pretest (0.356) and posttest (0.214) were greater than 0.05. Therefore, the data were normally distributed, and parametric analysis using the paired sample t-test was considered appropriate.

C. Paired Sample t-Test

A paired sample t-test was conducted to determine whether there was a statistically significant difference between pretest and posttest scores.

Table 2. Paired Sample t-Test Results

Variable Comparison	Mean Difference	Std. Deviation	t	df	Sig. (2-tailed)
Posttest – Pretest	20.74	7.12	19.10	42	0.000

Source: Author's analysis using IBM SPSS Statistics (2026)

As shown in Table 2, the significance value was 0.000 ($p < 0.05$), indicating a statistically significant difference between pretest and posttest scores. Therefore, the null hypothesis (H_0) was rejected, and the alternative hypothesis (H_1) was accepted. These results demonstrate that e-learning significantly improved students' learning outcomes in ICT-based courses.

D. N-Gain Analysis

To determine the level of learning improvement, normalized gain (N-Gain) analysis was performed.

Table 3. N-Gain Score Analysis

Indicator	Value
Mean Pretest Score	61.42
Mean Posttest Score	82.16
Maximum Score	100
Mean N-Gain	0.54
Category	Medium

Source: Author's calculation; N-Gain interpretation adapted from Hake (1999).

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The mean N-Gain score was 0.54, which falls within the medium improvement category. This finding indicates that e-learning produced a moderate but meaningful increase in students' mastery of ICT course materials.

E. Effect Size Analysis

To measure the magnitude of the treatment effect, Cohen's d was calculated.

Table 4. Effect Size Result

Statistic	Value
Cohen's d	1.35
Interpretation	Large Effect

Source: Author's calculation; interpretation adapted from Cohen (1988).

The effect size analysis produced a Cohen's d value of 1.35, indicating a large effect size. This suggests that the e-learning intervention had not only statistical significance but also substantial practical significance in improving student learning outcomes.

F. Discussion

The findings of this study demonstrate that e-learning significantly improves students' learning outcomes in ICT-based courses. This conclusion is supported by the increase in mean scores from pretest to posttest, as well as the paired sample t-test results indicating a statistically significant difference in students' academic performance before and after the e-learning intervention ($p < 0.05$). In addition, the N-Gain result indicates a moderate level of learning improvement, while the large Cohen's d effect size confirms that the intervention produced substantial practical benefits in the learning process.

These findings suggest that e-learning provides an effective instructional environment for ICT-based courses, which are inherently aligned with digital platforms and technology-mediated instruction. Unlike conventional face-to-face learning, e-learning enables students to access learning materials flexibly, revisit instructional content repeatedly, and engage with multimedia resources that accommodate diverse learning preferences. In ICT-related subjects, where students are expected to develop both conceptual understanding and digital competencies, such flexibility is particularly advantageous (Anthony et al., 2019; Mustaqim et al., 2025; Tham et al., 2005).

One possible explanation for the improvement in learning outcomes is the integration of interactive learning features within the e-learning environment. Discussion forums, online quizzes, digital assignments, and multimedia instructional materials may have enhanced student engagement and promoted active learning behaviors. Previous studies have

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shown that interactive digital learning environments improve academic achievement by increasing learner autonomy, supporting self-regulated learning, and providing immediate feedback during the learning process (Ellis et al., 2009; Martins et al., 2025; Teo et al., 2020).

The results of this study are consistent with prior research reporting the positive impact of e-learning on student academic performance. Previous studies have found that e-learning increases accessibility to learning resources, encourages autonomous learning behaviors, and improves time management, learning independence, and technological literacy in higher education contexts (Encarnacion et al., 2021; Halomoan et al., 2024; Hakiki et al., 2024; Rais et al., 2025).

Although e-learning significantly improved student performance, the moderate N-Gain result suggests that learning gains did not reach the high category. This indicates that the effectiveness of e-learning may still be influenced by several contextual and instructional factors, including students' digital readiness, internet accessibility, learning discipline, and instructional design quality. Some students may require additional support in adapting to self-directed online learning environments, particularly in maintaining learning consistency and motivation over time.

More specifically, the moderate improvement observed in this study may be associated with instructional design characteristics of the implemented e-learning model. The intervention primarily emphasized content accessibility, online assignments, and digital assessments, which effectively supported knowledge acquisition but may not have fully optimized higher-order learning processes such as problem-solving, reflection, and collaborative knowledge construction. In addition, limited synchronous interaction between lecturers and students may have reduced opportunities for immediate feedback, clarification, and deeper conceptual engagement.

Although multimedia learning materials were integrated into the platform, the level of interactivity may still be further enhanced through virtual simulations, adaptive feedback systems, collaborative projects, and project-based learning activities. These instructional components are particularly important in ICT-based courses, where practical engagement, iterative experimentation, and active problem-solving are central to competency development.

The large effect size further indicates that the observed improvement was not only statistically significant but also educationally meaningful. This finding strengthens the argument that e-learning should not be viewed merely as a supplementary or emergency instructional tool, but rather as a viable pedagogical strategy for ICT-based disciplines. Since ICT courses naturally involve digital interaction, software utilization, and technology-supported problem-solving, the integration of e-learning may offer both academic and professional advantages for students.

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From a practical perspective, these findings have important implications for higher education institutions. Universities should optimize e-learning implementation by improving learning management systems, ensuring reliable digital infrastructure, and providing lecturer training in effective online instructional design (Sulčič & Lesjak, 2009). The effectiveness of e-learning is likely to increase when digital platforms are supported by pedagogically sound practices, including collaborative learning activities, formative assessments, timely feedback, and meaningful learner interaction (Siritongthaworn et al., 2006; Trisnawati et al., 2025).

Despite these contributions, this study has several limitations. First, the research employed a one-group pretest–posttest design without a control group, which limits the ability to compare the intervention against traditional instructional methods under equivalent conditions. Although several measures were implemented to reduce threats to internal validity, such as using the same instructor, materials, assessment instruments, and instructional duration, the absence of a control group remains a methodological limitation. Second, the sample was limited to students from a single Information Technology Study Program, which may restrict the generalizability of findings across other disciplines or institutional contexts.

Future research is recommended to employ true experimental or quasi-experimental designs involving control groups and larger multi-institutional samples to strengthen causal evidence. Further studies should also examine which instructional design components such as multimedia interactivity, synchronous learning, adaptive feedback, and collaborative activities most strongly contribute to learning gains in ICT-based e-learning environments. Overall, the findings provide empirical support for the effectiveness of e-learning in ICT-based courses and reinforce its relevance as an instructional approach in contemporary higher education.

CONCLUSION

This study investigated the effectiveness of e-learning in improving students' learning outcomes in ICT-based courses using a quantitative experimental approach with a one-group pretest–posttest design. The findings demonstrated that the implementation of e-learning contributed to a significant improvement in students' academic performance. The statistical analysis confirmed that there was a significant difference between students' learning outcomes before and after the e-learning intervention, indicating that e-learning had a positive effect on academic achievement. The results further suggest that e-learning not only supports measurable improvements in student performance but also provides meaningful practical benefits in the learning process. These findings indicate that e-learning is an effective instructional approach for ICT-based courses, as the nature of such courses is highly compatible with digital learning environments. The flexibility of online access, the availability of multimedia resources, interactive learning features, and opportunities for self-

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paced learning appear to contribute positively to students' academic development. This study contributes to the growing literature on digital education by providing experimental evidence regarding the effectiveness of e-learning in technology-oriented higher education contexts. The findings also offer practical implications for universities and educators in designing and implementing more effective online learning strategies, particularly in ICT-related disciplines. However, this study has several limitations, including the absence of a control group and the limited sample scope from a single study program. Future research is therefore recommended to involve larger and more diverse samples, apply more rigorous experimental designs, and examine additional factors such as student motivation, digital literacy, and learning engagement. Overall, e-learning can significantly enhance learning outcomes in ICT-based courses and represents a promising pedagogical strategy for improving the quality of higher education in the digital era.

RECOMMENDATIONS

Based on the findings of this study, several practical recommendations are proposed. Higher education institutions should strengthen the implementation of e-learning in ICT-based courses by improving digital infrastructure, ensuring reliable internet access, and providing accessible learning management systems. In addition, lecturers are encouraged to develop more effective online instructional strategies by integrating multimedia resources, interactive assessments, discussion forums, and collaborative learning activities. These approaches may increase student engagement, motivation, and independent learning. Universities should also provide continuous training for lecturers to improve their competencies in online pedagogy, digital content development, and e-learning management. Effective implementation of e-learning depends not only on technology availability but also on sound instructional design.

FURTHER RESEARCH

Future studies are recommended to employ quasi-experimental or true experimental designs involving control groups to provide stronger evidence regarding the causal effect of e-learning on student learning outcomes. In addition, further research should investigate which instructional design components—such as multimedia interactivity, feedback mechanisms, synchronous learning sessions, and collaborative activities—most strongly influence student learning gains in ICT-based courses.

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