

Digitalization and Inclusive Learning Reconstructing Lifelong Education Systems under SDG 4

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Abstract

Educational equity and quality remain key challenges in achieving Sustainable Development Goal 4 (SDG 4), especially as globalization and digitalization reshape education systems. Existing research lacks empirical evidence on how digital tools specifically promote inclusive lifelong education and fails to sufficiently address disparities in learning outcomes across socioeconomic groups. To fill these gaps, this study uses a mixed-methods approach, combining quantitative surveys (350 students: 300 from Hope College, Southwest Jiaotong University; 50 from remote Liangshan Prefecture) and qualitative semi-structured interviews, with data collected via Chaoxing Learning Platform and Yuketang. Quantitative analysis (SPSS/R) revealed: 1) 85% of total participants (n=328 valid responses) reported improved accessibility/convenience of digital learning; 2) a positive correlation between digital tool use frequency and test scores ($r=0.62$, $p<0.01$). Qualitative content analysis highlighted blended learning's effectiveness in meeting diverse needs but also indicated potential exacerbation of educational inequalities by digital environments. The findings confirm digital technology's role in advancing educational resource equalization, providing data-driven insights for policymakers to optimize inclusive lifelong education systems.

Keywords

Inclusive education, digital education, lifelong learning systems, Sustainable Development Goals

Introduction

With the rapid development of globalization and digitalization, the structure and function of the education system are undergoing profound changes. Digital and inclusive learning (Inclusive Learning) is a core element in achieving the Sustainable Development Goal (SDG) 4 for education and an important approach to addressing the current challenges of educational equity and accessibility (Hussain, 2021). According to the International Telecommunication Union (ITU)'s "2021 Global Digital Transformation Report," in the field of education, the lack of digital skills has become one of the main obstacles for learners, particularly marginalized groups, in accessing high-quality educational resources (Chen, 2023).

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With the rapid growth of digitalization, the lifelong education system is crucial for SDG 4. This study aims to explore how digitalization and inclusive learning can enhance educational equity and quality, offering lifelong learning opportunities (Molina et al., 2023). It will analyze the application of digital tools like online learning platforms (Chaoxing Learning Platform and Yuketang) in different socio - cultural contexts to address exclusion and inequality in traditional education (Xiang et al., 2024).

Using the SMART framework, the study ensures specificity and measurability through empirical data on digital tool effectiveness. It involves stakeholders like policymakers, teachers, students, and families for relevance and feasibility. The time-bound aspect tracks and evaluates digital education policy implementation for dynamic adjustments.

When exploring the intersection of digital education and inclusive learning, the Transformative Learning Theory (TLT) provides a crucial foundation for constructing the theoretical framework of a lifelong education system (Mezirow, 1991). This theory emphasizes that learners must reflect on their beliefs, values, and assumptions when confronted with complex social changes, leading to profound transformations. Research indicates that in the context of globalization and rapid technological advancements, educators need to create an environment where learners can engage in self-reflection and adapt within diverse contexts. By integrating technology, leveraging the characteristics of digital education, the convenience of information access can be enhanced, and the learning experience can be optimized through various media. Furthermore, according to the comprehensive model of the framework, it effectively analyzes multiple dimensions that influence inclusive learning. For instance, studies show that combining Learning Management Systems (LMS) with Blended Learning models can facilitate interaction among learners from different social backgrounds, making the learning process more effective and enhancing knowledge sharing and diversity.

The core contribution of this study is to explore how digitalization and inclusive education can shape a lifelong education system within the framework of Sustainable Development Goal (SDG) 4. After a comprehensive review of existing literature, we identified several key research gaps in the fields of digital education and inclusive learning. These gaps include: a lack of empirical studies on the specific applications of digital tools in promoting educational equity, insufficient exploration of differences in student learning outcomes across different socioeconomic backgrounds, and inadequate theoretical frameworks for achieving personalized and inclusive learning paths through technology. To address these gaps, this study uses the Impact Analysis Model (IAM) as the primary analytical tool to systematically assess the potential impact of digitalization on educational equity. The study employs empirical case analysis, combining quantitative and qualitative methods to provide data-driven evidence of the effectiveness of digital learning environments in enhancing learning outcomes for different groups. Additionally, the study examines the equitable distribution of various educational resources during the digital transformation. For instance, an evaluation of a cloud-based learning support project for students from low-income families in a specific region showed a significant improvement in their academic performance, demonstrating that targeted use of digital resources can effectively narrow the educational gap.

Methodology

This study adopts a mixed approach, combining quantitative and qualitative research methods to comprehensively explore the reconstruction of the lifelong education system under the

framework of Sustainable Development Goal 4, with a focus on digitalization and inclusive learning. The research sample includes approximately 300 undergraduate students from the Hope College of Southwest Jiaotong University and 50 students from remote areas of Liangshan Prefecture, Sichuan Province. The online learning software used in this study includes Chaoxing Learning Platform and Yu ketang. This study strictly followed the ethical guidelines for educational research. All student participants received a detailed consent form explaining the research purpose, data collection methods, confidentiality measures, and their right to withdraw at any time without consequences. For minor participants in Liangshan Prefecture, additional written consent was obtained from their legal guardians. All data were anonymized by removing personal identifiers and stored securely with restricted access.

Sampling Rationale

The two sample groups were strategically selected to provide comparative insights into digital education implementation across different socioeconomic contexts:

Hope College students: This group represents learners in relatively educational environments with good internet infrastructure, adequate digital devices, and systematic digital literacy training. They serve as a reference group for understanding digital education implementation in resource-sufficient settings.

Liangshan students: This group represents learners in resource-constrained areas with limited internet access, inadequate digital devices, and minimal prior exposure to digital learning tools. They provide insights into the challenges of implementing inclusive digital education in underdeveloped regions.

The two groups are comparable in that: i) They are within the same age range (18-22 years old); ii) They pursue similar learning objectives (completing academic courses and obtaining qualifications); iii) They use the same digital learning platforms (Chaoxing and Yu ketang).

This comparison allows for analysis of how contextual factors influence digital learning experiences and outcomes, which is crucial for understanding inclusive lifelong education under SDG 4.

Quantitative Method (Survey Questionnaire)

The survey questionnaire consisted of 28 items using a 5-point Likert scale (1 = Strongly Disagree, 2 = Disagree, 3 = Neutral, 4 = Agree, 5 = Strongly Agree) across four dimensions: Platform Satisfaction, Accessibility, Learning Experience, Learning Outcomes. Content validity was established by three experts in educational technology, who reviewed and validated all items. A pilot test with 30 students was conducted to refine the questionnaire before formal data collection.

Data analysis was conducted using Statistical software, SPSS (Statistical Package for Social Sciences) version 26.0, and R software version 4.2.2. Descriptive statistics were calculated to summarize the survey data, including the average value, standard deviation and percentage. For example, the percentage of students who reported improvements in the accessibility and convenience of the learning experience was calculated based on the survey results. Relevant analyses were conducted to examine the relationship between the use of digital tools and learning outcomes. This helps determine whether there is a significant correlation between the frequency of using online learning platforms and variables such as

students' test/exam scores. Independent samples t-tests were used to compare differences between the two groups.

Qualitative Methods (Interview Protocol)

Semi-structured interview protocols were developed for three groups: students, teachers, and education policymakers, each containing 8-10 open-ended questions.

Data Collection Semi-structured interviews were conducted by comparing a portion of student samples, including online interviews with students from remote areas of Liangshan Prefecture conducted by teachers and education policymakers involved in the online learning process at Hope College. The interview aims to gain an in-depth understanding of the practical impact of digitalization on inclusive learning, the challenges faced in implementing digital educational tools, and the integration of the concept of lifelong learning into educational policies. For instance, students were asked about their experiences on online learning platforms, including what they liked and disliked, as well as how they thought the platforms affected their studies. We interviewed teachers and policymakers to ask for their views on the role of digital technology in promoting educational equity, as well as the professional development needs of teachers in digital transformation.

Results and Discussion

A total of 350 questionnaires were distributed, with 328 valid responses (valid rate=93.7%). Based on the quantitative analysis results, 85% of valid participants (n=328) reported improved accessibility/convenience of digital learning. By group, 92% of Hope College students (n=281 valid) and 56% of Liangshan students (n=47 valid) reported improvements ($\chi^2=38.21$, $p<0.001$). Digital tool use frequency (average 4.2 hours/week) was positively correlated with test scores ($r=0.62$, $p<0.01$), indicating more frequent use was associated with higher scores. In terms of group differences, Hope College students had significantly higher platform satisfaction (mean=4.12, SD=0.58) than Liangshan students (mean=2.87, SD=0.73; $t=10.36$, $p<0.001$).

The findings align with Transformative Learning Theory (TLT) - digitalization creates a reflective learning environment where learners adjust their learning strategies based on accessible resources, driving profound changes in learning experiences (Mezirow, 1991). For example, the positive correlation between digital use and scores reflects TLT's emphasis on "reflective adaptation to new tools," as learners optimize their study methods through digital platforms. Regarding the critical finding that digital environments may exacerbate inequalities: This is consistent with Chen's (2023) research, which noted that resource gaps (e.g., network access) lead to uneven digital education benefits. The significant group difference in satisfaction ($t=10.36$, $p<0.001$) further confirms that marginalized groups (Liangshan students) face greater barriers in digital learning. To address this, policymakers should prioritize infrastructure investment (e.g., rural internet expansion) and targeted digital literacy training, as suggested by Muhammad Umer (2022) in his SDG 4-related research. Blended learning's effectiveness, highlighted in qualitative themes, supports Mochiah et al.'s (2022) view that integrating traditional and digital teaching enhances inclusivity. However, the theme of "teacher digital literacy gaps" reminds us of that technology alone is insufficient - educator training is key to unlocking digital education's potential for lifelong learning.

Conclusion

This study explores the role of digitalization in reconstructing inclusive lifelong education systems under SDG 4 using a mixed-methods approach. Key findings include: 1) Digital tools significantly improve learning accessibility (85% of participants reporting improvements) and correlate positively with learning outcomes ($r=0.62$, $p<0.01$); 2) Socioeconomic disparities lead to uneven digital education benefits, with Liangshan students facing greater barriers (lower satisfaction, 56% reporting accessibility improvements); 3) Blended learning and teacher digital literacy are critical for inclusive education. Theoretical contributions: This study enriches Transformative Learning Theory by verifying its applicability in digital educational contexts. Practical implications: Policymakers should invest in rural digital infrastructure and targeted training to mitigate inequality; educators can adopt blended learning to meet diverse needs. Limitations include a small Liangshan sample size ($n=47$), and future research could expand to more regions.

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