

How E-Learning Improves Academic Achievement among Taxation Students: Experimental Evidence from an Open University Context

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Abstract

The rapid adoption of digital learning technologies has transformed higher education, particularly in open and distance learning institutions. However, empirical evidence on the effectiveness of e-learning in taxation education remains limited. This study examined the impact of e-learning on the academic achievement of taxation students at Universitas Terbuka, Indonesia. Using a quantitative experimental approach with a one-group pretest–posttest design, the study involved 218 undergraduate taxation students. Academic achievement was measured through a standardized achievement test administered before and after the e-learning intervention. Data were analyzed using descriptive statistics, the paired-samples *t*-test, normalized gain (*N*-Gain), and Cohen's *d* effect size. The results demonstrated a significant improvement in students' academic achievement after participation in e-learning activities. The mean score increased from 63.84 (*SD* = 8.72) to 82.67 (*SD* = 7.95), with the paired-samples *t*-test indicating a statistically significant difference $t(217) = 29.47, p < 0.001$. The *N*-Gain score of 0.52 indicated a moderate level of learning improvement, while Cohen's *d* value of 2.26 reflected a large practical effect. These findings suggest that e-learning effectively enhances students' understanding of taxation concepts and problem-solving skills. This study contributes to the literature by providing experimental evidence from taxation education in an open university context and highlights the potential of e-learning to improve academic achievement in distance higher education.

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Introduction

The digital transformation of higher education has fundamentally reshaped the way learning is delivered, accessed, and experienced. Among the most significant developments in this transformation is the widespread adoption of e-learning, which enables educational institutions to provide flexible, technology-mediated learning opportunities beyond the constraints of time and geographical location [1]-[2]. The increasing reliance on digital learning environments has become particularly important in open and distance universities, where technology serves as the primary medium for instructional delivery, learner interaction, assessment, and academic support [3]. As higher education institutions continue to expand access to lifelong learning and professional education, understanding how

e-learning contributes to student success has become a critical research and policy priority [4]-[5].

Existing literature generally suggests that e-learning has the potential to improve academic performance by facilitating self-paced learning, continuous access to learning resources, interactive content delivery, and collaborative learning experiences. Studies have demonstrated positive associations between e-learning engagement, self-regulated learning, learner satisfaction, and academic achievement in higher education settings [6]. Furthermore, recent evidence indicates that digital learning environments can enhance learning outcomes when supported by effective instructional design, active learning strategies, and meaningful learner interaction. Meta-analytic findings also reveal a positive relationship between online learning engagement and learning outcomes, emphasizing the importance of learner participation in achieving academic success [7], [8].

Despite these promising findings, the effectiveness of e-learning remains a subject of ongoing debate. Several studies have reported significant improvements in academic achievement through online and distance learning environments, whereas others have identified limited effects, contextual variations, or even performance gaps compared with conventional instructional approaches. Research comparing online and face-to-face learning has produced inconsistent results, suggesting that the impact of e-learning is highly dependent on institutional context, course characteristics, learner readiness, and instructional quality. Consequently, the question is no longer whether e-learning works, but rather under what conditions and for whom it produces meaningful improvements in academic achievement [10], [11].

A closer examination of previous studies reveals several important gaps. First, most e-learning studies have been conducted in general higher education contexts, focusing on broad student populations from diverse academic disciplines. Comparatively little attention has been devoted to taxation education, despite its distinctive pedagogical characteristics. Taxation courses require students to master complex regulations, interpret continuously evolving policies, perform quantitative analyses, and apply conceptual knowledge to authentic fiscal problems. These learning demands necessitate repeated practice, immediate feedback, and continuous access to learning resources, all of which may be facilitated by well-designed e-learning environments. However, empirical evidence specifically addressing the effectiveness of e-learning in taxation education remains scarce [12], [13].

Second, a substantial proportion of prior studies have employed cross-sectional survey designs that primarily examine perceptions, attitudes, satisfaction, technology acceptance, or behavioral intentions toward e-learning. While these studies contribute valuable insights regarding learner experiences, they provide limited evidence concerning the causal relationship between e-learning implementation and academic achievement. Recent studies continue to rely heavily on correlational and structural equation modeling approaches, emphasizing factors associated with online learning outcomes rather than directly testing whether e-learning interventions improve student performance. As a result, the causal



mechanisms through which e-learning influences learning achievement remain insufficiently understood [14].

Third, there is a notable contextual gap in the literature concerning open and distance universities. Most empirical investigations have been conducted in conventional universities where online learning functions as a supplementary or blended instructional strategy. In contrast, students enrolled in open universities depend extensively on digital learning systems as the primary means of educational engagement. Consequently, findings derived from traditional higher education institutions cannot necessarily be generalized to open and distance learning environments. Given the increasing global importance of distance higher education, more context-specific evidence is needed to understand how e-learning contributes to academic success within institutions where online learning constitutes the core instructional infrastructure [15], [16].

Beyond empirical limitations, a theoretical gap also remains evident. Existing studies have frequently examined e-learning from technology adoption perspectives, such as the Technology Acceptance Model (TAM) and Unified Theory of Acceptance and Use of Technology (UTAUT), focusing primarily on users' intentions and acceptance behaviors. While these frameworks explain technology utilization, they offer limited insight into how technology-mediated learning environments directly influence academic achievement [16-18]. Constructivist learning theory suggests that meaningful learning occurs when students actively construct knowledge through interaction, reflection, and engagement. Similarly, the Community of Inquiry framework emphasizes the integration of cognitive presence, social presence, and teaching presence as essential conditions for successful online learning. However, relatively few studies have empirically examined the extent to which e-learning environments grounded in these pedagogical principles contribute directly to measurable academic achievement among taxation students in distance higher education settings [17-20].

The present study addresses these gaps by investigating the effect of e-learning on academic achievement among taxation students enrolled in an open university context. This study contributes to the literature in several important ways. First, it extends e-learning research into taxation education, an academic field that remains underrepresented in the digital learning literature despite its growing professional relevance. Second, it shifts the focus from learner perceptions and technology acceptance toward objective academic achievement outcomes. Third, it provides evidence from an open university environment where e-learning functions as the principal mode of instruction rather than a supplementary learning tool. Fourth, it contributes to the growing body of research seeking to explain how technology-enhanced learning environments support academic success in distance higher education. Finally, by focusing on taxation students in Indonesia's open university system, this study enriches the predominantly Western-centric literature with evidence from a developing-country context, thereby improving the generalizability of e-learning scholarship.

The novelty of this study lies in its integration of three underexplored dimensions within a single investigation: (1) the examination of academic achievement rather than technology acceptance or learner satisfaction as the primary outcome; (2) the focus on taxation students, a specialized academic



population characterized by unique cognitive and professional learning demands; and (3) the investigation within an open university context where e-learning constitutes the dominant instructional ecosystem. These dimensions collectively provide a distinctive contribution to contemporary e-learning research and offer practical implications for improving instructional quality in distance higher education. Based on the identified research gaps and theoretical considerations, this study seeks to answer the following research questions:

- Does e-learning significantly improve the academic achievement of taxation students in an open university context?
- To what extent does participation in e-learning-based instruction influence students' academic achievement?
- How can e-learning contribute to enhancing learning effectiveness in taxation education within distance higher education environments?

Addressing these questions is expected to advance theoretical understanding of technology-enhanced learning while providing empirical evidence to inform the design and implementation of effective e-learning practices in open and distance higher education.

Literature Review

A. E-Learning in Higher Education

E-learning has become a central component of contemporary higher education, transforming traditional instructional practices into more flexible, technology-enhanced learning environments. Broadly defined, e-learning refers to the use of digital technologies, internet-based platforms, and electronic resources to facilitate teaching, learning, communication, and assessment processes [5]. The increasing integration of learning management systems (LMS), multimedia content, virtual classrooms, and online collaborative tools has expanded opportunities for students to access educational resources regardless of temporal and geographical limitations. In higher education, e-learning is increasingly recognized not merely as a technological innovation but as a pedagogical approach capable of promoting active, student-centered learning. Unlike conventional teacher-centered instruction, e-learning environments encourage learners to engage with educational content independently, participate in collaborative knowledge construction, and regulate their own learning processes. Consequently, e-learning has become particularly important in distance and open universities where instructional delivery relies heavily on digital platforms [6-9].

The effectiveness of e-learning is often attributed to its capacity to provide flexibility, accessibility, interactivity, and personalization. Students can review learning materials repeatedly, access resources at their convenience, and participate in learning activities that accommodate individual learning preferences. Such characteristics are particularly valuable in higher education contexts where learners possess diverse educational backgrounds, professional commitments, and learning needs [10], [12]. Despite these advantages, researchers have emphasized that the educational effectiveness of e-learning depends not solely on technological infrastructure but also on instructional design quality, learner engagement, academic



support systems, and opportunities for meaningful interaction. Therefore, understanding the mechanisms through which e-learning influences learning outcomes remains a critical area of educational research [2-5].

B. Academic Achievement in Distance Higher Education

Academic achievement represents one of the most important indicators of educational effectiveness and student success. In higher education research, academic achievement generally refers to the extent to which students attain intended learning outcomes, often measured through examination scores, course grades, competency assessments, or overall academic performance. Within distance higher education, academic achievement is influenced by a complex interaction of cognitive, motivational, technological, and environmental factors [7-9]. Unlike traditional face-to-face learning environments, distance learners are expected to demonstrate greater autonomy, self-discipline, and responsibility for managing their learning activities. Consequently, successful academic performance in online learning settings often requires students to effectively regulate their learning processes, maintain motivation, and actively engage with instructional materials [15-19].

Previous studies have identified several determinants of academic achievement in online learning environments, including learning engagement, self-regulated learning, digital literacy, technological readiness, and instructional support. Among these factors, access to well-designed e-learning environments has consistently emerged as an important contributor to student success. E-learning platforms that provide interactive content, timely feedback, collaborative opportunities, and flexible learning pathways can facilitate deeper cognitive processing and improve learning outcomes [6-9]. For taxation students, academic achievement is particularly significant because taxation education requires mastery of conceptual knowledge, procedural understanding, analytical reasoning, and practical problem-solving skills. Students must not only understand tax regulations and fiscal principles but also apply this knowledge to real-world scenarios. Therefore, educational approaches that enhance understanding, practice opportunities, and learner engagement are expected to contribute positively to academic achievement [18], [21].

C. Constructivist Learning Theory and E-Learning

The present study is grounded in Constructivist Learning Theory, which posits that knowledge is actively constructed by learners through interaction with their environment rather than passively transmitted from instructor to student. According to constructivist perspectives, meaningful learning occurs when students engage in exploration, reflection, collaboration, and problem-solving activities that facilitate knowledge construction. E-learning environments provide numerous opportunities to operationalize constructivist learning principles [17-21]. Digital learning platforms enable students to access diverse information sources, participate in interactive learning activities, engage in discussions, and receive immediate feedback. These features encourage active participation and facilitate deeper cognitive engagement with learning content [22].



From a constructivist perspective, technology serves not merely as a medium for content delivery but as a cognitive tool that supports knowledge construction and critical thinking. Students become active participants in the learning process, assuming responsibility for exploring concepts, solving problems, and applying knowledge to authentic situations [18]. This active engagement is expected to improve learning outcomes and academic achievement. In taxation education, constructivist learning is particularly relevant because students must develop the ability to interpret regulations, analyze fiscal cases, and apply taxation concepts to practical contexts. E-learning environments that support inquiry, discussion, and authentic problem-solving can facilitate these higher-order cognitive processes and contribute to improved academic performance [4-6].

D. Community of Inquiry Framework

The Community of Inquiry (CoI) framework provides an important theoretical lens for understanding learning effectiveness in online environments. Developed by Garrison, Anderson, and Archer, the framework proposes that successful online learning emerges through the interaction of three core dimensions: cognitive presence, social presence, and teaching presence. Cognitive presence refers to learners' ability to construct meaning through sustained reflection and discourse. Social presence reflects participants' ability to communicate openly, establish relationships, and develop a sense of community. Teaching presence encompasses instructional design, facilitation, and guidance provided by instructors throughout the learning process [4-9].

Within e-learning environments, these three dimensions interact to create meaningful educational experiences. Well-designed online courses provide opportunities for critical inquiry, collaborative learning, and instructor support, thereby fostering deeper engagement and knowledge construction [11-12]. Research consistently indicates that stronger cognitive, social, and teaching presence contributes positively to learner satisfaction, engagement, and academic performance. For taxation students, the Community of Inquiry framework is particularly relevant because learning taxation often involves collaborative problem-solving, interpretation of complex regulations, and instructor guidance in applying theoretical concepts. E-learning platforms that effectively integrate cognitive, social, and teaching presence can therefore facilitate improved academic achievement.

E. Empirical Studies on E-Learning and Academic Achievement

A growing body of empirical research has examined the relationship between e-learning and academic achievement. Numerous studies have reported positive effects of e-learning on student performance, suggesting that technology-enhanced learning environments can improve knowledge acquisition, engagement, and learning outcomes. Several investigations have demonstrated that students participating in online or blended learning environments often achieve academic outcomes equal to or better than those in traditional classrooms [8], [9]. Researchers attribute these improvements to increased learning flexibility, enhanced access to learning resources, personalized learning opportunities, and greater learner autonomy.



Meta-analytic evidence further supports the positive impact of e-learning on academic achievement, indicating that interactive digital learning environments contribute to improved cognitive outcomes across various educational contexts [15], [16]. However, findings remain inconsistent. Some studies have reported minimal or non-significant effects, highlighting the influence of contextual factors such as course design, learner characteristics, technological infrastructure, and instructional quality. Moreover, most existing studies focus on general higher education populations, medical education, engineering, business, or teacher education. Research specifically examining taxation students remains extremely limited. Likewise, relatively few studies have investigated e-learning effectiveness within open university contexts where online learning serves as the primary instructional mode. These limitations indicate the need for further research examining the role of e-learning in specialized academic disciplines and distance education environments.

F. Research Gap and Conceptual Framework

The literature review reveals three significant gaps. First, empirical evidence regarding the effectiveness of e-learning in taxation education remains limited despite the increasing importance of digital learning in professional and vocational disciplines. Second, previous studies have predominantly emphasized technology acceptance, learner satisfaction, and engagement rather than objective academic achievement outcomes. Third, insufficient attention has been given to open university contexts where e-learning functions as the principal learning environment. Addressing these gaps, the present study investigates how e-learning contributes to academic achievement among taxation students in distance higher education. Guided by Constructivist Learning Theory and the Community of Inquiry framework, the study assumes that e-learning facilitates active knowledge construction, meaningful interaction, and enhanced learning engagement, which ultimately contribute to improved academic achievement.

Methodology

A. Research Design

This study employed a quantitative approach using a pre-experimental design with a one-group pretest–posttest format. The design was selected to examine the effectiveness of e-learning in improving the academic achievement of taxation students in a distance higher education environment. The research involved measuring students' academic achievement before and after participation in e-learning-based instruction. The one-group pretest–posttest design can be represented as follows:

$$O_1 \text{ X } O_2$$

Where:

O_1 = Pre-test score (before e-learning intervention)

X = E-learning-based instruction

O_2 = Post-test score (after e-learning intervention)



This design enables the researcher to determine whether significant differences exist between students' academic achievement before and after exposure to e-learning.

B. Participants and Sampling Technique

The target population of this study consisted of undergraduate students enrolled in the Taxation Study Program at Universitas Terbuka, Indonesia, one of the largest open and distance learning institutions in Southeast Asia. As a distance higher education institution, Universitas Terbuka utilizes a comprehensive e-learning ecosystem that enables students to access digital learning resources, participate in online discussions, complete assignments, take assessments, and communicate with instructors through a Learning Management System (LMS). A total of 218 undergraduate taxation students participated in this study. The participants were selected using purposive sampling, a non-probability sampling technique commonly employed in educational intervention studies to identify individuals who meet specific research requirements and possess relevant experience with the phenomenon under investigation. This approach was considered appropriate because the study aimed to evaluate the effectiveness of e-learning among students who had actively engaged in online learning activities and completed all stages of the instructional intervention.

The sample size of 218 participants was considered adequate for experimental educational research and provided sufficient statistical power to detect meaningful differences between pretest and posttest academic achievement scores. Furthermore, the sample exceeded the minimum recommendation for paired-sample statistical analysis, thereby enhancing the reliability and robustness of the findings. [Table 1](#) summarizes the demographic characteristics of the participants.

Table 1. Demographic Characteristics of Participants (N = 218)

Characteristics	Frequency (n)	Percentage (%)
Gender		
Male	96	44.0
Female	122	56.0
Semester Level		
Semester 3	68	31.2
Semester 5	79	36.2
Semester 7	71	32.6
Total	218	100

C. Research Instrument

The primary instrument used in this study was an Academic Achievement Test designed to measure students' learning outcomes in taxation courses. The test was developed based on the learning outcomes of the Taxation Study Program at Universitas Terbuka and covered key competencies, including taxation concepts, tax regulations, tax calculations, case analysis, and problem-solving skills.

The instrument consisted of 30 items, comprising 25 multiple-choice questions and 5 case-based problem-solving questions, distributed across the



cognitive levels of Bloom's Revised Taxonomy. The test was administered twice: as a pretest before the implementation of e-learning and as a posttest after the intervention. Scores ranged from 0 to 100, with higher scores indicating greater academic achievement. The [Table 2](#) presents the academic achievement test instruments

Table 2. Blueprint of the Academic Achievement Test

Dimension	Indicator	Cognitive Level	Items
Taxation Concepts	Understanding fundamental taxation principles	C1–C2	6
Tax Regulations	Interpreting taxation laws and regulations	C2–C3	5
Tax Calculation	Performing taxation calculations	C3	7
Tax Analysis	Analyzing taxation cases	C4	7
Problem Solving	Solving authentic taxation problems	C4–C5	5
Total			30

D. Data Analysis

Data were analyzed using **IBM SPSS Statistics version 29**. The analysis aimed to examine the effectiveness of e-learning in improving taxation students' academic achievement. The analytical procedures consisted of descriptive statistics, assumption testing, hypothesis testing, learning gain analysis, and effect size estimation.

1. Descriptive Statistics

Descriptive statistics were used to summarize students' academic achievement scores before and after the e-learning intervention. The analysis included the mean, standard deviation, minimum score, and maximum score. The mean score was calculated using:

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

Where: $\bar{X}$ is the mean score, $\sum X$ is the total score, and N is the number of participants. The standard deviation was calculated as:

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

Where: SD represents the standard deviation, X is an individual score, and N is the sample size.

2. Assumption Testing

Prior to hypothesis testing, the normality of pretest and posttest scores was assessed using the Shapiro–Wilk test. Data were considered normally distributed when the significance value exceeded 0.05 ($p > 0.05$). Since the study employed a pretest–posttest experimental design with related samples, normality testing was necessary to justify the use of parametric statistical procedures.

3. Hypothesis Testing

To determine whether e-learning significantly improved students' academic achievement, a paired-samples t-test was conducted to compare pretest and post-test scores.

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

Where: $\bar{D}$ = mean difference between pretest and posttest scores, S_D = standard deviation of the difference scores, n = number of participants. The hypotheses were formulated as follows: H_0 : There is no significant difference between pretest and posttest scores. H_1 : There is a significant difference between pretest and posttest scores. The null hypothesis was rejected when $p < 0.05$.

4. Learning Gain Analysis

To evaluate the magnitude of learning improvement, the Normalized Gain (N-Gain) score was calculated:

$$g = \frac{\text{Posttest} - \text{Pretest}}{100 - \text{Pretest}}$$

The effectiveness criteria (Table 3) were interpreted as follows:

Table 3. Effectiveness Criteria

N-Gain Score	Interpretation
$g \geq 0.70$	High
$0.30 \leq g < 0.70$	Moderate
$g < 0.30$	Low

The N-Gain analysis provides evidence regarding the extent to which students' academic achievement improved after the intervention.

5. Effect Size Analysis

To complement statistical significance testing, Cohen's d was calculated to determine the practical significance of the e-learning intervention.

$$d = \frac{\bar{X}_{post} - \bar{X}_{pre}}{SD_{pooled}}$$

where:

$$SD_{pooled} = \sqrt{\frac{SD_{pre}^2 + SD_{post}^2}{2}}$$

The effect size (Table 4) was interpreted according to Cohen's guidelines:

Table 4. Effect size

Effect Size (d)	Interpretation
0.20–0.49	Small
0.50–0.79	Medium
≥ 0.80	Large

The e-learning intervention was considered effective when the following conditions were simultaneously met:

- a. The paired-samples t-test indicated a statistically significant difference between pretest and posttest scores ($p < 0.05$);
- b. The N-Gain score reached at least the moderate category ($g \geq 0.30$);
- c. The effect size demonstrated at least a medium practical effect ($d \geq 0.50$).

This combination of statistical significance, learning gain, and effect size analyses provides robust evidence regarding the effectiveness of e-learning in enhancing academic achievement among taxation students in an open and distance learning environment.

Results and Discussion

A. Descriptive Statistics of Academic Achievement

The primary objective of this study was to investigate the effectiveness of e-learning in improving the academic achievement of taxation students enrolled in an open and distance learning environment. To provide an initial overview of students' performance, descriptive statistics were calculated for both pretest and posttest scores. As shown in [Table 5](#), the mean pretest score was 63.84 (SD = 8.72), indicating a moderate level of prior knowledge before students participated in the e-learning intervention. Following the intervention, the mean posttest score increased substantially to 82.67 (SD = 7.95). This finding reflects an average increase of 18.83 points, suggesting considerable improvement in students' understanding of taxation concepts, regulations, calculations, and case analyses.

Table 5. Descriptive Statistics of Academic Achievement Scores (N = 218)

Test	Mean	SD	Minimum	Maximum
Pretest	63.84	8.72	42	81
Posttest	82.67	7.95	61	98

The reduction in standard deviation from 8.72 to 7.95 further suggests that students' performance became more homogeneous after participating in the e-learning activities. In addition, the increase in both minimum and maximum scores demonstrates that the improvement occurred across students with different academic abilities rather than being limited to a particular subgroup. These findings provide preliminary evidence that e-learning contributed positively to students' academic achievement in taxation courses.

B. Normality Test

Prior to conducting inferential statistical analyses, the normality assumption was assessed using the Shapiro–Wilk test. The results are presented in [Table 6](#).

Table 6. Results of the Shapiro–Wilk Normality Test

Variable	Statistic	df	Sig.
Pretest	0.988	218	0.087
Posttest	0.992	218	0.214

The results indicate that the significance values for both pretest ($p = 0.087$) and posttest ($p = 0.214$) exceeded the threshold value of 0.05.



Therefore, the distributions of both datasets can be considered normal. Since the assumption of normality was satisfied, the use of parametric statistical procedures, specifically the paired-samples t-test, was deemed appropriate for examining differences between pretest and posttest scores.

C. Effect of E-Learning on Academic Achievement

To determine whether participation in e-learning significantly improved students' academic achievement, a paired-samples t-test was conducted (Table 7).

Table 7. Paired-Samples t-Test Results

Variable	Mean Difference	SD Difference	t	df	p
Posttest Pretest	– 18.83	9.42	29.47	217	<0.001

The analysis revealed a statistically significant difference between pretest and posttest scores, $t(217) = 29.47$, $p < 0.001$. The mean difference of 18.83 points indicates that students achieved substantially higher scores after participating in the e-learning intervention. The magnitude of the t-value suggests that the observed improvement was not attributable to random variation but reflected a genuine educational effect. Consequently, the null hypothesis stating that there is no significant difference between pretest and posttest scores was rejected. These findings demonstrate that e-learning significantly enhanced taxation students' academic achievement within the context of open and distance higher education.

D. Learning Gain Analysis

Although statistical significance indicates whether an improvement occurred, it does not reveal the extent of learning progress achieved by students. Therefore, the normalized gain (N-Gain) score (Table 8) was calculated. The average N-Gain score obtained was 0.52, which falls within the moderate category. This result indicates that students achieved approximately 52% of the maximum possible improvement that could be attained based on their initial performance levels.

Table 8. N-Gain Analysis

Indicator	Value
Mean Pretest Score	63.84
Mean Posttest Score	82.67
Mean N-Gain	0.52
Category	Moderate

The moderate N-Gain score suggests that the e-learning intervention was effective in facilitating meaningful learning gains. Students not only improved their factual understanding of taxation concepts but also demonstrated enhanced abilities in applying taxation regulations, performing tax calculations, and solving authentic taxation-related problems. The result is particularly important in the context of distance education, where maintaining student engagement and ensuring learning effectiveness often present substantial challenges.

E. Effect Size Analysis

To assess the practical significance of the intervention, Cohen's d effect size was calculated. The effect size analysis (Table 9) yielded a Cohen's d value of 2.26, which substantially exceeds the threshold for a large effect ($d \geq 0.80$).

Table 9. Effect Size Analysis

Indicator	Value
Mean Pretest	63.84
Mean Posttest	82.67
Pooled SD	8.35
Cohen's d	2.26
Interpretation	Large Effect

This finding indicates that the improvement in students' academic achievement was not only statistically significant but also educationally meaningful. According to Cohen's interpretation, a value greater than 2.00 reflects an exceptionally strong intervention effect. The large effect size suggests that e-learning played a critical role in facilitating knowledge acquisition and skill development among taxation students. The integration of digital learning resources, asynchronous learning opportunities, discussion forums, and online assessments may have contributed to this substantial improvement.

F. Percentage Improvement in Academic Achievement

To provide additional evidence of the intervention's effectiveness, the percentage improvement in academic achievement was calculated. The findings indicate that students' academic achievement increased by 29.50% following participation in the e-learning intervention (Table 10).

Table 10. Percentage Improvement in Academic Achievement

Indicator	Value
Mean Pretest Score	63.84
Mean Posttest Score	82.67
Improvement (%)	29.50

This percentage increase highlights the substantial contribution of e-learning to students' learning outcomes. The improvement suggests that the online learning environment provided students with greater flexibility in accessing instructional materials, reviewing course content, and engaging in self-directed learning activities, all of which are essential characteristics of successful distance education.

G. Summary of E-Learning Effectiveness

To provide a comprehensive overview of the findings, Table 11 summarizes the key indicators used to evaluate the effectiveness of the e-learning intervention.

Table 11. Summary of Research Findings

Indicator	Result	Interpretation
Mean Score Increase	18.83 points	Improved
Paired-Samples t-Test	$p < 0.001$	Significant



Indicator	Result	Interpretation
N-Gain Score	0.52	Moderate
Cohen's d	2.26	Large Effect
Percentage Improvement	29.50%	High Improvement

The combined results of the descriptive, inferential, and effect analyses provide compelling evidence regarding the effectiveness of e-learning in taxation education. The significant increase in posttest scores, moderate N-Gain value, large effect size, and substantial percentage improvement collectively indicate that e-learning serves as an effective instructional approach for enhancing academic achievement among taxation students in an open university context.

Overall, these findings support the growing body of literature suggesting that well-designed e-learning environments can improve student learning outcomes by promoting flexibility, accessibility, learner autonomy, and continuous engagement. The results further demonstrate the potential of e-learning as a sustainable pedagogical strategy for taxation education within open and distance learning institutions.

H. Discussion

This study examined the effectiveness of e-learning in improving the academic achievement of taxation students in an open and distance learning environment. The findings revealed a significant increase in posttest scores, accompanied by a moderate learning gain and a large effect size, indicating that e-learning is an effective instructional approach for enhancing learning outcomes in taxation education [17], [18]. These findings strengthen the growing evidence that technology-enhanced learning environments can support meaningful learning experiences and improve academic performance in higher education [6-9].

The improvement in academic achievement suggests that e-learning provides favorable conditions for knowledge acquisition and skill development. Taxation courses require students to understand complex regulations, perform numerical calculations, and apply taxation principles to real-world cases [15], [20]. The flexibility of e-learning enables students to access learning materials repeatedly, review difficult concepts, and engage in self-paced learning. Such flexibility is particularly valuable in open and distance learning settings, where students often balance academic, professional, and personal responsibilities [19-21].

From a theoretical perspective, the findings support Constructivist Learning Theory, which emphasizes that knowledge is actively constructed through interaction with learning resources and experiences. Through digital content, online discussions, assessments, and independent learning activities, students were encouraged to engage actively with course materials, leading to deeper conceptual understanding and improved application of taxation knowledge [16-19]. The results also align with Self-Regulated Learning (SRL) Theory, which highlights the importance of learners' ability to plan, monitor, and evaluate their learning processes. The e-learning environment facilitated self-regulation through continuous access to learning resources,



self-assessment opportunities, and timely feedback, enabling students to optimize their academic performance [17-21].

The moderate N-Gain score indicates that the intervention generated meaningful educational benefits beyond statistical significance. This finding suggests that e-learning not only improved students' factual knowledge but also strengthened analytical and problem-solving skills that are essential in taxation education. Moreover, the large effect size demonstrates that the impact of e-learning was educationally substantial, confirming that the observed improvements were practically meaningful rather than merely statistical.

The findings are consistent with previous studies reporting positive relationships between e-learning and academic achievement. However, most prior research has focused on general higher education contexts or disciplines such as business, engineering, and health sciences. Evidence from taxation education remains limited. Therefore, this study extends the literature by providing empirical evidence from a specialized discipline characterized by both conceptual and procedural learning demands. In addition, unlike many studies conducted in blended learning settings, this research demonstrates the effectiveness of e-learning within a fully online open university context, where digital learning serves as the primary mode of instruction [12-16].

The findings have important practical implications. Universities should continue investing in robust e-learning infrastructures that promote accessibility, interaction, and learner engagement. Instructors should design interactive learning experiences that encourage active participation, collaboration, and authentic problem-solving [18], [20]. For taxation education, integrating case-based learning, simulations, and automated feedback systems may further enhance students' mastery of taxation competencies and professional skills.

Despite its contributions, this study has several limitations. The use of a one-group pretest–posttest design limits the ability to establish stronger causal relationships, while the focus on a single study program may restrict generalizability. Future research should employ randomized or quasi-experimental designs across multiple institutions and disciplines. Further studies may also investigate the mediating roles of learning engagement, self-regulated learning, digital literacy, and technology acceptance in explaining how e-learning influences academic achievement.

Overall, the findings provide strong empirical evidence that e-learning significantly improves academic achievement among taxation students in an open university context. The significant learning gains and substantial practical effects highlight the potential of well-designed digital learning environments to support academic success and strengthen the quality of open and distance higher education.

Conclusion

This study examined the effectiveness of e-learning in improving the academic achievement of taxation students in an open and distance learning environment. The findings revealed a significant improvement in students'



academic performance after participation in the e-learning intervention. The paired-samples *t*-test indicated a statistically significant difference between pretest and posttest scores, while the N-Gain analysis demonstrated a moderate level of learning improvement. Moreover, the large effect size confirmed that e-learning had a substantial and educationally meaningful impact on students' learning outcomes. The results suggest that e-learning effectively supports the acquisition of taxation knowledge and problem-solving skills by providing flexible access to learning resources, opportunities for self-paced learning, and greater learner autonomy. These findings support the perspectives of Constructivist Learning Theory and Self-Regulated Learning Theory, highlighting the importance of active engagement and independent learning in enhancing academic achievement. This study contributes to the literature by providing empirical evidence from taxation education within a fully online open university context, an area that remains underexplored in e-learning research. Practically, the findings underscore the need for universities and instructors to strengthen digital learning infrastructures and develop interactive, student-centered online learning experiences. Despite its contributions, the study is limited using a one-group pretest–posttest design and a single institutional context. Future research should employ more rigorous experimental designs and examine the roles of learning engagement, digital literacy, and self-regulated learning in explaining the relationship between e-learning and academic achievement. Overall, the findings confirm that e-learning is a viable and effective strategy for enhancing academic success in open and distance higher education.

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Availability of data and materials

The data used in this study are available from the authors upon reasonable request.



Competing interests

The authors declare that there are no competing interests.

Additional information

The authors declare that there is no additional information to report.

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