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Digital Learning Transformation: Implementing Technology-Based Cultural Discovery Learning to Enhance English Teaching Competence

Rafiqa[1]*, Muhammad Aswad[2]
[1,2]*Universitas Sulawesi Barat*
rafiqa@unsulbar.ac.id[1]

Abstract
Digital transformation has reshaped English language teacher education by requiring pre-service teachers to develop not only pedagogical knowledge but also digital literacy, intercultural awareness, and reflective teaching competence. However, the integration of technology, culture, and pedagogy remains limited in many teacher education contexts. This study investigated the effectiveness of technology-based Cultural Discovery Learning (CDL) in enhancing the teaching competence of pre-service English teachers and examined the quality of its implementation in the learning process. A quantitative approach with a quasi-experimental design was employed. The participants were 77 undergraduate students from the English Education Study Program at Universitas Sulawesi Barat, consisting of 38 students in the experimental group and 39 students in the control group. Data were collected through pre-tests, post-tests, classroom observation, and documentation. Descriptive statistics and an independent-sample t-test were used to analyze the data. The findings revealed that the experimental group achieved a higher gain score (21.39) than the control group (7.62). The independent-sample t-test showed a significant difference between the two groups, $t(75) = 6.212$, $p < .001$. Observation results also indicated that the CDL model was implemented with very high fidelity, with an average score of 90 across cultural objectives, authentic digital media, cultural discovery activities, reflection, and digital product creation. These findings suggest that technology-based CDL is an effective pedagogical framework for developing pre-service English teachers' pedagogical, digital, intercultural, and reflective competencies.
Keywords: *Cultural Discovery Learning, Digital, English Teaching, Technology, Teaching Competence.*

1. Introduction

The remarkable growthof digital technology has fundamentally transformed educational systems worldwide. The emergence of the Fourth Industrial Revolution and the transition toward Society 5.0 have shifted educational paradigms from teacher-centered instruction toward more flexible, collaborative, technology-enhanced, and learner-centered environments (An-Nisa et al., 2021; Aswad et al., 2022; Firmansyah et al., 2021; Irma et al., 2022; Mofareh A, 2019; Rafi & Usman, 2021). In this context, educational institutions are expected not only to transfer knowledge but also to prepare learners to become adaptive, critical, creative, and globally competent citizens. Consequently, teacher education institutions are challenged to redesign their pedagogical approaches to ensure that future teachers possess the competencies necessary to address the complexities of contemporary classrooms (Susanti et al., 2022).

English language education has become one of the most affected disciplines within this educational transformation. English no longer functions solely as a foreign language subject but has evolved into a global medium of communication that connects individuals from diverse cultural, social, and professional backgrounds (Altun & Ahmad, 2021; Bello Nawaila et al., 2020; Hambali et al., 2023; Yasseen Shukr & Adnan Jameel, 2022).

Accordingly, future English teachers are required to master multidimensional competencies that extend beyond linguistic proficiency. They are expected to integrate pedagogical knowledge, technological skills, intercultural awareness, creativity, critical thinking, and reflective practice into their professional identity. Such competencies have become essential for responding to the increasing demands of globalization and digitalization in education (Nawaila et al., 2020; Rafiqa, 2022b).

Teacher competence has consequently become a central issue in educational reform worldwide. Contemporary teacher competence encompasses not only instructional abilities but also teachers' capacities to design meaningful learning experiences, utilize digital resources effectively, foster student engagement, and create culturally responsive learning environments. Particularly in English language teaching, effective teachers are expected to facilitate communication across cultures and prepare students to become global citizens who can interact appropriately in diverse sociocultural contexts (Rafiqa & Munawir, 2017). Therefore, teacher education programs need to provide learning experiences that simultaneously develop pedagogical, technological, and intercultural competencies (Rafiqa, Sabil, et al., 2023; Rafiqa, 2022a; Rafiqa, Aswad, et al., 2023; Rosmayanti et al., 2023).

One important aspect that remains insufficiently addressed in many English teacher education programs is the integration of culture into pedagogical practices. Language and culture are inseparable constructs becauselanguage represents a society's beliefs, values, customs, traditions, and worldviews. . Learning a language without understanding its cultural dimensions may limit learners' communicative competence and hinder their ability to interact effectively across different cultural settings (Rafiqa, Aswad, et al., 2023; Rosmayanti et al., 2023). Although cultural elements are frequently introduced in English language classrooms, they are often treated as supplementary materials rather than integrated components of pedagogical design. Consequently, many pre-service teachers graduate with adequate linguistic knowledge but limited intercultural competence and insufficient experience in designing culturally responsive instruction.

Simultaneously, digital technology has created broaderopportunities for integrating authentic cultural experiences into English language learning. Digital platforms such as YouTube, Google Arts & Culture, virtual museums, online archives, social networking applications, interactive websites, and collaborative digital tools provide learners with direct access to authentic linguistic and cultural resources (An-Nisa et al., 2021; Rafi & Usman, 2021). Through these technologies, students can explore cultural practices, compare communication patterns, observe social interactions, and develop deeper intercultural understanding. Technology also supports personalized learning, collaborative inquiry, multimodal communication, and creative knowledge construction, all of which are aligned with contemporary educational principles (Aswad et al., 2022).

Despite these opportunities, the integration of technology in teacher educationhas yet to reach its full potential . In many higher education institutions, technology is primarily utilized for administrative purposes, such as uploading assignments, delivering presentation slides, or managing Learning Management Systems (LMS). Although these functions are beneficial, they do not necessarily foster higher-order competencies such as critical thinking, creativity, intercultural awareness, or reflective teaching (Mofareh A, 2019; Raja & Nagasubramani, 2018). Pre-service teachers often have limited opportunities to experience innovative instructional models that systematically combine technology, pedagogy, and culture within authentic learning environments. As a result, there remains a gap between technological availability and pedagogical innovation in teacher preparation programs (Yasseen Shukr & Adnan Jameel, 2022).

One promising instructional approach that may address these challenges is Cultural Discovery Learning (CDL). CDL is an inquiry-based pedagogical model that encourages learners to actively investigate cultural phenomena, interpret cultural meanings, compare cultural practices, and construct their own understanding through reflective exploration(Jeffreys & O'donnell, 1997). Rather than receiving cultural information passively, students become active investigators who discover cultural knowledge through authentic experiences and collaborative inquiry. This approach is grounded in constructivist learning theory, which posits that knowledge is actively constructed through interaction, experience, and reflection (Johnson, 2016).

The integration of digital technology into CDL potentially creates a more holistic pedagogical framework for teacher education. Technology-based CDL allows preservice teachers to access authentic cultural materials, collaborate through digital environments, critically analyze intercultural issues, and transform their discoveries into meaningful digital products. Such integration enables students to simultaneously develop pedagogical competence, digital literacy, intercultural awareness, creativity, and reflective thinking (Asfihana et al., 2024; Rafiqa, 2022b). Furthermore, the model positions students not only as consumers of information but also as creators of knowledge and future learning designers.

Several previous studies have investigated discovery learning, technology-enhanced learning, and intercultural pedagogy independently. Discovery learning has been widely recognized for improving learner autonomy, motivation, problem-solving abilities, and higher-order thinking skills (A. Aziz et al., 2017; Junina & Halim, 2020; Walo et al., 2021). Similarly, technology-enhanced learning has been found to increase student engagement, collaboration, flexibility, and access to authentic resources (Altun & Ahmad, 2021; Solihin et al., 2024). Studies on intercultural pedagogy have also demonstrated its effectiveness in promoting cultural awareness, empathy, and global competence (Dasli & Simpson, 2023; Holmes & Peña Dix, 2022; Zambrana, 2020). However, these studies generally focus on one dimension at a time rather than integrating all three dimensions into a comprehensive instructional framework.

Furthermore, existing studies have predominantly examined student learning outcomes, language achievement, or digital engagement, while relatively little attention has been given to developing the multidimensional teaching competence of pre-service teachers. Previous research also tends to treat cultural learning as complementary content rather than as a central component of pedagogical design. Moreover, digital technology is frequently implemented as a supporting tool instead of serving as an integral element of inquiry-based cultural exploration. Consequently, there remains limited empirical evidence regarding instructional models that simultaneously integrate culture, technology, and pedagogy to develop future teachers' professional competence (Rafiqa, 2022a; Rafiqa, Aswad, et al., 2023).

This study addresses these research gaps by implementing technology-based CDL within English teacher education. The study proposes an integrative pedagogical framework that unites cultural understanding, digital literacy, pedagogical competence, and reflective practice into a coherent learning experience. Unlike previous studies that focused separately on discovery learning, technology integration, or intercultural education, this study investigates how these dimensions can work synergistically to improve pre-service English teachers' teaching competences.

The novelty of this study lies in three aspects. First, it integrates CDL with digital technology within the context of English teacher education. Second, it positions intercultural

competence as a core pedagogical component rather than supplementary content. Third, it simultaneously develops four essential competencies required by 21st-century teachers, namely pedagogical competence, digital literacy, intercultural awareness, and reflective teaching ability. This multidimensional approach provides a more comprehensive framework for preparing future English teachers to respond to rapidly evolving educational demands.

The significance of this study extends both theoretically and practically. Theoretically, the study contributes to the growing body of knowledge on culturally responsive digital pedagogy by providing empirical evidence regarding the effectiveness of technology-based CDL. Practically, the findings may inform teacher education institutions, curriculum developers, policymakers, and educators about innovative strategies for preparing future teachers who are adaptive, culturally responsive, technologically competent, and globally oriented. Based on the background presented above, this study seeks to answer the following research questions: 1) Does technology-based CDL significantly enhance pre-service English teachers' teaching competences?; 2) How is technology-based CDL implemented within English teacher education classrooms?

2. Method

2.1. Research Design

This study employed a quantitative approach using a quasi-experimental design with a non-equivalent control group design. Quasi-experimental research is widely used in educational settings where random assignment is difficult to implement because participants are already organized into existing classes (Creswell & Guetterman, 2019). The design was selected to investigate the effectiveness of technology-based Cultural Discovery Learning (CDL) in enhancing pre-service English teachers' teaching competence.

Two groups participated in the study: an experimental group that received technology-based CDL instruction and a control group that received conventional instruction. Both groups completed pre-tests and post-tests to measure changes in teaching competence after the intervention. Two existing classes enrolled in the same teacher education course during the even semester of the 2025 academic year were selected as the research participants. The classes were chosen because they had comparable academic characteristics, including the same year of study, curriculum, course content, instructional schedule, and lecturer. Prior to the intervention, both classes completed a pre-test to examine their initial level of teaching competence. The pre-test results indicated that there was no meaningful difference between the two classes, suggesting that they were comparable at baseline before the intervention.

To minimize potential selection bias associated with the non-random assignment, both classes were enrolled in the same course, followed an identical syllabus, learning objectives, and assessment procedures, and were taught during the same academic semester. Furthermore, a pre-test was administered before the intervention to examine the baseline equivalence of the two groups. The pre-test results indicated that the experimental and control groups had comparable levels of teaching competence prior to the intervention, supporting the appropriateness of the non-equivalent control-group design for evaluating the effectiveness of the instructional treatment.

2.2. Research Setting and Participants

This study was conducted during the even semester of the 2025 academic year at the English Education Study Program, Faculty of Teacher Training and Education, Universitas Sulawesi Barat, Indonesia. The population consisted of 103 undergraduate students and purposive sampling was employed to select participants who met the research criteria

(Dagar & Yadav, 2016). A total of 77 students participated in the study and were divided into two groups: 38 students in the experimental group and 39 students in the control group.

2.3. Research Procedures

A number ofsteps in this research were conducted, namely: pre-test, treatment, observation, and post-test. The Intervention consisted five meetings, the first meeting started from first stage to the fifth meeting or last stage and each meeting lasted 90 minutes. Implementing the technology-based cultural discovery learning consisted five stages below: First stage: Cultural Orientation. Students were introduced to cultural issues related to English language teaching, including politeness, humor, classroom interaction, self-introduction, and intercultural communication. Second stage: Digital Cultural Exploration. Students accessed authentic cultural resources through digital platforms such as YouTube, Google Arts & Culture, websites, and online videos. Third stage: Cultural Discovery. Students analyzed cultural differences, identified cultural values, and interpreted intercultural phenomena collaboratively. Fourth stage: Cultural Reflection. Students reflected upon cultural discoveries and connected them with their local cultural contexts and future teaching practices. Fifth stage: Digital Product Creation. Students created digital artifacts, including intercultural communication videos, reflective e-portfolios, digital posters, and teaching materials. Meanwhile, the control group received conventional instruction through lectures, textbook-based discussions, routine exercises, and teacher explanations without systematic integration of digital cultural exploration.

2.4 Research Instruments

Two instruments were employed in this study: (1) a teaching competence assessment and (2) a classroom observation checklist. The teaching competence assessment was administered as both a pre-test and a post-test to measure changes in participants' teaching competence before and after the instructional intervention, while the observation checklist was used to evaluate the fidelity of Technology-Based CDL implementation.

Microteaching competence was assessed through a performance-based teaching assessment in which participants were required to conduct a microteaching session based on a lesson plan that they had prepared. Rather than relying on a paper-and-pencil test, the assessment measured participants' ability to demonstrate pedagogical knowledge and teaching skills in an authentic instructional context. The assessment rubric was developed by adapting indicators from English language teacher competence frameworks and previous studies on teacher education of FKIP Unsulbar (Rafiqa, Sabil, et al., 2023; Rafiqa, Aswad, et al., 2023), while also referring to the pedagogical competence standards for pre-service teachers in Indonesian higher education. The rubric consisted of ten assessment indicators grouped into five dimensions of teaching competence:

1. Lesson Planning, including the formulation of learning objectives and the organization of instructional activities.
2. Instructional Delivery, including explanation clarity, classroom interaction, questioning techniques, and classroom management.
3. Integration of Cultural Content, including the incorporation of intercultural perspectives and authentic cultural contexts into English language teaching.
4. Technology Integration, including the effective use of digital media and educational technologies to support learning.
5. Assessment and Reflection, including formative assessment strategies, feedback provision, and reflective evaluation of teaching performance.

Each indicator was evaluated using a five-point analytic rating scale, ranging from 1 (very poor) to 5 (excellent). Scores for all indicators were summed to obtain an overall

teaching competence score, with higher scores indicating higher levels of teaching competence.

To establish content validity, the assessment rubric was reviewed by three experts in English language teaching, educational technology, and teacher education. The reviewers evaluated the relevance, clarity, and representativeness of each indicator, and revisions were made based on their recommendations before the instrument was implemented. The internal consistency of the instrument was examined using Cronbach's alpha, yielding a reliability coefficient of $\alpha = 0.89$, indicating high reliability for measuring pre-service teachers' teaching competence.

Furthermore, a structured classroom observation checklist was employed to examine the fidelity of Technology-Based CDL implementation during the intervention. The checklist consisted of five instructional dimensions: (1) integration of cultural learning objectives, (2) utilization of authentic digital media, (3) implementation of cultural discovery activities, (4) reflective learning practices, and (5) digital product creation.

Each dimension was rated using a four-point implementation scale ranging from 1 (not implemented) to 4 (fully implemented). Observations were conducted throughout the intervention using the same observation protocol to ensure consistency across instructional sessions. The observation results were subsequently converted into percentage scores and classified into four implementation categories: Low, Moderate, High, and Very High.

2.5 Data Analysis

Data were analyzed using descriptive and inferential statistics. Descriptive statistics included mean scores, standard deviations, and gain scores. Inferential statistics employed an independent-sample *t*-test to determine whether differences between groups were statistically significant. All analyses were performed using SPSS.

3. Results

3.1. Findings

3.1.1. The Effects of Technology-Based Cultural Discovery Learning on Teaching Competence

The first research question examined whether technology-based CDL significantly enhanced pre-service English teachers' teaching competence. Students' teaching competence was measured through pre-tests and post-tests administered before and after the intervention. The comparison of students' performance between the experimental and control groups is presented in Table 1.

Table 1. Comparison of Students' Teaching Score

Group	N	Pretest Mean	Posttest Mean	Standard Deviation	Gain Score
Experimental	38	67.95	89.34	6.41	21.39
Control	39	68.21	75.83	5.92	7.62

Table 1 reveals several important findings regarding the impact of technology-based CDL on students' teaching competence. First, both groups started from relatively comparable levels of competence before the intervention. The pre-test mean scores of the experimental group (67.95) and the control group (68.21) differed by only 0.26 points, indicating that both groups possessed relatively equivalent initial abilities. This similarity strengthens the internal validity of the study because the observed differences in post-test performance are more likely attributable to the instructional intervention rather than pre-existing differences between groups.

Second,although post-instruction improvements were observed in both groups, the scale of these gains varied considerably. . The experimental group exhibited a remarkable increase from 67.95 to 89.34, representing an improvement of 21.39 points. In contrast, the control group improved from 68.21 to 75.83, producing a gain score of only 7.62 points. The difference in gain scores indicates that students exposed to technology-based CDL experienced nearly three times greater improvement than students who received conventional instruction.

Third, the findings suggest that technology-based CDL provided a richer and more meaningful learning environment for developing teaching competence. Students were not merely exposed to theoretical concepts but actively engaged in cultural inquiry, authentic digital exploration, reflective learning, and digital product creation. These learning experiences appear to have facilitated deeper conceptual understanding and more effective skill development.

Furthermore, the standard deviation values indicate relatively consistent performance among students in both groups. The experimental group obtained a standard deviation of 6.41, while the control group obtained 5.92. These relatively small variations suggest that the intervention produced positive effects across most participants rather than benefiting only a small number of high-performing students. Therefore, the findings indicate that CDL may be broadly applicable to students with diverse learning abilities. Overall, the descriptive findings demonstrate that technology-based CDL substantially contributed to the enhancement of teaching competence among pre-service English teachers.

To further determine whether the observed differences were statistically significant, an independent-sample t-test was conducted. The results are presented in Table 2.

Table 2. Independent-Sample t-Test Results

Variable	t	df	p	Interpretation
Teaching Competence	6.212	75	.000	Significant

Table 2 presents the inferential statistical analysis comparing the post-test performance of the experimental and control groups. The analysis yielded a t-value of 6.212 with 75 degrees of freedom and a significance level of $p < .001$. Since the obtained probability value was substantially lower than the predetermined alpha level of .05, the null hypothesis was rejected. The magnitude of the *t*-value indicates a strong difference between the two instructional approaches. This finding provides robust empirical evidence that technology-based CDL had a significant positive effect on pre-service English teachers' teaching competence.

The statistical significance also suggests that the observed improvement was not due to random variation but was systematically associated with the intervention implemented in the experimental group. Students who participated in CDL consistently outperformed those who experienced conventional instruction across various dimensions of teaching competence. Moreover, the findings imply that integrating cultural inquiry, digital technology, and reflective practice creates synergistic effects that strengthen professional competence development. This multidimensional learning environment appears to support students in acquiring not only instructional knowledge but also the ability to contextualize, analyze, reflect, and creatively apply pedagogical concepts in authentic educational settings.

Taken together, the descriptive and inferential findings confirm that technology-based CDL constitutes an effective instructional framework for improving pre-service English teachers' teaching competence and may serve as an innovative alternative to conventional teacher education practices.

3.1.2 The Implementation of Technology-Based Cultural Discovery Learning (CDL)

The quality of CDL implementation was assessed through an observation checklist that measured five components. The results are presented in the following table.

Table 3. CDL Implementation Observation

CDL Component	Average Score (10–100)	Category
Learning objectives include cultural aspects	92	Very High
Use of authentic digital	88	High
Cultural discovery activities	94	Very High
Cultural reflection	89	High
Digital products (portfolio/video)	86	High
Average	90	Very High

Table above showed that Cultural Learning Objectives was very high. The inclusion of cultural dimensions in learning objectives was well integrated. Each lesson explicitly incorporated *cultural learning outcomes*, such as "students can identify differences in social norms between English and Indonesian cultures." Use of Authentic Digital Media was high, the authentic digital tools such as *YouTube*, *Google Arts & Culture*, *Word wall*, and *Canva* were frequently used. These resources allowed students to explore authentic cultural contexts, enhancing their understanding of language as a cultural construct rather than merely a linguistic system. Cultural Discovery Activities was Very High, this component achieved the highest score. Students actively investigated cultural phenomena through discovery tasks for example, analysing differences in self-introduction, politeness expressions, and humour between Western and Indonesian cultures. These exploratory tasks encouraged critical thinking and reflective interpretation. Cultural Reflection (Score: 89 was High. After exploration, students engaged in reflective activities to connect cultural discoveries with their own local and personal experiences. Digital Product Creation was High. The students produced digital projects such as intercultural communication videos, reflective e-portfolios, and interactive posters. Tools like *Canva* and *Cap Cut* were used to create innovative and visually engaging outputs. Despite some technical variability across projects, most students demonstrated strong independence, creativity, and reflective ability, indicating that CDL successfully encouraged them to become *active digital creators* rather than passive consumers.

The Last, overall, with an average score of 90 (Very High), the CDL model was implemented effectively and consistently across all components. There were no weak elements, showing strong alignment between theoretical design and practical application. This coherence validates the model's implementation, in line with design-based research principles, where success is assessed not only by learning outcomes but also by the quality of implementation. These findings confirm that technology-based CDL can be executed with high quality in English teacher education.

3.2. Discussion

The findings of this study provide strong empirical evidence that technology-based CDL significantly enhances pre-service English teachers' teaching competence. Students who participated in CDL achieved substantially higher post-test scores and gain scores than those who received conventional instruction. More importantly, these findings demonstrate

that effective teacher education is no longer solely concerned with transmitting pedagogical knowledge but with developing multidimensional competencies that integrate pedagogy, technology, culture, and reflection.

The superior performance of the experimental group can be explained by the integrative nature of CDL itself. Unlike conventional instruction, which often emphasizes content delivery and procedural teaching skills, CDL actively engages learners in inquiry, exploration, interpretation, and knowledge construction. Throughout the learning process, students were not positioned as passive recipients of information but as active investigators who explored cultural phenomena, analyzed authentic resources, reflected upon their discoveries, and transformed their understanding into pedagogical products. Such learning experiences enable students to develop a deeper conceptual understanding of teaching as a dynamic and socially situated practice.

These findings strongly support constructivist learning theory, which argues that knowledge is actively constructed through interaction, experience, and reflection rather than passively transmitted from instructors to learners (Dagar & Yadav, 2016). In CDL, students continuously negotiated meaning, constructed cultural understanding, and connected new information with their prior experiences. This iterative process promoted higher-order cognitive engagement and facilitated meaningful learning experiences that are essential for teacher professional development (Esmailzadeh et al., 2019).

The findings also suggest that intercultural plays a pivotal role in shaping future teachers' professional identity. Language teaching can no longer be separated from cultural understanding because language inherently embodies social values, beliefs, norms, and communication patterns (Dewi, 2023; Jeffreys & O'donnell, 1997; Qiang & Yue, 2021; Simamora & Saragih, 2019). Through cultural exploration activities, students developed awareness that effective English teaching extends beyond grammar and vocabulary instruction (Rafiqa, Aswad, et al., 2023; Yani et al., 2021). Instead, English teachers function as intercultural mediators who facilitate communication across diverse sociocultural contexts. This finding supports the argument that intercultural pedagogy should become an integral component of teacher education rather than supplementary content (Shukr & Jameel, 2022; Yu, 2020; Zambrana, 2020).

The incorporation of authentic digital resources further contributed to the effectiveness of CDL. Digital technology functioned not merely as an instructional tool but as a transformative learning environment that expanded students' access to authentic cultural experiences. Through platforms such as YouTube, Google Arts & Culture, and other online resources, students engaged directly with real-world language use and cultural practices. These findings align with previous studies suggesting that technology enriches learning experiences by increasing engagement, interaction, and accessibility to authentic resources (Altun & Ahmad, 2021; Solihin et al., 2024).

Another important contribution of this study lies in the integration of technology, pedagogy, and cultural content, which closely aligns with the Technological Pedagogical Content Knowledge (TPACK) framework. Effective teacher preparation requires future teachers to simultaneously master technological knowledge, pedagogical knowledge, and content knowledge (Aniq et al., 2022; Pradita et al., 2023; Suryanti et al., 2022). Technology-based CDL operationalizes this integration by positioning students as designers of learning experiences rather than mere technology users. Throughout the intervention, students learned how to select appropriate technologies, contextualize cultural content, and design pedagogically meaningful instructional activities. Therefore, the present study extends the

application of TPACK by incorporating intercultural competence as an additional dimension that enriches teacher professional development.

The findings also extend previous studies on discovery learning. Existing studies have demonstrated that discovery learning improves learner autonomy, motivation, and higher-order thinking skills (R. A. Aziz, 2018; Junina & Halim, 2020; Walo et al., 2021). However, most previous studies were conducted in general educational contexts and primarily focused on students' academic achievement. The present study contributes new empirical evidence by demonstrating that discovery learning becomes significantly more powerful when integrated with digital technology and intercultural pedagogy within teacher education programs. This integrative approach shifts the focus from content mastery toward the development of multidimensional professional competence.

Reflection emerged as another critical mechanism that contributed to competence development. Reflective activities encouraged students to evaluate cultural discoveries, connect them to local contexts, and reconsider their future instructional practices. Reflection transformed learning from information acquisition into professional identity formation. Through reflection, students began to view themselves not simply as university students but as future educators responsible for creating inclusive, culturally responsive, and globally oriented classrooms. This finding supports previous research indicating that reflective practice is fundamental for developing adaptive and lifelong learning professionals (Belz, 2005).

Digital product creation further strengthened students' professional readiness. More importantly, it facilitated the transition from passive information consumption to active knowledge production. Such competencies have become increasingly important because contemporary teachers are expected to design innovative, multimodal, and technology-enhanced learning environments that address diverse learners' needs (Pretorius, 2018; Rafi & Usman, 2021).

The high implementation fidelity observed in this study also deserves attention. The consistency across cultural learning objectives, authentic digital media utilization, discovery activities, reflection, and digital product creation indicates that CDL is not only theoretically sound but also practically feasible (Nawaila et al., 2020; Dinneen, 2021; Rafi & Usman, 2021). This finding is important because many innovative pedagogical models demonstrate strong conceptual foundations but face challenges during classroom implementation. In contrast, CDL exhibited strong alignment between pedagogical design and instructional execution, suggesting its potential for wider adoption within teacher education institutions.

The study also contributes theoretically to the emerging field of culturally responsive digital pedagogy. Existing models often emphasize either technological integration or intercultural learning independently. The present study demonstrates that combining these dimensions within a discovery-based learning environment produces synergistic effects that enhance teacher competence more comprehensively. Thus, technology-based CDL may be considered an innovative pedagogical framework that extends existing theories of teacher education by integrating four essential domains of contemporary teaching competence: pedagogy, digital literacy, intercultural awareness, and reflective practice.

In general, these findings suggest that future teacher education should no longer separate technology, culture, and pedagogy into independent domains. Instead, these dimensions should be integrated within coherent instructional models that provide authentic, inquiry-driven, and reflective learning experiences. Such integration is essential for preparing future English teachers who are not only competent instructors but also culturally responsive, digitally adaptive, and globally oriented professionals.

4. Conclusion

This study investigated the effectiveness of technology-based CDL in enhancing pre-service English teachers' teaching competence and examined its implementation within English teacher education. The findings demonstrated that students who participated in CDL significantly outperformed those who received conventional instruction. Technology-based CDL effectively enhanced pedagogical competence, digital literacy, intercultural awareness, reflective thinking, and creative instructional abilities.

The high implementation consistency further confirmed that CDL can be systematically integrated into teacher education programs. The combination of cultural inquiry, authentic digital resources, reflective activities, and digital product creation enabled students to become active knowledge constructors rather than passive recipients of information. Overall, this study positions technology-based Cultural Discovery Learning as a holistic pedagogical framework capable of preparing future English teachers to respond to the educational demands of the 21st century and Society 5.0.

Several limitations should be acknowledged. First, the study was conducted at a single institution with a relatively small sample size, which may limit the generalizability of the findings. Second, the intervention period was relatively short, preventing the examination of long-term effects on teaching competence development. Third, the study employed a predominantly quantitative design that did not fully capture students' experiences and perceptions during the learning process. The last, the study employed a quasi-experimental design using two existing intact classes rather than random assignment of participants. Although pre-test analyses indicated that the experimental and control groups were comparable prior to the intervention, the absence of random assignment may have introduced potential selection bias and therefore limits the extent to which causal inferences can be generalized.

Future studies are recommended to involve multiple institutions, larger samples, and longitudinal designs to examine the sustainability of CDL outcomes. Mixed-method approaches are also encouraged to provide deeper insights into the development of intercultural awareness, professional identity, and reflective teaching practices among pre-service English teachers.

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