

ONLINE LEARNING MODEL TO IMPROVE THE STUDENTS' ACHIEVEMENT IN DESIGN OF INFORMATION AND COMMUNICATION TECHNOLOGY

MODELO DE APRENDIZAGEM ONLINE PARA MELHORAR O DESEMPENHO DOS ALUNOS EM PROJETO DE TECNOLOGIA DE INFORMAÇÃO E COMUNICAÇÃO

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ABSTRACT

The rapid advancement of technology and the growing demand for ICT skills have necessitated innovative educational approaches to improve student achievement. Traditional classroom-based teaching often struggles to keep pace with the dynamic and evolving nature of ICT education. The variability in student learning styles and the increasing requirement for digital skills necessitate a flexible and scalable educational model. This study focuses on developing an effective online learning model tailored to enhance student performance in the field of Design of Information and Communication Technology (ICT). The study employed a mixed-methods approach, combining quantitative and qualitative data. Participants included undergraduate students enrolled in an ICT Design course. They were given access to an online learning platform offering interactive video lectures, multimedia resources, assessments, and collaborative projects. Data collection included pre- and post-tests to measure academic performance, surveys to gauge student satisfaction, and focus group discussions to gather qualitative insights into their learning experience. The findings indicated a significant improvement in student achievement, with post-test scores consistently higher than pre-test scores across all participants. The model's flexibility allowed students to learn at their own pace, leading to a deeper understanding of key concepts. Interactive resources and collaborative projects enhanced engagement and fostered critical thinking. Moreover, the majority

of students expressed high satisfaction with the online learning experience, citing the variety of resources, self-paced learning opportunities, and collaborative forums as significant contributors.

Keywords: Online learning model. Student achievement, ICT, Design capabilities.

RESUMO

O rápido avanço da tecnologia e a crescente procura de competências em TIC exigiram abordagens educativas inovadoras para melhorar o desempenho dos alunos. O ensino tradicional baseado em sala de aula muitas vezes luta para acompanhar a natureza dinâmica e evolutiva da educação em TIC. A variabilidade nos estilos de aprendizagem dos alunos e a crescente exigência de competências digitais exigem um modelo educativo flexível e escalável. Este estudo se concentra no desenvolvimento de um modelo de aprendizagem on-line eficaz, adaptado para melhorar o desempenho dos alunos na área de Design de Tecnologia da Informação e Comunicação (TIC). O estudo empregou uma abordagem de métodos mistos, combinando dados quantitativos e qualitativos. Os participantes incluíram estudantes de graduação matriculados em um curso de Design de TIC. Eles tiveram acesso a uma plataforma de aprendizagem on-line que oferece videoaulas interativas, recursos multimídia, avaliações e projetos colaborativos. A coleta de dados incluiu pré e pós-testes para medir o desempenho acadêmico, inquéritos para avaliar a satisfação dos alunos e discussões em grupos focais para recolher conhecimentos qualitativos sobre a sua experiência de aprendizagem. As descobertas indicaram uma melhoria significativa no desempenho dos alunos, com pontuações pós-teste consistentemente mais altas do que pontuações pré-teste em todos os participantes. A flexibilidade do modelo permitiu que os alunos aprendessem em seu próprio ritmo, levando a uma compreensão mais profunda dos principais conceitos. Recursos interativos e projetos colaborativos aumentaram o envolvimento e promoveram o pensamento crítico. Além disso, a maioria dos alunos expressou grande satisfação com a experiência de aprendizagem on-line, citando a variedade de recursos, as oportunidades de aprendizagem individualizadas e os fóruns colaborativos como contribuidores significativos..

Palavras-chave: Modelo de aprendizagem on-line, Desempenho dos alunos, TIC, capacidades de design.

Introduction

Technological advancements have significantly impacted the field of education, particularly with the rise of digital platforms and online learning. While these advancements have increased access to quality education, challenges remain in ensuring that digital approaches effectively meet the academic needs of students, especially in specialized disciplines like Information and Communication Technology (ICT). Research indicates that the COVID-19 pandemic has disrupted traditional teaching methods, raising concerns about the negative impact on student learning during the shift to online education (Gore et al., 2021). Studies emphasize the importance of synchronous and asynchronous class attendance in predicting

academic success in online education, highlighting the flexibility that online learning offers to students (Nieuwoudt, 2020).

Factors such as student satisfaction, engagement, and achievement are critical in the effectiveness of online learning. Structural models have been developed to understand the relationships between course structure, student interaction, instructor presence, and academic outcomes (Kim & Kim, 2021). Additionally, the use of blended learning approaches has been recommended to help students better adapt to online learning environments (Segbenya et al., 2022). Moreover, students' achievement goal orientations have been shown to influence their adoption of self-regulated learning strategies and online learning behaviors, ultimately affecting their academic outcomes (Yeh et al., 2019). Integrating students' learning styles with blended learning approaches has been explored to enhance the effectiveness of digital teaching methods (Shamsuddin & Kaur, 2020).

Interactive learning modules and immersive delivery models have been identified as effective strategies to enhance student engagement and academic achievement in online education (Goode et al., 2022). Collaborative learning tools and cognitive presence have been demonstrated to support students' learning processes in specialized disciplines like mathematics and science (Nungu et al., 2023). While technological advancements have transformed education, addressing challenges to ensure that online learning effectively meets students' academic needs, particularly in specialized fields like ICT, is crucial. By understanding the factors influencing student satisfaction, engagement, and achievement, educators can design more effective online learning experiences to improve student outcomes.

Online learning models have been extensively studied in recent research. Factors influencing student achievement in online learning include course structure, student engagement, instructor presence, and student satisfaction (Kim & Kim, 2021). Additionally, the acceptance of e-learning Web-apps plays a crucial role in enhancing learning outcomes, with ICTv acceptance significantly impacting student performance (Marín-Vinuesa & Rojas-García, 2023). Moreover, the adoption of e-learning post-COVID-19 has led to the development of machine learning models to predict student performance during online classes, with features like activity type

and timing statistics being key predictors (Segbenya et al., 2022). Furthermore, student emotional engagement is vital in online learning, with emotional states like joy and boredom significantly impacting student performance (Brahim, 2022). Overall, positive attitudes towards ICT, autonomous use, and engagement are associated with higher academic performance in online learning environments (Goode et al., 2022).

The traditional classroom setting often poses challenges for teaching technical subjects such as ICT due to limited resources, lack of flexibility, and difficulty in accommodating different learning styles. As educators transition to online models, it's crucial to address issues like student engagement, instructional quality, and the development of collaborative skills, which are pivotal in technology-driven fields. Despite widespread adoption, there remains a gap in the research regarding the efficacy of online learning models specifically designed for technical subjects. Understanding how these models can be optimized to improve student performance in ICT design is imperative.

This study aims to investigate the potential of an online learning model to improve student achievement in the design of ICT by enhancing engagement, collaboration, and personalization. Implement multimedia resources and gamified assessments that encourage active participation, catering to diverse learning styles. Establish virtual workspaces that allow students to collaborate on projects, share insights, and engage in peer learning. Provide personalized feedback using adaptive assessments that help students recognize their strengths and areas for improvement. Train instructors in managing interactive online environments, providing timely feedback, and fostering a supportive learning culture.

Creating virtual workspaces for collaboration is essential in online education to promote interaction and engagement (Nieuwoudt, 2020). Encouraging students to share ideas, participate in peer learning, and collaborate on projects can deepen their grasp of course material and foster a sense of community in the virtual learning environment. Training instructors to effectively manage interactive online environments and offer timely feedback is crucial for the success of online education. Research underscores the multifaceted role of teachers as facilitators,

technology experts, and mentors in online learning (Hadriana et al., 2021). Instructors need to be equipped to cultivate engaging and supportive learning environments that nurture student success. By integrating multimedia resources, gamified assessments, virtual collaboration spaces, and personalized feedback through adaptive assessments, educators can create dynamic and inclusive online learning experiences that cater to diverse learning styles. Properly training instructors to manage interactive online environments and provide timely feedback is vital for cultivating a supportive learning culture and enhancing student outcomes.

This study distinguishes itself by focusing specifically on the field of ICT design, where practical application and collaborative problem-solving are vital. Unlike previous research that examined generic online learning approaches, this study provides unique insights into how tailored online models can be used to maximize student achievement in technical disciplines. The focus on adaptive assessments and virtual collaborative environments offers a nuanced understanding of how these components contribute to knowledge retention, creativity, and practical problem-solving in ICT design.

Theoretical framework and literature review

The rapid advancement of technology has revolutionized education, shifting learning from traditional classrooms to digital platforms. Online learning models represent the pinnacle of this transformation, providing new and innovative ways for students to access education from anywhere, at any time. By offering flexibility and breaking down geographical barriers, online learning has enabled a more inclusive approach to education, benefiting diverse learners globally. However, as these models continue to evolve, understanding their growth, historical roots, and relevance to technical education is crucial.

Historical Progression of Online Education

Distance learning has a rich history dating back to the 19th century with correspondence courses delivered via mail. The advent of the internet in the 1990s ushered in web-based learning, enabling educational institutions to offer virtual

courses through learning management systems (LMS) (Johansen, 2023). This evolution laid the foundation for modern online learning models, which saw significant growth in the early 21st century with the emergence of Massive Open Online Courses (MOOCs) (Kirsten & Greefrath, 2023). MOOCs revolutionized education by providing free and affordable courses from prestigious universities to a global audience, democratizing access to education on an unprecedented scale (Rienties et al., 2023). This sudden transition highlighted the importance of online learning management systems and the utilization of digital platforms to facilitate education during times of crisis. The evolution of online education has been shaped by technological advancements and the need for flexible and accessible learning options, emphasizing the role of online platforms in providing education beyond traditional classroom settings.

Current Global Trends in Online Learning Adoption

The adoption of online learning has rapidly accelerated in recent years, primarily driven by technological advancements and global disruptions like the COVID-19 pandemic. The COVID-19 pandemic has accelerated the integration of online learning into mainstream education, prompting institutions to embrace digital solutions and innovative teaching strategies. This shift has led to substantial investments in digital infrastructure, training, and innovative methodologies for effective virtual teaching (Kim & Kim, 2021). The pandemic-induced transition has also propelled the development and extensive use of new technologies such as video conferencing tools, virtual classrooms, and interactive content, revolutionizing the educational landscape (Segbenya et al., 2022).

As schools and universities continue to navigate the challenges posed by the pandemic, hybrid learning models have emerged as a popular choice, blending the flexibility of digital learning with the advantages of traditional classroom settings (Jamil et al., 2023). This shift has not only transformed educational delivery methods but has also necessitated the exploration of novel teaching approaches and technologies to enhance student engagement and learning outcomes (Müller et al., 2023). The incorporation of hybrid learning models signifies a move towards more adaptable and inclusive educational practices, transcending geographical barriers

and providing learners with diverse opportunities to access education from any location, at any time (Goode et al., 2022). The COVID-19 pandemic has indeed served as a catalyst for the widespread adoption of online learning and the development of hybrid learning models, emphasizing the importance of flexibility and inclusivity in education. This necessitates continuous adaptation and enhancement of virtual teaching methodologies to meet the evolving needs of students in the digital age.

Educational institutions worldwide had to innovate and adapt to ensure continuity in teaching and learning processes during the pandemic, emphasizing the importance of structured online education systems (Criollo-C et al., 2023). The use of technology in education, including web applications and interactive tools, has not only facilitated studying but also contributed to the evolution of teaching methods towards more innovative models. As a result, the educational sector has witnessed a significant digital transformation, paving the way for flexible and hybrid learning approaches that are increasingly gaining popularity.

Importance of ICT Education in the Digital Era

In the digital era, ICT skills have become essential across various industries. Programming, networking, cybersecurity, and systems design are integral to the functioning of modern economies. Effective ICT education helps students build the technical competencies needed to innovate, create, and solve complex challenges in today's interconnected world. ICT education plays a crucial role in shaping job opportunities in the tech sector. Research indicates that the motivation to study IT is often driven by intrinsic interest rather than external factors like salary or job security (Natal et al., 2022). However, gender stereotypes associating technology with men can hinder women's interest in tech-focused education, impacting their career choices (McKenzie & Bennett, 2022). Furthermore, the perception of university teaching staff regarding the capacity of ICTs to meet students' needs influences their attitudes and active behavior towards incorporating ICT tools in the classroom, emphasizing the importance of training educators in ICT knowledge and management (Tellhed et al., 2023). Overall, ICT education not only influences individuals' career choices but also plays a significant role in preparing them for the evolving job opportunities in the tech industry.

Learning is facilitated by participation and interaction, which can occur synchronously or asynchronously in online education. The impact of synchronous and asynchronous class attendance on academic success has been investigated (Nieuwoudt, 2020). During the COVID-19 pandemic, students' perspectives on online learning in distance education have been modeled (Segbenya et al., 2022). College students' achievement goal orientations have been found to predict their expected online learning outcomes, mediated by self-regulated learning strategies and supportive online learning behaviors (Yeh et al., 2019). The importance of online engagement and interactive learning modules on student achievement has been highlighted (Goode et al., 2022). Additionally, collaborative online learning has been shown to enhance cognitive presence in mathematics and science education (Nungu et al., 2023). These studies provide valuable insights for educators aiming to enhance ICT education and promote effective online learning experiences for students.

Role of Online Learning in Delivering Technical Subjects

While delivering technical subjects like ICT online poses challenges due to the need for practical, hands-on learning, digital platforms offer several benefits. Simulations, virtual labs, and collaborative projects allow students to experiment and apply theoretical knowledge in practice. Personalized learning paths and adaptive assessments empower students to pace their learning according to their needs, enhancing their understanding of complex concepts. Online learning also provides access to diverse experts and resources, ensuring students receive comprehensive education in the latest ICT trends and practices.

Digital platforms have revolutionized technical education, offering solutions to challenges in delivering subjects like ICT online. While practical, hands-on learning is crucial, modern platforms provide simulations and virtual labs (Johansen, 2023; Yosep et al., 2023), enabling students to apply theoretical knowledge practically. Features like personalized learning paths and adaptive assessments (Songkram et al., 2023) enhance understanding by allowing students to tailor their learning experience. Additionally, online learning facilitates collaboration with experts and access to diverse resources (Vogt et al., 2022),

ensuring students stay updated on the latest ICT trends. These benefits collectively enrich students' educational experience, bridging the gap between theoretical concepts and practical application in the field of ICT.

Learning is facilitated by participation and interaction, which can occur synchronously or asynchronously in online education (Minhas et al., 2021). Many researchers have explored effective ways to conduct online courses, considering dynamic relationships between variables such as structure and dialogue (Damo & Padagas, 2020). The role of online gadgets is crucial in ensuring successful online facilitation, especially during the COVID-19 pandemic (Adarkwah, 2021). College students' achievement goal orientations, such as mastery-approach (MAP) goals and mastery-avoidance (MAV) goals, predict the adoption of self-regulated learning strategies and supportive online learning behaviors, ultimately influencing students' expected academic outcomes in online courses (Cárdenas-Robledo & Peña-Ayala, 2019). Engagement in online learning, including interactive learning modules and synchronous class attendance, significantly impacts student achievement, particularly in immersive delivery models (Teichert & Isidro, 2022).

Online collaborative learning plays a vital role in enhancing cognitive presence in mathematics and science education, although challenges exist, such as limitations in conducting experiments in online STEM education (Bazelais & Doleck, 2018). Online education has expanded access to high-quality instruction across the globe. Students in remote or underserved areas can now benefit from expert instruction and resources previously unavailable. However, challenges remain regarding internet connectivity and digital literacy in some regions. These trends collectively suggest that online learning will continue to evolve, integrating advanced technologies, flexible learning models, and global resources to cater to the changing demands of learners and educators worldwide

Research design and methods

The selected students in this study were the Elementary School Teacher Education programme at Institut Agama Islam Negeri (IAIN) Metro Lampung. The number of participants was 105 students consisting of 67 female students and 38

male students. All participants had no experience of online learning or online examinations before entering the university. All students had at least one electronic device (personal computer, tablet, mobile phone, laptop, or iPad) with Internet access to follow and participate in the online learning sessions. The students had different demographic profiles and similar educational backgrounds.

Quantitative data is collected from learning outcome files submitted by each student after approval by the lecturer and programme study coordinator. As part of the quality requirements, the department collects data files for each course that include attendance, learning activity reports, quizzes, assignments, midterm and end-of-semester grades. In addition, using a questionnaire instrument, an online 5-point scale (5 = strongly agree; 4 = agree; 3 = neutral; 2 = disagree; 1 = strongly disagree) surveyed student satisfaction and preferences for the academic experience on campus with online learning. This research uses two data collection techniques, namely quantitative data: covering the value or score of student achievement, which can be obtained through pre-test and post-test to assess the improvement of students' abilities before and after the application of the online learning model. Qualitative data: includes student feedback or responses to the learning model, which can be collected through interviews or questionnaires.

The data analysis technique used paired t-test to compare the scores before and after the application of the learning model, as explained in the previous response. The paired t-test is a statistical method used to compare two means of paired data. This technique is particularly useful for assessing differences in outcomes before and after an intervention on the same sample or in situations comparing two similar conditions. Qualitative data such as interview transcripts were coded to facilitate the identification of specific frequencies and patterns relating to students' perceptions and experiences using the online learning model. The triangulation technique is to combine the results of quantitative and qualitative data analysis to strengthen the conclusions.

Results

Respondent demographic data

The sample consisted of 63.61% females and 36.39% males. The majority of the participants had an age range of 20-21 years (51.1%) and the others were in the age range of 22-23 years (31.8%); and over 23 years old (17.1%). The demo chart data of the participants is presented in Table 1.

Table 1 – Participant Demographic Data

Demographic background	Frequency	Percentage (%)
Gender		
Female	67	63.61
Male	38	36.39
Age range		
20-21	54	51.1
22-23	33	31.8
>23	13	17.1
Major Subject		
Primary School teacher education program	105	100

Small group trial results

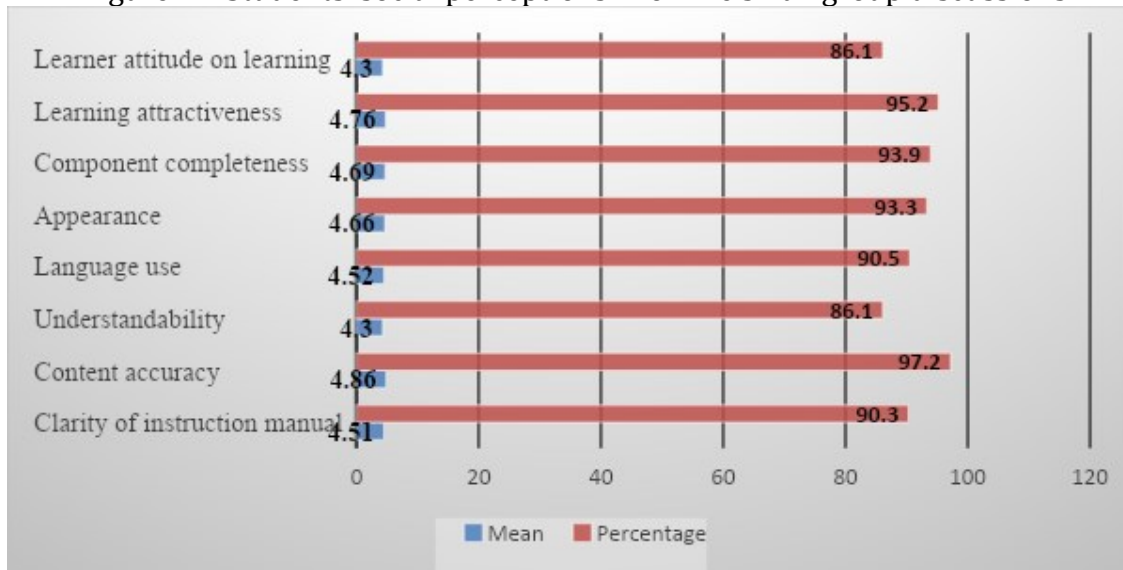
We administered a five-point Likert scale questionnaire that had eight indicators: Clarity of instruction manual, Content accuracy, Understandability, Language use, Appearance, Component completeness, Learning attractiveness, and Learner attitude on learning. Specifically, the questions were aimed at gathering information from students' experiences and perceptions of learning the design of Information and Communication Technology through small group discussions. The findings are presented in Table 2.

Table 2 – The Result of Small Group Trial

Indicator	Mean	Percentage	Category
Clarity of instruction manual	4.51	90.3 %	Excellent
Content accuracy	4.86	97.2 %	Excellent
Understandability	4.30	86.1 %	Excellent
Language use	4.52	90.5 %	Excellent
Appearance	4.66	93.3 %	Excellent
Component completeness	4.69	93.9 %	Excellent
Learning attractiveness	4.76	95.2 %	Excellent
Learner attitude on learning	4.30	86.1 %	Excellent

The results of small group trials on online learning for each indicator are excellent and the average value is 4.57 or 91.50% in the excellent category. Online learning is very interesting, starting from the appearance of the material, the web is not limited by space and time, it is fun and easy to understand. Thus, practical online learning is used for all levels of student competency. Furthermore, the product can be tested on students through a field trial. Reported for each category and supported by observations ascribed to the researcher. The findings revealed that learning through online small group discussions made a significant contribution to student success. Furthermore, the researcher presented the information for each item using grouped bar charts to better understand the participants' perceptions. The bar chart is plotted in Figure 1.

Figure 1 – Students’ social perceptions in online small group discussions



Effectiveness Test Results

The field trial aims to see the effectiveness of the online learning model in achieving the learning objectives that have been set previously. In addition, it is also to obtain information about the learning component, material component and display component. The field trial was conducted with 98 students, which was adjusted to the number of Primary School Education programme students who were taking part in the Information and Communication Technology Design learning process. The main trial process was carried out like a small group trial, except that the population or number of students was greater than the small group trial. Students were given a module and guided, and given an intervention with learning for 14 meetings through the Zoom Meeting Cloud application. This was done because to identify deficiencies or weaknesses in the modules and guides, both the material, instructional objectives and learning outcomes that are expected to improve design skills. In accordance with the main objectives of the online Learning Model to improve the students' achievement in Design. In addition, the field trial criteria before the intervention was carried out, a pre-test was conducted to see students' initial understanding of the ability to design and at the end of the learning

process a post-test was given to measure the students' achievement in Design. The results of the pre-test and post-test of this field trial can be seen in Table 3.

Table 3 – Pre-test and Post-test Results of the Field Trial

Indicators	Pre-test			Post-test		
	N	Mean	SD	N	Mean	SD
Learning process quality	94	3.48	0.316	94	4.51	0.289
Learning material quality	94	3.50	0.304	94	4.52	0.278
learner guideline and test	94	3.60	0.237	94	4.50	0.300
Students attitude on learning	94	3.68	0.139	94	4.56	0.160
The effectiveness of learning quality development	94	3.40	0.234	94	4.40	0.143
Product feasibility	94	3.55	0.011	94	4.44	0.049
Product update	94	3.63	0.059	94	4.56	0.053

Based on table 3, the average pre-test score compared to the average post-test score increased. This shows a significant increase in the quality of learning materials as perceived by participants after the intervention. The comparison of the pre-test and post-test results of this field trial can be seen in table 3, Before the t-paired test process, a normality test is carried out to determine the distribution of data. Based on the results of the normality test, the value of Sig. 0.527 > 0.05, it can be concluded that the data is normally distributed so it can be continued with the Paired t-test. The t-paired test results that the statistical value is 28.5 when compared to the t table at df 93 of 1.660, meaning that the pre-test score is different from the post-test. It can also be seen by looking at the Sig. (2-tailed) p-value 0.001

<0.05. This means that there is a difference between before and after treatment. For the Mean value -1.03 is negative, meaning that there is a tendency for the post-test score to increase after treatment. The average increase is 1.03. It can be concluded that, the online learning model is effective for improving learning achievement in Information and Communication Engineering design.

Discussion

This study explored the impact of an online learning model on student achievement in the design of Information and Communication Technology (ICT). Key findings revealed that:

Improved Engagement and Retention

The flexible and interactive nature of the online learning model facilitated increased engagement among students, fostering better retention of knowledge. Students who actively participated in discussion forums and utilized multimedia resources exhibited marked improvement in their project outcomes. The flexibility of online education has been shown to support students in their academic endeavors (Nieuwoudt, 2020). Research indicates that active participation in discussion forums and the use of multimedia resources can lead to improved project outcomes (Goode et al., 2022). Moreover, the utilization of online platforms has been linked to positive impacts on students' academic achievements and satisfaction (Abuhassna et al., 2020). Engagement in online learning is essential as it can result in better retention of knowledge and enhanced academic performance (Sulla et al., 2022). The interactive elements of online learning, such as immersive learning modules, have been found to boost student engagement and performance (Goode et al., 2022). Additionally, the rise of e-learning has expanded the availability of online learning data, enabling better predictions of student success based on their online interactions (Brahim, 2022).

Online learning offers advantages such as flexibility and autonomy in the learning process (Müller et al., 2023). It allows students to access diverse resources

and engage in collaborative learning, which can improve critical thinking skills (Nungu et al., 2023). Furthermore, online learning can be personalized to meet individual student needs through adaptive learning, potentially increasing motivation and learning outcomes (Ross et al., 2018).

Enhanced Accessibility and Collaboration

The online platform enabled better access to learning materials, irrespective of geographical constraints. Moreover, collaborative tools allowed students to work on projects in teams, despite not being physically present in the same location. This collaborative environment helped students to share insights, develop creative ideas, and troubleshoot design challenges effectively. The online platforms discussed in the provided contexts facilitated improved access to learning materials without geographical limitations (Li et al., 2022; Shimizu et al., 2022). Additionally, collaborative tools on these platforms enabled students to engage in team projects effectively, even when not physically co-located (A. Smith et al., 2022). This collaborative environment supported students in sharing insights, fostering creativity, and effectively addressing design challenges (Vona et al., 2014).

The platforms not only enhanced access to educational resources but also promoted interactive and collaborative learning experiences, essential for developing critical thinking and problem-solving skills among students. The combination of online access to materials and collaborative tools created a conducive environment for students to work together, exchange ideas, and collectively tackle challenges, thereby enhancing their overall learning outcomes. The online platform has significantly improved access to learning materials and promoted collaboration among students, transcending geographical limitations. The collaborative tools available in online education have not only facilitated effective teamwork but also encouraged knowledge sharing, creativity, and problem-solving skills among students, ultimately contributing to a more engaging and enriching learning experience.

Adaptability and Personalization

The online learning environment allowed students to tailor their learning experience based on individual preferences. Adaptive assessments provided personalized feedback, enabling students to identify their strengths and areas needing improvement, ultimately leading to enhanced performance in ICT design tasks. The online learning environment plays a crucial role in tailoring students' learning experiences based on individual preferences. Research has shown that students' perceptions of the blended learning environment significantly impact their academic outcomes (Han & Ellis, 2023). Additionally, the Community of Inquiry (CoI) framework highlights the interaction of individual elements with the broader environment, emphasizing the importance of considering macro and meso levels in online learning (Arifeen, 2023). Moreover, the use of Personal Learning Environments (PLEs) has been linked to sustainable learning and the development of collaborative work competencies, ultimately enhancing academic results (Ruscas et al., 2021). Furthermore, incorporating Universal Design for Learning (UDL) in online module redesign has been found to support cognitive, social, and teaching presence, positively influencing student engagement and performance (Seymour, 2024).

These findings collectively emphasize the significance of personalized feedback and adaptive assessments in enhancing student performance in ICT design tasks within the online learning environment. By utilizing adaptive assessments, personalized feedback, interactive learning modules, and synchronous engagement, online learning platforms have allowed students to tailor their learning experiences, leading to improved performance in ICT design tasks. This personalized approach fosters a supportive and effective learning environment, ultimately enhancing student outcomes in online education.

Teacher Involvement and Support

Timely instructor feedback and support were crucial for student achievement. Teachers facilitated problem-solving sessions and maintained a supportive online presence, which encouraged students to seek help when needed.

Timely instructor feedback and support play a crucial role in student achievement in online learning environments. highlighted that teacher engagement positively impacts students' English achievement (Wang et al., 2022). Additionally, emphasized the importance of online engagement, interactive learning modules, and synchronous class attendance in enhancing student achievement (Goode et al., 2022). Furthermore, demonstrated that adaptive quizzes can boost student motivation, engagement, and learning outcomes, contributing to improved academic performance (Ross et al., 2018). These studies collectively underscore the significance of supportive teacher presence, interactive learning tools, and personalized assessments in fostering student success in online education.

This study enriches online learning theory by demonstrating how engagement, collaboration, and personalized feedback positively influence students' learning experiences and outcomes in technical subjects like ICT design.

Constructivist Learning

By promoting collaborative learning and self-regulated practices, the study supports constructivist learning principles that emphasize active participation and knowledge construction. It adds empirical evidence regarding the role of collaboration and active involvement in improving performance in digital learning environments.

Instructional Design Models

The findings expand instructional design models by providing evidence on incorporating adaptive assessments and multimedia tools, thereby enabling better learning experiences tailored to individual student needs. The research studies provide valuable insights into enhancing instructional design models to cater to individual student needs effectively. By incorporating adaptive learning technologies (Keese et al., 2023), individualized professional development (Vincent-Ruz & Boase, 2022), and instructional multimedia tools (Duncan & Tseng, 2011), educators can create more personalized and engaging learning experiences. Adaptive learning technologies have been shown to engage students in discipline-

specific thinking, leading to improved outcomes (A. R. Smith et al., 2011). Similarly, individualized professional development has proven to facilitate the implementation of technological tools in university teaching, enhancing faculty understanding and use of such tools (Huang et al., 2014). Additionally, instructional multimedia has been found to be an efficient method for teaching psychomotor skills in allied health education, influencing student study behavior positively. By integrating these approaches, educators can tailor learning experiences to meet the diverse needs of students effectively.

Educators can design more effective online ICT courses by leveraging multimedia content, collaborative projects, and adaptive assessments, ensuring courses cater to diverse learning styles and student needs. Institutions can offer professional development programs for instructors to help them create and manage interactive online learning environments, thus enhancing the quality of support and guidance provided to students. Academic institutions can optimize their resource allocation by prioritizing investments in robust online learning platforms, thereby improving access and fostering collaborative workspaces.

The study relied on a limited sample size from a demographic region, restricting the generalizability of its findings. Future research should include a larger and more diverse sample to obtain more comprehensive results. The research incorporated self-reported data, which could introduce biases regarding students' perceived engagement and satisfaction levels. Complementary assessment methods, such as direct observation, should be considered. The study did not assess the long-term impact of the online learning model on students' achievement. Longitudinal studies are required to understand how sustained use of such models influences the learning trajectory over time.

The online learning model in this study improved student achievement in ICT design courses by promoting engagement, collaboration, and personalized learning. Despite its limitations, the research contributes valuable insights into how online environments can be structured to maximize student learning outcomes.

Conclusion

The online learning model has positively influenced students' achievements in Design of Information and Communication Technology (ICT). By offering structured digital resources, interactive assessments, and accessible online lectures, students exhibited increased engagement and understanding of complex concepts, leading to higher grades and improved comprehension. The flexibility of the online learning model allowed students to learn at their own pace, resulting in better grasping of the material. Students who required additional time to understand intricate ICT designs could review the resources and engage with supplementary exercises to reinforce their knowledge.

The inclusion of multimedia resources, quizzes, and collaborative projects facilitated diverse learning styles. This model allowed visual, auditory, and kinesthetic learners to effectively engage with the course material in a way that suits them best, enhancing their academic performance. Online forums, peer reviews, and group projects enabled students to build a collaborative learning environment. This not only improved peer relationships but also fostered teamwork skills essential for future ICT professionals. Educational institutions should consider integrating more online learning models into their ICT curriculums. By blending traditional methods with digital resources, they can cater to a broader range of learning styles and needs.

Instructors need specialized training to effectively manage online learning environments. Educators should be skilled in utilizing diverse online tools and fostering student engagement through these platforms. Institutions should invest in the necessary infrastructure to support comprehensive online learning. This includes reliable internet access, learning management systems, and a wide variety of digital resources. Further studies could examine specific aspects of online learning models, such as which multimedia tools are most effective for particular ICT topics. Additionally, longitudinal research can track long-term outcomes to see if students retain and apply their knowledge in professional settings. With increased reliance on online learning, institutions must establish robust support systems for

students facing challenges, whether academic or technical. These could include virtual tutoring services, mental health support, and technical assistance.

These conclusions and implications highlight the potential of online learning models to revolutionize ICT education and prepare students for the rapidly evolving technological landscape.

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