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Editorial – Volume 26, Issue 3

Agnieszka (Aga) Palalas
Editor-in-Chief

As we continue to celebrate IRRODL's remarkable journey, this issue exemplifies our journal's enduring commitment to advancing open and distributed learning through rigorous scholarship and global collaboration. Detailed in "Twenty-five years of innovation and knowledge sharing: the legacy and future of the international review of research in open and distributed learning," which opened our first 2025 issue, since founding in 2000 as a diamond open access journal, free to both readers and authors, IRRODL has remained steadfast in publishing high-quality research while maintaining international diversity in authorship, readership, and editorial contributions. Our accessibility and innovation have resulted in over 13.5 million downloads and 4 million unique visitors since 2011, with high citation rates and steady impact factor growth reinforcing our advocacy for diamond open access and inclusive scholarship.

With authors from 31 countries contributing to recent volumes (2023–2024), we maintain strong North American and UK representation, while 64.3% of our readers come from the Global South, demonstrating our international relevance. This global reach reflects IRRODL's position as the most cited Canadian education journal and our ranking among the top 20 educational technology journals worldwide.

Fittingly, the current issue includes authors from 7 countries: Australia, Canada, China, Indonesia, Taiwan, Turkey, and the United States. They report on digital education effectiveness during crisis periods, innovative pedagogical approaches including implementation of OER, virtual reality (VR), flipped classroom (FC) and trauma-informed strategies to improve student engagement and consequently learning outcomes across K-12, higher education, music, and language education contexts. The articles also explore teacher preparedness and professional development, including digital literacy training, technology integration, and crisis-responsive teaching methods in collaborative settings that bridge educational gaps in ODL.

Trauma-Informed Education in Open Online Courses

Watt, Krishnamoorthy, Ong, and **Rees** examine the intersection of trauma-informed care and open online courses (OOCs) in their evaluation of teacher continuous professional development during COVID-19. Their study demonstrates how educators adapted trauma-sensitive classroom management techniques through distributed learning, highlighting the importance of "clear routines, supportive environments, and flexible professional development to address diverse student needs." They observe that OOCs can serve as both foundational platforms for continuous professional development and valuable resources supporting educators' long-term effectiveness in student support. The authors provide valuable insights for designing resilient online educational frameworks addressing both academic and emotional learner needs.

Enhancing Distance Education Resilience

Also situating their study in the COVID-19 context, **Kizil, Kizil,** and **Jang** contribute to our understanding of distance education (DE) resilience through their scale development supporting effective DE implementation during global crises. Using the technology acceptance model (TAM) and exploratory factor analysis with elementary school teachers in Turkey, they identify four critical factors: teachers' prior knowledge and experience, perspectives on Educational Informatics Network (EIN), stakeholder support, and technology integration knowledge. Their findings emphasize comprehensive teacher training and collaborative support systems as essential for strengthening DE resilience and effectiveness in elementary schools during global crises.

Advancing K–12 Open Educational Resources through Strategic PD

Continuing with K-12 research, **Arispe, Hoye,** and **Haynes** report findings from a longitudinal design-based research (DBR) study evaluating K–12 teachers' gains in awareness, use, and perceptions about OERs before and after the Pathways Project (PP). Their comparison reveals that strategic long-term professional development significantly enhances teachers' OER engagement, with training cohorts showing statistically significant increases in awareness of the 5Rs (retain, reuse, revise, remix, redistribute) and improved perceived effectiveness of OER for learning outcomes.

VR Versus Videoconferencing in Music Education Online

Moving to higher education in China, **Zhang** compares VRChat and Zoom as instructional environments for practising musical skills. This investigation of virtual reality versus videoconferencing platforms for Chinese folk music education on oboe demonstrates the potential of immersive technologies in specialized learning contexts. While revealing no significant differences in performance mastery, the study discovers that VR environments significantly enhance student motivation, aesthetic experience quality, and cultural nuance transmission in musical performance, particularly in conveying lyrical artistic aspects and intonation subtlety characteristic of Chinese folk music.

Academic and Non-Academic Support Services in Distance Learning

Yang's structural equation modeling (SEM) analysis of 1,234 students in China explores the distinct mechanisms by which academic and non-academic support services impact student engagement and academic performance in open education contexts. The findings reveal that student engagement partially mediates the relationship between academic support services and learning performance, while completely mediating the relationship between non-academic support services and learning performance. The findings suggest that DE institutions should focus greater attention on non-academic support services while improving resource allocation to create more efficient and logical resource distribution.

Enhancing Flipped Classroom Effectiveness Through Group Awareness

Encouraging students to invest more in pre-class preparation within FC environments is a challenge identified by ODL literature. **Lin, Lin,** and **Hung** address this persistent lack of student preparedness through their innovative "flipped classroom combined with group awareness" (FC+GA) model. Their extended experimental study demonstrates that incorporating group awareness tools, such as providing visual information about peers' learning status, can significantly improve students' preparation efforts and

learning outcomes compared to traditional FC approaches. The proposed model offers a practical solution for enhancing student engagement in FC environments.

Instructional Design Evolution: Systematic Mapping Analysis

Özkan, Çevik, Saylan, and **Çakıroğlu** provide a comprehensive systematic mapping analysis of instructional design (ID) models for online learning, tracing the paradigm shift from traditional content-centric frameworks toward adaptive learner-centered designs. Using Reigeluth's (2016) framework as a roadmap, this study categorizes ID models considering their applicability to instructional contexts within online learning environments. The findings present emerging trends emphasizing motivation, social interaction, personalization, and technological integration, offering practical recommendations for selecting and implementing models that align with dynamic learner needs and support future ID advancements.

Science Experiment Design in Online Learning: A Systematic Review

This systematic review examines trends in science experiment implementation across online learning environments from 2015 to 2022. Using PRISMA methodology, **Ubaidillah** and colleagues analyze 32 peer-reviewed articles demonstrating diverse pedagogical approaches to science experiments in ODL, including hands-on home experiments, virtual laboratory simulations, and augmented reality applications, with interactive simulations emerging as the dominant trend. Virtual laboratories are found to serve as crucial technology infrastructure, while experiment reports remain the primary assessment method across online science learning contexts. Unsurprisingly, the findings point to significant publication growth since the pandemic, highlighting how emergency remote learning accelerated adoption of digital science experimentation.

E-Books Versus Printed Books in Language Learning

Listanto and colleagues conduct a comprehensive meta-analysis of 12 studies to evaluate the comparative effectiveness of electronic versus printed books in language learning contexts. Their random-effects analysis reveals a medium positive effect size (0.5) favoring e-books, with particularly strong benefits observed for Arabic and Turkish language learning. The study concludes that interactive e-books significantly outperform non-interactive versions, while native language learning shows greater improvement than foreign language acquisition. Notably, e-books demonstrate positive effects on speaking, writing, and listening skills, though reading improvements appear smaller. These findings underscore the importance of developing interactive, culturally responsive digital learning materials that leverage multimedia features to enhance language acquisition.

Open Pedagogy Theory and Practice: A Critical Review

Jhangiani reviews the inaugural volume of a new open access monograph series exploring the intersection of open pedagogy, critical pedagogy, and social justice in higher education. The collection features seven collaborative essays examining values-based frameworks, implementation challenges, and practical applications of open educational practices across diverse institutions. Key insights include the transformative potential of renewable assignments, the importance of addressing digital equity concerns, and the need for institutional policies that support open pedagogical approaches. The review highlights the

volume's commitment to amplifying diverse voices while providing honest examinations of tensions inherent in open educational practice. This critical analysis offers valuable guidance for educators and institutions seeking to implement open pedagogy initiatives while navigating practical implementation challenges.

Collaborative OER Policy Development at The University of the West Indies

McGreal and **Hill** document the comprehensive process undertaken by the University of the West Indies St. Augustine Campus to develop an institutional OER policy through stakeholder engagement and collaborative design. Their mixed-methods approach included systematic review of 44 existing OER policies, online surveys, Delphi focus groups, and a three-day participatory workshop involving diverse campus stakeholders. The process revealed strong institutional support for OER adoption while identifying key barriers including copyright concerns, faculty development needs, and infrastructure limitations. Significantly, the study demonstrates effective integration of genAI for policy comparison and content refinement, with AI recommendations strongly aligning with participant-generated policy elements. The resulting draft policy framework provides a replicable model for institutions seeking to implement collaborative, transparent approaches to OER policy development while addressing local contextual factors.

Looking Forward

These articles collectively illustrate the dynamic evolution of open and distributed learning, from trauma-informed online pedagogy to innovative applications of VR in specialized education. They demonstrate how our field continues to address real-world challenges through research that bridges theoretical advancement with practical application.

The diversity of methodologies - from SEM to DBR, from systematic mapping to extended experimental studies - reflects the methodological sophistication characterizing contemporary scholarship in our field. The international scope of contributions, spanning authors from seven countries, exemplifies IRRODL's commitment to fostering global dialogue and knowledge exchange.

As we advance into an era of increasing digital and AI integration and consequent educational transformation, these studies provide valuable insights for educators, policymakers, and researchers working to create more effective, inclusive, and resilient learning environments that promote learning and wellbeing of all stakeholders. They remind us that the future of open and distributed learning lies not merely in technological innovation, but in our continued commitment to understanding the complex human dimensions of teaching and learning in digital contexts.

Through continued rigorous, accessible research, our journal remains dedicated to advancing ODL while maintaining our foundational commitment to democratic access to knowledge for all. Thank you, authors, reviewers, and the IRRODL team for your contributions!

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Trauma-Informed Education in Open Online Courses: Lessons from Teacher Continuous Professional Development During COVID-19

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Abstract

This study evaluates the feasibility and impact of the Open Online Course (OOC) aimed at enhancing teachers' trauma-informed care practices during the onset of the COVID-19 pandemic. Educators from two public primary schools in Queensland, Australia, completed the course. Twenty-six educators were interviewed about their experience of the OOC. Thematic analysis revealed the feasibility of the OOC was influenced by participants' ability to navigate the digital divide and allocate time for learning. The impact of the OOC was reflected in reports of the adoption of trauma-sensitive classroom management techniques amongst participants. The findings highlight that sustaining OOC-based teacher education on trauma-informed practice requires long-term access, integration of trauma-informed strategies, and ongoing support for hyflex and blended learning models. Findings are mapped onto a trauma-informed education framework and inform recommendations for future OOC design and delivery in post-pandemic educational settings.

Keywords: open online courses, trauma-informed practice, implementation, teacher education, thematic analysis

Introduction

The COVID-19 pandemic disrupted global education, forcing school closures and remote learning, which impacted children's academic, social, and emotional development, heightening stress and anxiety (Rao & Fisher, 2021). Several students even experienced acute stress disorders due to the prolonged isolation and disruptions to daily routines (Acosta et al., 2021). Additionally, physical distancing and mask wearing further hindered social interactions, intensifying feelings of separation (Kaim et al., 2023). These disruptions underscore the critical need for trauma-informed educational practices to address the heightened emotional and psychological challenges faced by students during and after the pandemic.

Trauma-informed care, as outlined by the Substance Abuse and Mental Health Services Administration (SAMHSA, n.d.), is based on six principles: safety; trust; peer support; collaboration; empowerment; and cultural, historical, and gender sensitivity. These principles are designed to create an environment where individuals feel secure, understood, and supported. Safety refers to the physical and emotional security provided to individuals, ensuring that the environment is non-threatening and predictable. Trustworthiness and transparency emphasize the importance of clear, consistent, and open communication, fostering a sense of reliability and integrity within the organization. Peer support involves leveraging relationships among individuals with shared experiences to promote recovery and support. Collaboration and mutuality focus on equal partnerships, reducing power imbalances between staff and clients and encouraging shared decision making. Empowerment and choice prioritize the strengths of individuals, offering opportunities for them to make choices and take active roles in their care. Finally, cultural, historical, and gender issues acknowledge and address the unique cultural, historical, and gender contexts that influence individuals' experiences and needs (SAMHSA, n.d.).

Trauma-informed pedagogy integrates these principles into educational settings, focusing on practices such as building strong teacher–student relationships, providing predictable routines, and designing instruction that is sensitive to the diverse needs of students (Brunzell et al., 2018). These practices have been operationalized in programs such as the Healthy Environments and Response to Trauma in Schools (HEARTS; Dorado et al., 2016), the Berry Street Education Model (BSEM, 2019), and the Trauma-Informed Behaviour Support (TIBS; Ayre & Krishnamoorthy, 2020) program. The HEARTS program emphasizes creating trauma-informed, safe, and supportive school environments through prevention and intervention strategies, focusing on building resilience and fostering emotional well-being among students and staff (Dorado et al., 2016). Similarly, the Berry Street Education Mode provides practical frameworks for trauma-informed teaching, highlighting strategies to enhance student engagement, emotional regulation, and academic readiness in diverse educational contexts (Brunzell et al., 2018).

Trauma-informed pedagogy extends beyond individual classroom strategies to encompass a holistic approach that recognizes the interconnectedness of students' emotional well-being, social dynamics, and academic performance. For example, the TIBS framework advocates for multitiered supports that address not only immediate classroom needs but also systemic factors that influence student outcomes, such as cultural responsiveness and community collaboration (Bellamy et al., 2022). Through this lens, trauma-informed pedagogy becomes a bridge to equity-focused education, addressing the unique and intersecting needs of diverse learners. Pilot studies of the TIBS program in Australian schools, particularly among First Nations students, have demonstrated improvements in academic outcomes and increased trauma-informed practices among educators (Krishnamoorthy et al., 2024; Schimke et

al., 2022). Similar approaches have been adopted in tertiary education, where trauma-informed strategies have been embedded into nursing and social work training programs, emphasizing the need for self-care, resilience, and cultural competence (Carello & Butler, 2015). In vocational education, trauma-informed pedagogy has been used to support adult learners from marginalized backgrounds, fostering empowerment and employability (Skiba, 2020; Gavin et al., 2024). These examples highlight the versatility of trauma-informed frameworks across diverse educational contexts. These findings highlight the potential for trauma-informed practices to mitigate the negative effects of the pandemic on students and suggest a pathway for future educational interventions.

Online Courses for Teacher Education

The COVID-19 pandemic accelerated the adoption of online teacher education, with virtual professional learning communities and microcredentials efficiently enabling collaboration and skill development (Heap et al., 2020; Terlich et al., 2024). Time management and technical issues limit the effectiveness of digital platforms, underscoring the need for ongoing support in trauma-informed education. Self-paced online courses offer additional benefits, such as the ability for educators to learn at their own pace and on their own schedule (Shaffer et al., 2015). Such courses have been found to be effective when used in combination with in-personal training and other digital training resources. Hybrid-flexible training models—referred to as hyflex—involve participants choosing between attending in-person sessions, participating in live online webinars, or engaging with self-paced modules (Beatty, 2019). This adaptability not only accommodates diverse schedules but also supports equitable access to professional development, particularly for educators balancing work and caregiving responsibilities (Kyei-Blankson et al., 2014). The impact of self-paced courses and hyflex approaches on actual classroom practices remains under-researched (Bowyer at al., 2023; Etchells et al., 2021). This gap in the literature suggests that more empirical studies are needed to assess the effectiveness of self-paced online courses in promoting trauma-informed teaching strategies.

Digital technologies offer significant opportunities to build trauma-informed practice capabilities in educators, though research on their use in K-12 teacher professional development remains limited. Open Online Courses (OOCs) represent a scalable solution, providing high-quality training accessible to educators regardless of location (Lay et al., 2020). However, challenges such as the digital divide, high dropout rates, and the need for culturally responsive content must be addressed to maximize their effectiveness (Shankar et al., 2021). These challenges underscore the importance of integrating SAMHSA's six principles into OOCs to ensure that the training is not only accessible but also relevant and supportive of educators' well-being. Addressing these challenges could enhance the efficacy of OOCs and contribute to more widespread adoption of trauma-informed practices in schools.

Designing OOCs for trauma-informed practice training requires careful consideration. Such courses must not only impart knowledge about trauma and its effects but also cultivate the empathy, compassion, and self-awareness necessary for effectively implementing trauma-informed practices (Carello & Butler, 2015; Collier et al., 2022a). Despite these challenges, the potential benefits of using OOCs for trauma-informed practice training are compelling. As educators continue to navigate the psychological impact of the pandemic on students, equipping them with the necessary knowledge and skills is paramount. The scalability and accessibility of OOCs make them a promising tool for achieving this goal, especially in a context where traditional training methods may be less feasible.

Research Aims and Questions

Given the limited research on the impact of online trauma-informed practices, the present study seeks to evaluate the experience, influence, and acceptability of the Trauma-Informed Behaviour Support (TIBS) program, an OOC developed by Dr Kay Ayre and Dr Govind Krishnamoorthy, at two public primary schools in Queensland, Australia. A qualitative approach was employed to understand the effect of TIBS training on teachers' knowledge, attitudes, and pedagogical practices. This study specifically aims to answer the following research questions:

1. How did educators perceive the feasibility of the OOC for trauma-informed practice as a professional development approach during the COVID-19 pandemic?

2. What were the beneficial and challenging pedagogical elements of the OOC?

3. What was the impact of the OOC for trauma-informed practice on teacher instructional practices during the pandemic?

Method

This study employed a qualitative research approach to explore the impact of the TIBS program at two primary schools in Queensland, Australia. The asynchronous TIBS program aimed to enhance educators' trauma-informed practices during COVID-19, with support from a "program champion"—a teacher who collaborated with program developers to facilitate the implementation. The qualitative design was chosen for its ability to capture the multifaceted experiences of educators as they navigated the complex educational demands during the pandemic.

The TIBS program offered trauma-informed training through four asynchronous online modules (Krishnamoorthy & Ayre, 2021; Table 1), each taking 60 to 90 minutes, with pandemic-related supplementary content. Participants completed the training within three months.

Table 1

Modules and Supplementary Materials for the Trauma-Informed Behaviour Support Program's Open Online Course

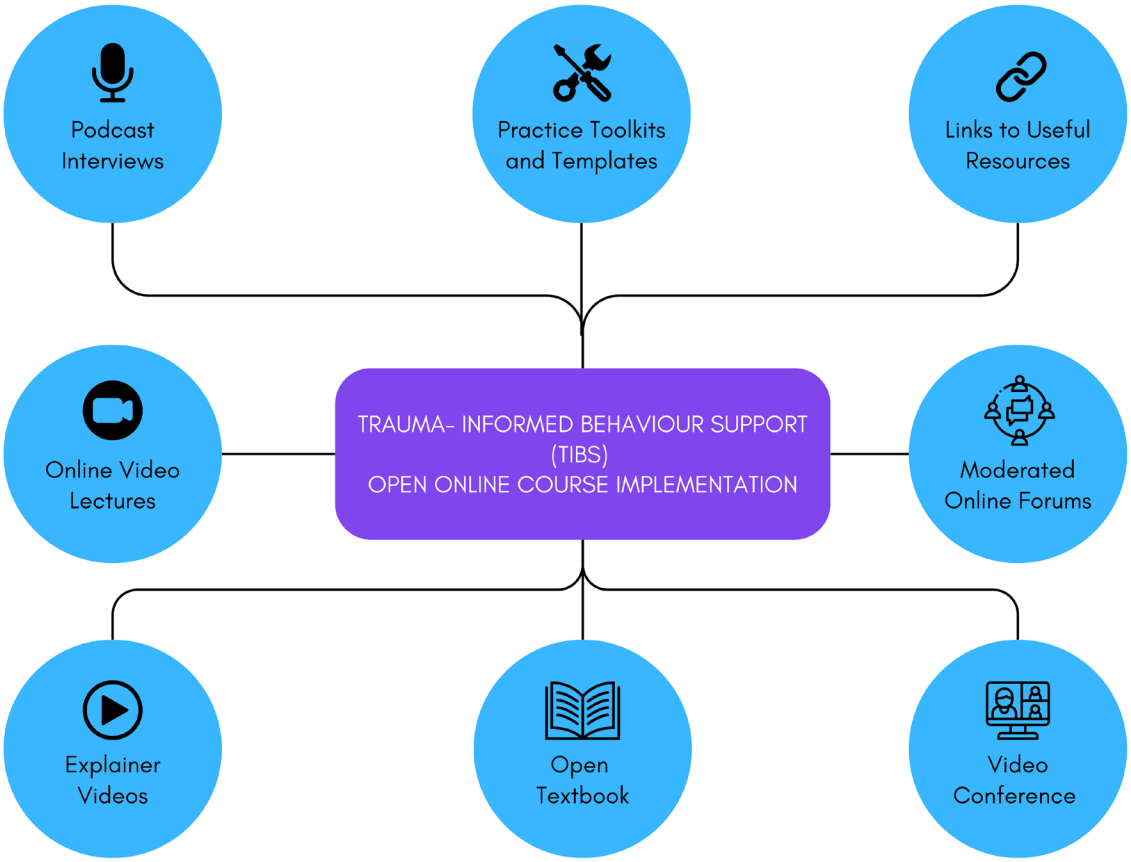
Module title	Description of module content	Description of COVID-19 supplementary materials
Module 1: Understand and Empathize	The module introduces educators to the influence of social determinants and mental health on learning and school functioning. The module provides educators with strategies to understand and respond to basic needs, as well as needs for physical and psychological safety.	Supplementary content (Module: Care) highlights how pandemics have disproportional impacts on marginalized students and their families—with restrictions compounding pre-existing structural inequalities.

Module 2: Prevent and Contain	The module introduces educators to the impacts of trauma on brain development and physical arousal. A framework known as the window of tolerance is investigated in relation to managing escalated behaviours.	This section (Module: Calm) provides guidance on the role of health-related anxiety and pandemic-related restrictions on the learning and well-being of students. Guidance is also provided on managing the teacher's own arousal in response to the pandemic, and its impact on attuning to student mental states.
Module 3: Connect and Validate	This module emphasizes the necessity of establishing trust and rapport with vulnerable students. Ideas on the influence of trauma on the experience and responsiveness of positive reinforcement are discussed.	The supplemental content (Module: Connect) provides in this module focuses on the impact of increased stress on students and teachers during the pandemic, and its role in amplifying pre-existing relational vulnerabilities in student–teacher relationships.
Module 4: Teach and Reinforce	Educators are introduced to the specific impacts of exposure to traumatic experience on attention, motivation, executive functioning, mood, and engagement. Whole-of-school and classroom-based accommodations for academic and social-emotional learning are introduced.	This section (Module: Coach and Collaborate) introduces teachers to the impact of health messaging during a pandemic and its impact on students with learning difficulties.

Figure 1 depicts the pedagogical elements and implementation strategies of the TIBS OOC. The course content, which included multimedia elements such as podcasts, toolkits, video lectures, and forums, provided theoretical and practical tools for trauma-informed practices. These components were designed to support implementing these practices in educational settings. For instance, podcast interviews with experts offered insights into trauma-informed education, while practice toolkits provided step-by-step guides for applying these strategies in schools. Online video lectures and explainer videos clarified key concepts, making them accessible and engaging for participants. The course also featured an open textbook that served as the primary reading material, along with video conference support meetings to facilitate real-time discussions and collaborative learning among participants.

Figure 1

Pedagogical Elements and Implementation Strategies of the Trauma-Informed Behaviour Support Program's Open Online Course



Setting

The study was conducted at two public primary schools in Queensland's West Moreton region, each serving over 1,000 students from Prep (with students typically aged 4 years) to Year 6 (with students aged 11 years) and employing more than 60 teaching staff. Both schools had an Index of Community Socio-Educational Advantage value of 937, below the average school value of 1000, indicating lower educational advantage compared with the national average. The student populations faced significant challenges, with over half of the families in the bottom socio-economic quartile and 52% of students speaking a language other than English at home. These socio-economic factors contributed to developmental vulnerabilities among the students, prompting the schools to implement wide-ranging behavioural interventions to address the social-emotional needs of their students.

The COVID-19 pandemic significantly disrupted education systems worldwide, necessitating a rapid shift to remote learning. In Australia, prolonged school closures risked long-term educational disengagement and persistent disadvantage for vulnerable students (Drane et al., 2020). In early 2020, the first wave of COVID-19 led to the lockdowns and closure of schools across Australia, marking the beginning of a rapid and, for many, chaotic transition to remote learning. Teachers were suddenly tasked with designing and delivering lessons online, often with minimal preparation time and inadequate digital infrastructure. By mid-2020, during the time of the OOC being disseminated, many

educators reported high levels of stress and burnout, as the demands and the uncertainty surrounding the pandemic continued. The chronic nature of the disruptions led to a "COVID hangover," where the lingering effects of the pandemic—including anxiety, decreased student engagement, and challenges in maintaining academic progress (Drane et al., 2020). The educators completed the OOC between March and May 2020. The return to in-person learning in late 2020 and early 2021 did not fully alleviate these issues, as both students and staff struggled to readjust to the classroom environment after months of remote interaction.

Procedure

The research was conducted following approval from the the University of Southern Queensland (USQ) Human Research Committee (application ID: H21REA031). In-depth interviews were conducted by student researchers with the educators of the participating schools. Online interviews were conducted, and video recorded via the teleconferencing software Microsoft Teams. Interview lengths varied between approximately 30 to 60 minutes, averaging 37 minutes. Upon completion of the interview, each participant was offered to have their transcript sent for review; however, all participants declined. It is important to note that the program developers were not involved in the interviews. The questions were based on trauma-informed education and practices, and the educator's experience with asynchronous online courses. The appendix details the questions posed to participants to guide the semi-structured interviews. Participation in the program evaluation was voluntary. After completing the course, participants were invited via email to schedule an interview to discuss their experience of the OOC.

Participants

Study participants included 26 female primary school educators from the public system. While both male and female educators were invited to participate in the study, only female educators chose to participate in the research. Twenty-two participants held a bachelor's degree, while four held a Master of Education. The average participant age was 45, with the youngest being 26 years and oldest being 58 years. Teaching experience was diverse, with an average of 11 years working with children and 12 years in the profession. In-depth interviews were conducted with the educators participating in the OOC in June 2020. To ensure that participants had fully completed the course, we used an online analytics platform to track their progress before they were invited to participate in the interviews. Participants were given the option to review their transcripts, but all declined.

Semi-Structured Interviews

Semi-structured interviews used employed as the primary qualitative measurement tool, allowing participants to elaborate on their responses. The interview questions, provided in Appendix A, were designed to explore educators' experiences with trauma-informed education and the OOC. Interviews commenced with open-ended questions, allowing a balance between planned conversation and deviation toward impromptu points of relevance and specific beliefs of participants (Chafouleas et al., 2019; Shernoff et al., 2017). Supplementary probes were used as required to uncover valuable insights. Interviews were recorded for transcription. Transcriptions were generated using automatic speech recognition function and subsequently reviewed for accuracy by the researchers.

Reflexivity and Analytic Approach

The analysis of the interviews was conducted by student researchers completing the research as part of post-graduate course requirements. To ensure rigour in coding, each student researcher completed coding of the data independently first, followed by a process of working together to develop the final

themes and codes. The student researchers were supervised by the lead researchers. Recognizing the inherent power dynamics in the supervisor-student researcher-participant relationship, both the student researchers and supervisor maintained a reflexive stance by documenting our thoughts and decisions in a reflexive journal and engaging in discussions periodically as a team. Discussions of experiences working in and with schools, personal experiences of the educational system and reflections on the impact of COVID-19 informed the reflexive acknowledge in the analysis of the interview data.

Thematic analysis methodology (Braun & Clarke, 2020) was employed to identify common themes. This approach includes five steps: becoming familiar with the data; generating codes; constructing themes; reviewing, defining, and naming themes; and producing the report (Braun et al., 2018). Interviews were uploaded to a secure automatic speech recognition application, where captions were reviewed. Themes were aligned with the research questions. Two coding cycles were conducted: initial coding to interpret commonalities and pattern coding to highlight key themes.

Findings

Table 2 displays the four overarching themes that emerged from the analysis: the feasibility of the OOC; trauma-informed pedagogical affordances; impact on instructional practice; and sustaining OOC-based teacher education on trauma-informed practice (see Table 2). These themes reflect both the benefits and the challenges of using OOCs for teacher education during the COVID-19 pandemic. The findings also underscore the complexities of applying trauma-informed practices in schools with a high number of students facing complex psychosocial needs, especially amid the demands and restrictions imposed by the pandemic.

Table 2

Themes and Sub-Themes of Using Open Online Courses (OOCs) for Teacher Education

Theme	Description	Sub-themes
Feasibility of the OOC	The viability of OOCs for teacher education during the pandemic	- Navigating the digital divide - Making time for learning
Trauma-informed pedagogical affordances	Trauma-informed care considerations in the design and implementation of the OOCs	- Learning about complex and sensitive topics online - Creating collaborative online support networks
Impact on instructional practice	The benefits and drawbacks of technology-mediated learning for implementing trauma-informed practice	- Trauma-sensitive virtual classroom management techniques - Discovering intersectional student needs
Sustaining OOC-based teacher education on trauma-informed practice	Requirements for long-term access to OOC and integration of trauma-induced practice acquired through OOCs	- Ecological systems view of student needs and multitiered trauma-induced practice - Ongoing support for hyflex approaches to teacher education

Theme: Feasibility of the Open Online Course

While teachers recognized the potential of the TIBS OOC to enhance trauma-informed practices, their engagement with the course was affected by their access to technology, their home life demands, and course accessibility.

Sub-Theme: Navigating the Digital Divide

Teachers reported a significant digital divide among students, families, and even themselves. One teacher remarked, "We had to think outside the box with our lessons. Most families couldn't afford the latest gadgets, and some kids had never even used a computer before."

This sentiment was echoed by another participant who noted, "Many of my students didn't have their own computers or reliable Internet. Some were trying to work on laptops that just didn't cut it." Teachers, too, faced challenges adapting to the new technology demands. As one teacher shared, "Honestly, a lot of us were struggling as much as the kids with the tech. Some of us didn't even know how to set up a Teams meeting, and, well, the Internet was often pretty patchy." Technical issues often took more time than teaching as one participant noted,

"There were days when I spent more time fixing tech problems than actually teaching. It felt like we were always playing catch-up." Despite these hurdles, many teachers praised the course's accessibility and multimedia resources, including videos, podcasts, and practical toolkits. "I liked that the course moved smoothly from one video to the next, and it was helpful that they previewed what was coming up, whether it was a reading or a podcast,"

one teacher said, adding, "The podcasts were great—I could listen on my morning walks or while doing [other tasks]."

Sub-Theme: Making Time for Learning

The pandemic significantly affected participants' ability to engage with the OOC, particularly for those balancing professional and caregiving responsibilities. All participants were women and mothers, and the disproportionate burden of caregiving during COVID-19 impacted their capacity to focus on the course. One participant explained, "I was juggling teaching my own kids, helping out with online classes, and caring for my elderly dad. I just didn't have the energy left to sit down and study." Another teacher shared,

> Caring for my family was my top priority. With my husband working long hours at home and my kids home from school, I felt like I was in survival mode … the course was something I'd try to squeeze in whenever I could.

The intersection of professional and personal responsibilities meant the course often took a backseat to more immediate concerns. This experience highlights the need for professional development opportunities that are not only flexible but also sensitive to the unique challenges faced by educators during times of crisis.

Theme: Trauma-Informed Pedagogical Affordances

Trauma-informed pedagogical strategies in online courses are increasingly recognized as essential for effectively teaching sensitive topics. Learning about trauma can evoke emotional responses, creating barriers to learning, especially in online environments where interaction is limited.

Sub-Theme: Learning About Complex and Sensitive Topics Online

Videos presenting real-life scenarios through dramatic enactments helped bring the content to life, making it more relatable for teachers. One participant noted, "The videos where the presenters shared their stories made everything more relatable and helped me see how I could apply these strategies with my students." However, the emotionally charged content sometimes stirred up difficult feelings, as one teacher shared, "I found myself reflecting on my students and feeling a sense of grief for what they might be dealing with at home."

The course addressed these emotional aspects by providing regular reminders about available support, such as school counsellors and external mental health resources. "There were moments when the content hit close to home, but having the option to stop and talk to the school counsellor was helpful," one participant explained. This support was crucial for educators dealing with their own trauma or pandemic-related stress, although some expressed a desire for face-to-face discussions to process their reactions. Many teachers also found the course unexpectedly beneficial for personal growth. As one teacher reflected, "Some of the topics really resonated with my own experiences. I realized that some of the strategies we're taught for students could actually help me deal with my own stress."

Sub-Theme: Creating Collaborative Online Support Networks

The peer support networks fostered through the OOC were particularly valuable during the pandemic, providing teachers with the necessary support to navigate the rapidly changing educational landscape. Participants appreciated the online forums and weekly Teams meetings, where they could discuss the course and share experiences. One teacher remarked, "I found it helpful to connect with other teachers and brainstorm how to apply what we were learning in our classrooms."

These discussions extended beyond course content, offering a space to share personal challenges related to the pandemic. As one participant put it, "The forums and Teams meetings weren't just about the course. It was comforting to know I wasn't the only one struggling."

For teachers with family members at higher risk during the pandemic, these peer support networks provided a sense of understanding and solidarity. "My kids have respiratory conditions, and I was really anxious about everything. It helped to hear from another teacher in a similar situation," one participant shared. The collaborative atmosphere fostered resilience among educators, enabling them to support one another in both professional and personal capacities.

Theme: Impact on Instructional Practice

The OOC provided educators with a range of evidence-based strategies for managing virtual classrooms. The supplementary modules guided educators on the use of these strategies in line with trauma-informed care principles, as well as accommodating for the constraints and impacts of the pandemic.

Sub-Theme: Trauma-Informed Virtual Classroom Management

Teachers found proactive strategies, such as setting clear routines and incorporating regular breaks, particularly beneficial. One teacher noted, "I found the idea of setting clear, consistent routines in the virtual classroom useful. It gave the students a sense of stability." Others appreciated the emphasis on mindful communication, with one participant saying, "Simple things like slowing down, using encouraging language, and being mindful of tone made a big difference."

However, some teachers felt the course could have provided more guidance on challenging situations. One teacher explained, "The strategies were a great start, but sometimes I wasn't sure if I was doing enough to support my students emotionally while also meeting curriculum demands." This comment reflects the tension between academic requirements and social-emotional support, particularly in the online setting. The reduced capacity to attune to children's emotional states online made this balance even more challenging. As one participant noted, "It was hard to gauge how the kids were feeling or how engaged they were. Sometimes it felt like I was missing the subtle cues I'd pick up on in a physical classroom."

Sub-Theme: Discovering Intersectional Student Needs

Intersectionality, which refers to how various social identities (such as race, class, disability, and gender) intersect to create unique experiences of discrimination or privilege, became increasingly relevant during this period. The pandemic highlighted the intersectional challenges faced by students from diverse backgrounds, particularly those with disabilities or other learning needs. Educators became more aware of the multiple, intersecting challenges their students faced. One teacher observed, "It became clear that some students are struggling not just because of the schoolwork, but because they're dealing with other things at home."

The shift to online learning provided educators with a window into their students' home lives, revealing the stressors many children faced. As one teacher reflected, "Seeing students in their home environments was confronting. It highlighted why trauma-informed practices are so necessary." While the OOC did not explicitly address intersectionality, educators applied trauma-informed practices to better understand and respond to these complexities.

Theme: Sustaining Teacher Education on Trauma-Informed Practice Acquired Through Open Online Courses

OOC-based teacher education on trauma-informed practice requires an integrated approach that addresses the interconnected challenges faced by the entire school community, recognizing that both student and teacher well-being are linked.

Sub-Theme: Holistic View of Student Needs and the Need for Multi-Tiered Trauma-Informed Practice

Educators recognized that challenges at home, in the community, and at school shape students' experiences. One participant noted, "Understanding that students are dealing with challenges at home, in their neighbourhoods, and within the school itself has made me rethink how we approach education." The pandemic further highlighted the interconnectedness of these factors, revealing how stressors in one area can ripple through others, affecting both students and educators. "COVID-19 has shown how interconnected everything is. The stress from home, the lack of resources, and even our own mental health as teachers all affects our students," one teacher explained.

Sub-Theme: Ongoing Support for Hyflex Approaches to Teacher Education

Participants expressed a desire for future courses to continue offering flexible training options, combining in-person sessions with online modules, including live Teams meetings. "Having different ways to access the training was really helpful," one teacher said, adding, "The ability to choose how and when to engage with the content made it easier to fit the training into my schedule." This flexibility was seen as vital for managing the demands of busy schedules while enhancing engagement with the

content. As one participant noted, "With all the challenges we've faced during COVID-19, having different ways to access the training was crucial. I hope we continue to have these options."

Discussion

This study aimed to evaluate the impact of the TIBS OOC as a professional development tool for educators during the COVID-19 pandemic. Designed to address the heightened stressors faced by students and teachers, the OOC sought to equip educators with the knowledge and skills necessary to implement trauma-informed practices in virtual classrooms. The findings contribute to the broader discourse on trauma-informed education, highlighting the importance of flexibility in delivering such training during times of crisis. The research focused on three primary questions: the feasibility of delivering the OOC during the pandemic, the identification of beneficial and challenging pedagogical elements within the course, and the overall impact of the OOC on instructional practices.

Feasibility of the Open Online Course

The feasibility of implementing the TIBS OOC as a teacher education tool during the pandemic was influenced by several factors, both challenging and advantageous. The rapid transition to online learning presented challenges such as limited technology access, poor Internet, and varied digital competence among educators (Chisadza et al., 2021). These challenges were particularly pronounced in rural and low-income areas, where the digital divide posed a significant barrier to consistent engagement with the course materials (Garland & Wotton, 2001). Additionally, educators with limited digital literacy faced steep learning curves, often requiring extra time and support to navigate the online environment effectively (Lai & Widmar, 2020).

The pandemic further strained the balance between professional and personal responsibilities, especially for women educators. The increased demands of remote teaching, coupled with the necessity of caring for children or elderly relatives at home, created significant time constraints (Kotowski et al., 2022). This finding aligns with existing research documenting how the pandemic disproportionately impacted women, intensifying their caregiving responsibilities and limiting their capacity to participate in professional development (Stefanova et al., 2021). Despite these barriers, strategies such as providing e-learning training support and fostering online learning communities helped some educators engage with the OOC, though time constraints remained a significant hurdle (Gosselin et al., 2016). The preference for a hybrid approach to professional development, such as the hyflex model, reflects a broader trend toward adaptable learning experiences tailored to individual needs (Kyei-Blankson et al., 2014). This adaptability is particularly relevant for trauma-informed education, as it accommodates the diverse personal and professional demands on teachers, especially those with caregiving responsibilities (Patterson et al., 2020).

Pedagogical Design and Implementation Considerations

Table 3 presents a summary of the implications of the findings for trauma-informed online learning pedagogical design and implementation. The implications link directly to the findings on the OOC's diverse pedagogical components (e.g., forums, multimedia resources) and to SAMHSA's six trauma-informed principles. Multimedia resources were a notable strength of the OOC, offering diverse formats such as videos, podcasts, and interactive modules that enhanced engagement and allowed for personalized learning experiences (Al-Aghbari et al., 2021).

Table 3

Trauma-Informed Considerations in Open Online Courses

Principles for trauma-informed practice	Feasibility issues in access and use of online training	Pedagogical considerations in online training	Transfer of learning to practice	Supporting implementation and ongoing practice
Basic needs and safety	- Ensure reliable Internet access and devices for all participants. - Provide technical support to prevent access issues.	- Include clear content warnings and allow opt-out options. - Use asynchronous modules to accommodate different comfort and pacing in completing modules.	- Encourage application of child safeguarding practices in the virtual classroom. - Provide ongoing support for managing emotional reaction to course / emotional burden.	- Provide accessible mental health resources to the participants. - Regularly check in on participants' learning and well-being.
Trustworthiness and transparency	- Clearly communicate course expectations and requirements. - Pilot and check all resources are easily accessible.	- Maintain options for timely communication with trainers throughout the course. - Provide clear learning objectives and rationale/intent.	- Assess and align course content with educators' professional goals and school policies. - Encourage safe, respectful, timely feedback on practice.	- Use participant feedback to refine course content. - Provide follow-up sessions to address ongoing concerns.
Peer support	- Facilitate online spaces for informal interaction (e.g., discussion boards, social media groups).	- Incorporate peer-to-peer learning opportunities (e.g., group projects, scheduled group Teams meetings).	- Encourage sharing of strategies and challenges among peers. - Use peer networks to reinforce learning and exemplary practice.	- Establish peer mentoring systems for ongoing support. - Create forums for continued professional exchange.
Collaboration and mutuality	- Provide collaborative tools (e.g., shared docs, online whiteboards) that are easy to use and accessible to all.	- Design group activities that promote discussions and mutual learning. - Prompt participants to co-create to suit their unique context.	- Foster a collaborative culture in the virtual classroom. - Encourage school team-based approaches to problem-solving, supported by program champions.	- Engage participants regularly in collaborative reflection sessions. - Promote shared leadership in implementation.
Empowerment, voice, and choice	- Offer multiple ways to engage with the content (e.g., live sessions, podcasts, interactive elements).	- Allow participants to choose their own learning paths and pace. - Use surveys to gather participant preferences and learning needs.	- Encourage educators to identify personal and professional strengths relevant to trauma-informed practice. - Provide coaching and tools for personalized application.	- Assess evolving learning needs of participants to inform professional development. - Review policies and procedures to support online education based on teacher feedback.
Cultural, historical, and gender issues	- Assess whether the content is respectful, representative, and relevant to diverse cultural and socio-economic backgrounds.	- Review that online material is culturally and linguistically responsive. - Use case studies from diverse contexts.	- Highlight the importance of culturally responsive practices in the classroom. - Encourage supported reflections on cultural implications.	- Provide access to cultural brokers and training for ongoing cultural competence development. - Support discussions on historical and gender issues on coping with workplace demands.

The OOC's trauma-sensitive topics presented emotional challenges, with the virtual format limiting immediate emotional support and leaving teachers to process content alone. This experience is consistent with findings from previous research, which suggests that learning about trauma in isolated settings can heighten stress and emotional fatigue (Luthar & Mendes, 2020). The course design did attempt to mitigate these challenges by integrating exercises to promote reflexivity and providing access to supports both in and outside of the school. However, some participants reported that the online setting still exacerbated feelings of isolation and emotional burden, highlighting the need for more robust, real-time support mechanisms during trauma-informed training (Olson et al., 2021).

Peer support networks within the OOC were another beneficial element, facilitating collaborative learning and offering a space for educators to share experiences and strategies. This aligns with the value of virtual interaction and multidisciplinary collaboration in enhancing the learning experience (Scott et al., 2009). However, the lack of sufficient guidance for addressing complex student needs poses a significant challenge, reflecting broader concerns about the limitations of OOCs in providing comprehensive support for educators (OECD, 2017). Therefore, it is essential for educators to adopt a critical approach when implementing OOCs, ensuring that pedagogical design principles facilitate active collaboration and interaction while addressing the inherent limitations of online learning management systems (Al-Aghbari et al., 2021).

Impact of the Open Online Course on Teacher Instructional Practices

One of the most significant outcomes of the OOC was the integration of trauma-informed strategies into daily instructional practices. Teachers found the course useful for establishing consistent routines and mindful communication, aligning with trauma-informed goals of creating safe, stable environments (Stokes, 2022). This approach was particularly crucial in the virtual classroom, where the lack of physical presence often made it more challenging to gauge student well-being. The OOC also heightened teachers' awareness of the broader ecological systems influencing student behaviour. Educators began to recognize the complex interplay between home environments, community contexts, and school expectations, particularly during the disruptive events such as the pandemic (Stribley et al., 2025). Supporting students from priority equity groups and those with intersectional identities, particularly during the pandemic and within online learning environments, emerged as a critical area requiring further guidance.

The OOC highlighted gaps in addressing the specific needs of students from culturally and linguistically diverse backgrounds and low socio-economic status families. Research indicates that students from these groups are disproportionately affected by the digital divide and face unique challenges in accessing and engaging with online learning (Evans et al., 2021). Educators noted the importance of explicit guidance on recognizing and responding to potential safety concerns in a virtual context, where traditional signs of distress might be less visible. Teachers also expressed concern over meeting curriculum requirements while addressing the social-emotional needs of their students. This tension is well-documented in the literature, where educators often struggle to balance fostering a supportive, trauma-informed environment with ensuring academic goals are met (Kataoka et al., 2018). While the OOC provided valuable strategies, teachers felt that more guidance was needed on integrating these practices without compromising academic standards.

Informal interviews conducted in June 2024 with six of the participants revealed that they continued to re-visit content from OOC periodically as they integrated trauma-informed practices into their classrooms. All the participants referred to new learnings from revisiting the content to support a

growing sophistication in the implementation of these practices. Three educators spoke of personalizing the implementation of trauma-informed practice based on individual student's strengths, interests, and preferences, while also adapting whole-of-class practices based on mix of academic and well-being needs of the students. These reflections suggest that OOCs can provide a foundation for sustained professional growth, while also being a resource for ongoing professional development and long-term success in supporting students.

Study Limitations and Future Directions

The geographic focus on Australia and timing during the COVID-19 pandemic may limit the findings' generalizability. While these conditions are integral to understanding the impact of trauma-informed practices during a crisis, they also introduce variables that may not be present in more typical educational settings (Collier et al., 2022b; Watson et al., 2022). Future research should consider longitudinal studies to assess the long-term impacts of the TIBS program on both teachers and students. Investigating how trauma-informed practices evolve and sustain effectiveness over time would provide valuable insights into the durability of these interventions. There is also a need for more in-depth exploration of how trauma-informed practices can be integrated into hybrid and online learning environments, particularly as these modalities become more prevalent in post-pandemic education (Harper & Neubauer, 2020). Examining the effectiveness of different scaffolding strategies and support systems in these contexts could further refine the implementation of trauma-informed practices. For example, future research could investigate caregiver perspectives to better understand how home environments intersect with trauma-informed practices in online learning contexts.

Conclusion

This study underscores the importance of trauma-informed practices, especially during crises. It highlights the need for clear routines, supportive environments, and flexible professional development to address diverse student needs. Virtual learning poses challenges in maintaining engagement and support. As educators, policymakers, and researchers continue to navigate the evolving educational landscape, it is imperative to prioritize the development and implementation of trauma-informed practices that are adaptable to diverse contexts. The insights gained from the OOC should inform the creation of flexible, accessible professional development opportunities that meet the varying needs of educators. Collaborative environments are crucial for sustaining trauma-informed practices across educational settings.

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Appendix

Interview Guide

1. Can you describe your teaching background and experience?
2. What motivated you to participate in the online course?
3. How did you find the process of accessing and navigating the online course? Were there any challenges?
4. How did you manage your time to engage with the online course? Did any factors make this easier or more difficult?
5. What aspects of the online course material and content did you find most relevant or helpful for your teaching practice?
6. Were there any parts of the course that were particularly challenging? How did you handle this?
7. Can you give examples of how you have applied what you learned from the online course in your classroom?
8. Have you noticed any changes in your students' behaviour or engagement since implementing trauma-informed strategies from the online course?
9. What support have you received to continue applying trauma-informed practices after completing the online course?
10. What recommendations do you have for improving the online course, especially in terms of long-term support for teachers?
11. Is there anything else you would like to add about your experience with the online course or the implementation of trauma-informed practices?

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Enhancing Distance Education Resilience: Developing a Scale for Effective Implementation During Global Crises

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Abstract

The global shift to distance education during the COVID-19 pandemic challenged the resilience and efficiency of educational systems worldwide. This study investigated the factors influencing the effectiveness and resilience of distance education in elementary schools in Türkiye. Using a quantitative method, 100 elementary school teachers from various regions of Türkiye were surveyed. Guided by the technology acceptance model (TAM) and employing exploratory factor analysis (EFA), the study identified four critical factors: (a) teachers' prior knowledge and experience with distance education; (b) perspectives on the Educational Informatics Network (EIN); (c) stakeholder support; and (d) technology integration knowledge and experience. The findings emphasized the role of comprehensive teacher training programs in equipping educators to adapt to digital teaching environments. They also underlined the importance of national educational platforms like EIN, which served as a critical resource during the pandemic. Collaborative support systems involving school administration, parents, and technical teams were found to significantly enhance the success of distance education. Furthermore, teachers' ability to integrate technology into their teaching practices emerged as a crucial factor. These results have significant implications for educational policy, and highlight the need for a multidimensional strategy to strengthen distance education systems and ensure their resilience during global crises.

Keywords: distance education, technology integration, global crisis, elementary schools

Introduction

Effects of the COVID-19 pandemic have caused a startling shift in the educational landscape. Educational institutions have had to quickly modify their traditional teaching strategies to fit the needs of distance education. This has tested the adaptability and durability of global education systems (Hodges et al., 2020). Like many other nations, Türkiye's swift adoption of distance education has demonstrated the immense possibilities and noteworthy constraints of distance education during emergencies (Bozkurt & Sharma, 2020; Mishra et al., 2020).

The education community was unprepared for the abrupt shift to remote learning. Many teachers were unaware of the importance of certain topics in distance education. For remote learning settings to be effective, teacher training, technology infrastructure, and support are essential (König et al., 2020). In times of crisis, distance education can be a useful substitute for traditional in-person instruction; however, its efficacy is contingent upon many factors, including the technological proficiency of the teacher, administrative support, family support, and teacher preparation (Bao, 2020; Ozudogru, 2021).

Elementary schools have found it particularly difficult to make the switch to distance education because younger pupils require more direction and engagement (Wysocka-Narewska, 2022). Since many teachers had limited experience with online teaching practices, they were challenged to swiftly adjust their pedagogical approaches. Significant inadequacies in teacher preparation programs were exposed by this abrupt change, underscoring the need for more comprehensive professional development programs with emphasis on technology integration and online teaching techniques (Carrillo & Flores, 2020; Dhawan, 2020).

Access to and use of technology have been major factors in the efficacy of distance learning. The gap between students with easy access to computers and the Internet and those without, known as the digital divide (Van Dijk, 2020), has become even more pronounced. Like many other nations, Türkiye has seen disparities in educational possibilities due to disparities in technology and high-speed Internet access. These disparities have particularly affected students from low socioeconomic backgrounds and those who live in rural regions (Bozkurt et al., 2020; Logan & Burdick-Will, 2017).

There has also been an examination of the function of policy execution and administrative assistance. Making quick judgments on curriculum adaption, assessment techniques, and resource allocation forced school administrators and education policymakers to traverse unfamiliar ground (Fernandez & Shaw, 2020). The ability of educational leaders to give instructors, students, and parents clear direction, technical help, and emotional support is often critical to the success of distance learning projects (Huber & Helm, 2020; Rasmitadila et al., 2020).

The COVID-19 pandemic also made clear the importance of family support to the process of remote learning. As education began to take place in homes, parents and guardians assumed the role of de facto educators for their kids. This highlighted strong school-family partnerships and the significance of providing families with the knowledge and resources necessary to support their children's remote learning (Bhamani et al., 2020; Garbe et al., 2020).

Using the experiences of elementary school teachers in Türkiye during the pandemic as a guide, we investigated the elements influencing the efficacy of distance education during the crisis. We examined the challenges they faced, the strategies they used, and the resources they thought were very beneficial to them during their distance learning. The technology acceptance model (TAM) served as the basis for

our study. It provided a thorough framework for understanding the factors affecting the adoption and efficacy of technology in the classroom (Davis, 1989). TAM effectively explained how perceptions of technology's usefulness and ease of use can influence adoption. This aligned with the study's focus on understanding the role of technology integration in distance education.

This study aimed to provide educators, administrators, and policymakers with a diagnostic tool to assess key elements influencing distance education resilience. By using this tool, institutions can strengthen remote learning environments and enhance preparedness for future challenges. The findings offered a preliminary framework to guide policy and future research on distance education resilience. By identifying critical factors such as teacher training, stakeholder support, and technology integration skills, this study offered practical recommendations for improving the effectiveness and resilience of distance education systems during crises.

While existing studies have explored various aspects of distance education during the COVID-19 pandemic (Bozkurt & Sharma, 2020; Hodges et al., 2020; Mishra et al., 2020), limited attention has been given to the specific challenges faced by elementary school teachers in Türkiye, who had to adapt to the unique needs of younger students requiring greater engagement and direction (Wysocka-Narewska, 2022). While research has explored distance education resilience, few efforts quantified its key influences. This study proposed a preliminary scale as a framework for assessment, though further validation is needed for broader application.

In summary, our research aimed to investigate and improve the resilience of distance education, particularly in the context of elementary school teachers in Türkiye during global crises, such as the COVID-19 pandemic. In this study, we developed a scale to enable distance education to be carried out successfully when it is necessary to switch to distance education in times of a national or global crisis. Additionally, this study provided a framework for future-proofing education systems, ensuring they are better prepared to deliver effective distance education in the face of global emergencies. Hopefully, addressing the challenges of the present have made a contribution to building resilient and adaptable education systems for the future.

The following research questions guided our study.

1. What factors influenced the resilience and effectiveness of distance education in elementary schools during global crises?

2. What factors affected distance education in elementary schools during the COVID-19 pandemic in Türkiye?

Although we conducted this study in Türkiye, the factors influencing distance education resilience are common in other global contexts (e.g., United States, Finland, South Korea). Previous studies (e.g., Bozkurt et al., 2020; König et al., 2020) have shown that teacher preparation, access to technology, and administrative support are critical for effective distance learning worldwide. The findings of this study contributed to this growing literature by providing an evidence-based framework that can be adapted to multiple educational settings.

Literature Review

The COVID-19 pandemic underscored the need for resilience in education. Central to this transition were the roles and experiences of teachers, whose knowledge, skills, and access to resources significantly influenced the effectiveness of online teaching. Our literature review explored four critical components shaping the success of distance education: (a) teachers' prior knowledge and experience; (b) their perspectives on educational platforms like the Educational Informatics Network (EIN); (c) support from various stakeholders; and (d) teachers' technology integration skills. These interconnected elements provided a foundation for understanding how to enhance the resilience and efficiency of distance education systems, particularly during global crises.

Teachers' Distance Education Prior Knowledge and Experience

Many studies have highlighted the importance of teachers' pre-existing knowledge and experience in distance education. Educators with previous online teaching experience were better equipped to handle the sudden transition to remote learning brought on by the COVID-19 pandemic (Mishra et al., 2020). König et al. (2020) found that a teacher's ability to maintain high-quality instruction in online settings was closely linked to their digital proficiency, often gained from previous experience. Distance education's success is reliant on educators' knowledge of online teaching tools and methods, obtained through either prior experience or training, (Bao, 2020). Trust and Whalen (2020) found that educators who had previously taught online were more inclined to use a wider variety of digital tools and better involve students in remote learning.

Teachers' Perspectives of Educational Informatics Network

Within Türkiye, the EIN has played a crucial role in facilitating distance education. In their study on educators' perspectives of EIN during the epidemic, Duzgun (2021) found that most educators viewed it as essential for online teaching. However, some teachers encountered difficulties maximizing the platform's capabilities due to technical issues or a lack of familiarity. In their investigation into the efficacy of EIN from the viewpoint of teachers, Karalar and Dogan (2017) discovered that although many valued its extensive content, a few thought that additional interactive elements could improve student involvement. This is consistent with research by Ozer (2020), who hypothesized that EIN's capacity to assist remote learning might be greatly increased by ongoing modification and enhancement based on instructor input. While EIN has been instrumental in Türkiye, its role aligns with global efforts to develop national digital learning platforms.

Receiving Support from Stakeholders

For distance education to be effective, several stakeholders must support the program. According to Rasmitadila et al. (2020), school management played critical role in helping instructors adjust to online learning by giving them tools, direction, and emotional support. They discovered that schools with robust administrative assistance were better able to sustain academic standards during the pandemic. The importance of parental support came to light, particularly for younger students. Research by Garbe et al. (2020) showed that parental involvement significantly impacted students' achievement and engagement in online learning. Technical support has been identified as another crucial element. Dhawan (2020) emphasized that robust technical support was essential for addressing the inevitable technological challenges that arose in distance education, helping to minimize disruptions to teaching and learning.

Teachers' Technology Integration Knowledge and Experience

The key to success in distance education has been teachers' ability to successfully incorporate technology into their lessons. According to Tondeur et al. (2019), educators with greater expertise and familiarity with technology integration demonstrated greater flexibility and inventiveness in their virtual teaching methodologies. Ozudogru (2021) looked at how instructors' attitudes toward distance learning and their ability to integrate technology were related. According to the study, educators who were more confident of their capacity to incorporate technology into their lessons also expressed more positivity toward online learning and experienced fewer implementation difficulties. Author (2024) stated that teachers' lack of knowledge and skills was an important internal challenge that prevented them from using technology effectively in literacy classes. The research emphasized that teachers' technology integration skills are not limited to technical knowledge but should also include pedagogical practices. For example, a teacher's lack of knowledge of how to use technology in writing and reading activities posed an obstacle to using these tools effectively in education. In this context, it has been stated that in-service training programs and professional development opportunities played a critical role in overcoming such challenges by increasing teachers' technology integration skills.

Theoretical Background

The Technology Acceptance Model

TAM, the theoretical foundation for our study, offered a thorough treatment of the variables influencing the uptake and effectiveness of technology in education (Davis, 1989). TAM was especially appropriate for our research because it concentrated on accepting and adopting technology. One of the most crucial elements in successfully putting distance learning into practice is technology, particularly in times of an international emergency like the COVID-19 pandemic. With its robust empirical backing, this model offered a sound basis for exploring the variables that affected instructors' preparedness and desire to use technology in their lesson plans. TAM was the basis for our thorough assessment of the perspectives and attitudes of elementary school teachers in Türkiye regarding technology use in online teaching, given the significance of teacher preparation and technology integration in distance education. Furthermore, TAM aligned with the overarching objectives of our study by helping us create a scale to quantify these crucial elements. Several studies have made use of TAM for research into remote learning. For example, Scherer et al. (2019) examined teachers' adoption of technology in 11 countries using an extended version of TAM and discovered that instructors' intentions to use technology were highly impacted by perceived utility and simplicity of use. Likewise, Teo et al. (2019) used TAM to investigate pre-service teachers' intentions to use technology, emphasizing the role that perceived utility played in influencing these intentions. While TAM explains technology adoption, it overlooks socio-economic disparities and policy barriers in distance education. Al-Adwan et al. (2023) have suggested extending TAM to address these limitations.

Methods

Method and Design

In this study, we adopted a quantitative research design and used the survey method to collect data

from elementary school teachers across all regions of Türkiye. The study aimed to examine the factors influencing distance education's resilience, durability, and effectiveness during a global crisis, specifically the COVID-19 pandemic. We distributed the survey link to approximately 200 elementary school teachers, of which 105 completed the form. This approach enabled us to identify key factors contributing to the success of distance education under challenging circumstances, providing insights into the unique experiences of educators during the pandemic.

Data Collection Tool

We designed an online survey comprising three sections. To facilitate descriptive analysis, the first section, demographic information, collected data on participants' age, gender, and teaching experience. The second section, key analytical questions, included targeted items such as the participation rate of students in online classes to gather data for inferential analysis and address the study's primary research objectives. The third section consisted of 12 statements rated on a 5-point Likert scale, ranging from 1 (*strongly disagree*) to 5 (*strongly agree*). It included items that asked respondents to assess whether they received adequate support for the technical problems they experienced during distance education. Since our study was carried out in Türkiye, the survey was conducted in Turkish, the participants' native language, to ensure clarity and accuracy.

Sampling

The sample for this study initially comprised 105 elementary school teachers representing all socioeconomic and geographic regions of Türkiye, including the Marmara, Aegean, Central Anatolia, Mediterranean, Black Sea, Eastern Anatolia, and Southeastern Anatolia regions. Exploratory factor analysis (EFA) requires 5 to 10 participants per variable (Hair et al., 2010; Kline, 2013), making 100 participants sufficient for our 12-item scale. While larger samples improve generalizability, prior research (Scherer et al., 2019) has confirmed that moderate samples can yield valid structures for well-defined constructs such as teacher training, stakeholder support, and technology integration. Participants were selected based on their experience providing distance education during the COVID-19 pandemic. However, five responses were excluded due to insufficient information, resulting in a final sample of 100 teachers. A convenience sampling technique (Creswell & Creswell, 2017) was practical and accessible given the restrictions and challenges posed by the pandemic.

Data Collection Procedure

Due to the restrictions imposed by the COVID-19 pandemic, the survey was conducted virtually to ensure the safety of participants and researchers while maintaining accessibility. The survey link was distributed electronically to elementary school teachers via e-mail and professional networks. Before completing the survey, participants were required to read and sign an informed consent form, which detailed the purpose of the study, the voluntary nature of their participation, and the measures in place to ensure confidentiality. Data collection was carried out over a period of six weeks in 2021, allowing ample time for participants to respond at their convenience. This virtual approach adhered to pandemic-related restrictions and facilitated participation from teachers across diverse geographic regions of Türkiye.

Data Analysis

For data analysis, we used the Statistical Package for the Social Sciences (SPSS) version 29. The analysis process involved several steps. First, we conducted a descriptive analysis by calculating the means and

standard deviations of the scale items and demographic factors. Second, reliability analysis involved calculating Cronbach's alpha to assess the internal consistency of the scale. Third, in EFA, principal component analysis with Oblimin rotation was used to allow for correlated factors aligned with the interdependent nature of our constructs. Prior studies (Teo et al., 2019) have reinforced the use of Oblimin rotation in similar educational models.

Findings

Descriptive Statistics

The elementary school instructors who took part in our study came from seven distinct locations in Türkiye. The participants' age ranges and teaching experiences varied significantly, while they were evenly distributed by gender. The participants' diverse backgrounds allowed for a thorough evaluation of distinctions and similarities across different demographic groups as we analyzed the resilience, durability, and effectiveness of distance education.

Initially, 105 individuals responded to our survey. Five responses were excluded due to insufficient data, resulting in a final sample of 100 participants. Our sample had a balanced gender distribution, with 50 male and 50 female participants. See Table 1 for complete descriptive statistics.

Table 1

Descriptive Statistics

Category	Subcategory	Count
Gender	Male	50
	Female	50
Age	21–30	33
	31–40	46
	41–50	15
	51–61	6
Teaching experience	0–3 years	14
	4–7 years	23
	8–11 years	23
	12–15 years	15
	16–20 years	14
	20+ years	11
Geographic region	Eastern Anatolia	23
	Marmara	21
	Southeastern Anatolia	20
	Central Anatolia	16
	Mediterranean	8
	Aegean	7
	Black Sea	5

Reliability

Reliability of the questionnaire was confirmed with a Cronbach alpha value of 0.749. This indicated a satisfactory level of internal consistency for the 12 items in the survey. The items reliably measured the

intended constructs and the survey was considered reliable for further analysis.

Exploratory Factor Analyses

We conducted EFA to explain inferential statistics succinctly and divide relevant questions into component groups. As a result of EFA, we found that the questions of our study focused on four components.

EFA determined the structures underlying the survey items. We used principal component analysis with Oblimin rotation. It revealed a more accurate structure, taking into account possible correlations between factors. By selecting a rotation method that aligned closely with real-world applications, the analysis minimized potential errors and ensured a more reliable representation of the data.

As a result of EFA, the survey items were sorted under four components. Table 2 shows the loading of each item according to relevant factors and the strength of these loadings. This table helps us understand which items loaded more on which factors and the content of these factors. According to these loadings, the components were named as follows:

Component 1: Prior knowledge and experience

Component 2: Educational Informatics Network (EIN)

Component 3: Support from stakeholders

Component 4: Technology integration

Table 2

Pattern Matrix for Principal Component Analysis with Oblimin Rotation

	Component			
Factor	1	2	3	4
1. I think I had enough experience in distance education before the COVID-19 pandemic.	.835			
2. I took a sufficient number of distance education courses during my undergraduate/graduate education.	.469			
3. I find the in-service training given to us before distance education sufficient.	.777			
4. The courses I took during my undergraduate studies guided me on how technology could affect the teaching strategies I use in my classes.	.441			
5. I can use the strategies I learned about teaching with technology throughout my				.751

undergraduate life in my classes.				
6. It is easy for me to integrate technology into teaching content (i.e., math, reading/writing, science, life studies).				.720
7. I received adequate support for the technical problems I experienced during distance education.			.567	
8. My students' parents made positive contributions during my online classes.			.591	
9. The school administration has made positive contributions to my online courses.			.835	
10. EIN plays an important role during my online courses.		-.920		
11. I think the efficiency of my online lessons has increased with EIN.		-.952		
12. The content provided by the EIN is sufficient for the presentation of online classes.		-.734		

Note. Extraction Method: Principal Component Analysis. Rotation Method: Oblimin with Kaiser Normalization.[a]

[a.] Rotation converged in 12 iterations.

Factors obtained from EFA explained 65.025% of the total variance. Table 3 shows the amount of variance explained by each component and the cumulative percentage of variance explained. As seen in Table 3, the first component explained 29.532% of the variance, the second explained 14.114%, the third explained 12.135%, and the fourth component explained 9.243%. Together, these components explained 65.025% of the total variance. This shows that most of the scale items were explained by these four components and reveals the validity of the structure of the scale. Furthermore, when the fifth and sixth components are included, the total variance explained increases to 80%. This indicates that incorporating these additional components strengthened the scale and enhanced its explanatory power, suggesting a more robust measurement tool.

Table 3

Total Variance Explained by Principal Component Analysis

Component	Initial eigenvalues			Rotation sums of squared loading[a]
	Total	% of variance	Cumulative %	Total
1	3.544	29.532	29.532	2.324
2	1.694	14.114	43.647	2.821
3	1.456	12.135	55.782	1.770
4	1.109	9.243	65.025	1.902
5	.947	7.892	72.917	

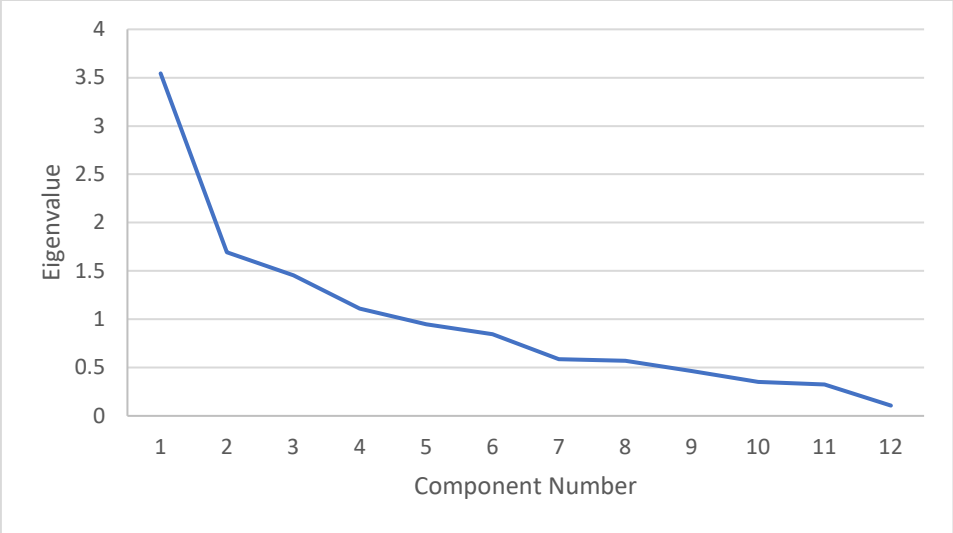
6	.845	7.042	79.959
7	.587	4.892	84.851
8	.571	4.760	89.611
9	.464	3.867	93.478
10	.350	2.918	96.396
11	.326	2.715	99.111
12	.107	.889	100.000

Note. Extraction Method: Principal Component Analysis.
[a] When components are correlated, sums of squared loadings cannot be added to obtain a total variance.

In the Figure 1 we can see the loading of each component and the amount of variance explained by them. The table clearly shows that the first and second factors are the most important and that they explain the largest part of the variance. Conversely, the last factor is the least significant and explains the smallest part of the variance. Figure 1 illustrates the relative importance of each component in the analysis.

Figure 1

Scree Plot of Principal Component Analysis



Discussion

Our study aimed to investigate the factors influencing the resilience and effectiveness of distance education in elementary schools during global crises, with a specific focus on the COVID-19 pandemic in Türkiye. The results of the factor analysis revealed four key components that played crucial roles in this context: (a) teachers' prior knowledge of and experience in distance education, (b) teachers' perspectives on the EIN, (c) support received from stakeholders, and (d) teachers' technology integration knowledge and experience.

Teachers' Prior Knowledge and Experience Regarding Distance Education

The findings highlighted the critical importance of teachers' prior knowledge of and experience in distance education. This aligned with previous research by König et al. (2020), who found that educators with prior online teaching experience were better equipped to handle the sudden transition

to remote learning. The strong loading of items related to pre-pandemic experience and undergraduate training in distance education suggested that teacher preparation programs should incorporate more extensive training in online teaching methodologies. This finding was further supported by Trust and Whalen (2020), who observed that teachers with previous online teaching experience were more likely to use a wider variety of digital tools and effectively engage students in remote learning environments. Similarly, Bao (2020) emphasized that effective distance education relied heavily on instructors' familiarity with online teaching tools and pedagogies, which is often acquired through prior experience or training. The importance of prior knowledge extended beyond just familiarity with technology. Carrillo and Flores (2020) found that teachers with previous experience in online education were better able to adapt their pedagogical approaches to the digital environment, maintaining student engagement and learning outcomes. This adaptability is crucial, as Hodges et al. (2020) pointed out that emergency remote teaching differed significantly from well-planned online learning experiences. Furthermore, our results were consistent with Toquero (2020), who suggested that teacher training programs should be revamped to focus more on educational technology and online teaching methods. This is especially crucial considering the possibility of future interruptions to conventional in-person teaching, whether caused by pandemics or unexpected events. The significant link between previous knowledge and successful execution of remote learning further reinforced Ferdig et al. (2020), who highlighted that educators who had previous experience in online teaching were more self-assured, creative in their pedagogical methods, and better equipped to cater to their students' educational requirements amidst the pandemic.

Teachers' Perspectives on Educational Informatics Network

The emergence of EIN as a distinct influence underscored its significance in the Turkish context. This finding supported the work of Duzgun (2021) and Karalar and Dogan (2017), who identified EIN as a valuable tool for online instruction in Türkiye. The positive correlation between this factor and teachers' prior knowledge suggested that familiarity with distance education may have led to more effective use of platforms like EIN. The importance of EIN in the Turkish educational landscape during the pandemic was further emphasized by Ozer (2020), who highlighted the platform's role in ensuring educational continuity. Ozer noted that EIN's rapid expansion and adaptation were crucial in meeting the sudden surge in demand for online educational resources. This aligned with our findings, which showed that teachers' perspectives on EIN significantly influence the effectiveness of distance education. Karatas and Tuncer (2020) carried out an in-depth examination of the characteristics of EIN and determined that the platform's ease of use and varied content were key factors in its popularity among Turkish teachers. Our findings supported this idea, indicating that teachers' favorable views of EIN were associated with its usefulness and user-friendliness, important components in the TAM (Davis, 1989). The connection between teachers' previous knowledge and their viewpoints on EIN was especially remarkable. Teo et al. (2019) found that teachers' attitudes toward new digital platforms were positively affected by their previous experience with educational technology, supporting this relationship. This means that teachers with greater experience in online learning were more likely to make the most of EIN's features. Nevertheless, it is crucial to acknowledge that despite its overall success, EIN still faces obstacles. Karalar and Dogan (2017) highlighted that some teachers faced challenges in making full use of EIN's capabilities because of technical problems or inadequate training. This emphasized the importance of continuous professional growth and technical assistance, as mentioned in our third factor. Lastly, the positive perception of EIN among teachers, as revealed in our study, supported the findings of Akbulut et al. (2020), who reported high levels of satisfaction with EIN among both teachers and students. This positive reception suggested that EIN, and similar platforms, may continue to play

a significant role in Turkish education even beyond the pandemic, potentially reshaping the landscape of educational technology in the country.

Support From Stakeholders

The importance of support from school administration, parents, and technical staff emerged as a separate influence, confirming the findings of Rasmitadila et al. (2020) and Garbe et al. (2020). Similar patterns were observed globally, such as in Indonesia, where Rasmitadila et al. (2020) found that administrative support and stakeholder collaboration significantly influenced online education success. Likewise, in the US, Garbe et al. (2020) emphasized the role of parental involvement, paralleling our findings on stakeholder engagement. However, in our study it is seen that stakeholder support varied by socio-economic context. Parents in low-income households may have limited time or digital literacy, affecting their ability to assist with remote learning. Policies should account for these disparities. This highlighted the need for a holistic approach to distance education, where success depends on teachers and a supportive ecosystem involving multiple stakeholders. The critical role of school administration in facilitating effective distance education was further emphasized by Fernandez and Shaw (2020), who argued that educational leaders need to provide clear guidance, technical assistance, and emotional support to teachers during crisis-driven transitions to online learning. This aligned with our findings, which showed that administrative support significantly influences teachers' ability to deliver effective distance education. Parental support, another key element in our findings, has been corroborated by the work of Bhamani et al. (2020), who found that parental involvement was crucial in maintaining student engagement and motivation during remote learning. Additionally, Dong et al. (2020) noted that the efficacy of online education, particularly for younger students, was greatly influenced by parents' capacity to create a supportive learning environment at home. Our study emphasized the significance of technical support, which aligned with Dhawan's (2020) findings stressing the importance of strong technical infrastructure and support in overcoming technological obstacles in distance education. This idea has also been backed up by Trust and Whalen (2020), who discovered that teachers with consistent technical support were more inclined to try out various online teaching methods and tools. Furthermore, our study's results were in line with Garrison et al.'s (2010) suggestion of the community of inquiry model, which underscored the significance of social presence in virtual educational settings. Different stakeholders' support helps build a feeling of community that improves the overall learning experience. Support's rise as an individual factor aligns with Huber and Helm's (2020) research, which revealed that collaborative school environments and supportive leadership played crucial roles in schools effectively managing distance education during the COVID-19 pandemic globally.

Teachers' Technology Integration Knowledge and Experience

The fourth component of our study highlighted the importance of teachers incorporating technology into their teaching practices. This supported the findings of Tondeur et al. (2019 and Ozudogru (2021), indicating that teachers with advanced technology integration abilities demonstrated increased adaptability and enthusiasm for online education. The strong connection between this component and teachers' previous experience with distance education indicated that these abilities are connected and support each other. Koehler and Mishra (2009) backed up this discovery with their proposed technological pedagogical content knowledge (TPACK) framework. TPACK highlighted the significance of teachers' capacity to efficiently merge technology, pedagogy, and content knowledge in their instructional methods. The findings of our study resonated with this model, emphasizing the vital importance of technology integration skills in effective distance learning. Ertmer and Ottenbreit-Leftwich (2010) suggested that teachers' views and feelings about technology played a major role in

their capacity to incorporate it into their teaching practices. This aligned with our results and indicated a strong link between teachers' understanding of technology integration and their performance in online teaching. Scherer et al. (2019) further emphasized the significance of proficiency in integrating technology through a meta-analysis of studies on the TAM in the educational sector. They discovered that teachers' perceptions of technology as easy to use and useful were important in predicting their intention to use technology in teaching. This was consistent with our results and indicated that educators who have more advanced technology integration abilities may view online teaching resources as more beneficial and user-friendly. Our results supported the idea of a connection between technology integration skills and previous experience with distance education, which was also evident in König et al. (2020). They discovered that teachers' proficiency in using digital tools, often acquired from prior experience with technology-aided teaching, strongly influenced their capability to uphold high standards of instruction in virtual settings. Additionally, Sánchez-Cruzado et al. (2021) stressed the significance of continuous professional growth in technology integration, and highlighted that educators who consistently participate in such programs had more skill in successfully integrating technology into their instructional methods. This indicated the importance of continually developing technology integration skills, rather than just making a single attempt.

Limitations

Our study had several limitations. First, the sample was limited to 100 elementary school teachers in Türkiye, which may affect the generalizability of the findings. While participants were selected from different regions, a larger and more diverse sample could offer deeper insights. Second, the cross-sectional design of the study limited our ability to assess changes in teachers' perceptions and practices over time; longitudinal studies could address this. Third, the reliance on self-reported data carries risks of biases such as social desirability or recall errors. Future research could incorporate methods like classroom observations, interviews, and student outcomes for a more holistic analysis. Finally, this study focused solely on teachers' perspectives, excluding those of students, parents, and administrators, whose views could enhance our understanding of distance education's effectiveness and durability.

Conclusions and Recommendations

The purpose of our research was to analyze the factors that impacted the strength and success of remote learning in elementary schools in Türkiye during the COVID-19 pandemic. Our study has pinpointed four essential components that are vital in this situation: (a) teachers' prior knowledge of and experience in distance education, (b) teachers' perspectives on the EIN, (c) support received from stakeholders, and (d) teachers' technology integration knowledge and experience. Our study introduced a validated scale that enabled quantifiable assessment of these key components. Unlike prior conceptual models, this tool provided measurable means for evaluating institutional preparedness and instructional resilience. Although developed in Türkiye, the scale was designed to address global challenges in online education (Bozkurt et al., 2020; König et al., 2020) and can be adapted to different educational contexts. Future research can validate its cross-cultural applicability. While this study introduced a framework for assessing resilience in distance education, additional validation is necessary to establish its broader applicability and effectiveness in diverse educational settings. Future

adaptations of this scale could consider context-specific factors in different education systems, such as infrastructure disparities in developing regions and variations in policy-driven distance learning models worldwide.

These results have highlighted the intricate and multi-dimensional aspects of successful distance learning, especially during emergency situations. The rise of four separate but interconnected factors underscored the importance of taking a comprehensive approach to improving the resilience and effectiveness of distance education.

The information we gathered has shown that teachers' prior knowledge of and experience in distance education are essential for effective online teaching. This highlighted the need to include thorough distance education training in teacher preparation programs and in continuing professional development efforts. The importance of the EIN in Türkiye illustrated how national educational platforms can help facilitate widespread shifts to online learning. Nevertheless, it also emphasized the necessity of ongoing enhancements and adjustments to these platforms to address changing educational requirements.

Support from school administrators, parents, and technical staff is essential for effective remote learning, requiring strong collaboration among stakeholders. Policies should foster partnerships among teachers, school leaders, parents, and IT support teams to enhance distance education resilience.

Our findings have key implications for educational policy and practice, calling for

- stronger teacher preparation programs with training in distance education and technology integration.
- continued investment in and improvement of national educational platforms like EIN.
- comprehensive support systems involving school administration, parents, and technical staff.
- ongoing professional development for teachers' technology integration skills.

Beyond Türkiye, these findings inform global efforts to strengthen distance education. Governments and institutions can use this scale to assess gaps in teacher training, stakeholder support, and technology integration, guiding investments in professional development and digital infrastructure. Adapting this framework across diverse education systems can help shape targeted policies for equitable and sustainable remote learning.

In summary, our study highlighted that the strength and success of distance education during the global crisis relied on various factors such as teacher readiness, technological support, stakeholder involvement, and teachers' skill in using technology in teaching. Educational systems can improve their ability to deliver high-quality education despite challenging situations such as the COVID-19 pandemic by tackling these factors in a thorough and organized fashion.

It would be beneficial to investigate how the factors revealed in our study are expressed in various cultural and educational settings, and how they change as online learning becomes more highly integrated in worldwide education systems. Furthermore, long-term studies may offer important perspectives on the lasting effects of these factors on student academic outcomes and overall quality of

education.

Authors' Note

This paper was reviewed, edited, and refined with assistance from ChatGPT (Model 4.0 as of December 2024) serving as a complement to the human editorial process. The human authors critically evaluated and validated all content to ensure academic rigor and addressed any potential biases in the AI-generated contributions. The final responsibility for the content and conclusions of this paper lies solely with the human authors (Bozkurt, 2024).

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The Impact of Professional Development on K–12 Teacher Awareness, Use, and Perceptions of OER

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Abstract

This paper reports the findings from cycles three and four in a longitudinal design-based research (DBR) study with K–12 teachers to evaluate their gains in awareness, use, and perceptions about open educational resources (OER) in general and after engaging with the Pathways Project (PP), a repository of 900 world language activities. Two groups of teachers participated in distributed learning with different engagement levels to apply the 5Rs of OER (i.e., retain, reuse, revise, remix, and redistribute), specifically using OER from the PP. The Pathways subscribers (n = 23) attended webinars and received monthly newsletters throughout the project period. A smaller group, referred to as the Pathways training cohort (n = 16), participated in a four-month cohort including a synchronous workshop, monthly synchronous meetings, and asynchronous tasks. The study was conducted in the Mountain West region of the United States, where access to quality teaching materials varies across rural and urban districts, and professional development (PD) opportunities are lacking. The findings revealed that the training cohort self-reported statistically significant increases in awareness of all 5Rs, and increased frequency of revising and remixing OER; their belief in the effectiveness of OER for learning also increased. Conversely, while the subscribers group did show some gains in awareness, use, and perceived value of OER, none of these were statistically significant. These findings suggested that K–12 teachers valued OER but require strategic, long-term PD to achieve gains in awareness, use, and perceived value of OER. This study responded to the challenge of sustaining open pedagogy, particularly for an under-studied K–12 population.

Keywords: OER, OEP, K–12 teachers, professional development

Introduction

This study responded to a needs assessment conducted in 2016 with K–12 world language teachers struggling to align their teaching practices to new state standards in a state characterized as 80% rural in the Mountain West region of the United States. The needs assessment revealed two fundamental problems: a need for quality teaching materials and time for teachers to evolve their teaching practices. These challenges were further exacerbated by two factors. First, this region is largely characterized as rural, and in many cases, it has been physically impossible for teachers to attend professional development (PD) opportunities. Second, teachers outside of STEM or English Language Arts have been chronically under-resourced and content-isolated, often the only instructors in their district or county. Not only have they lacked PD, but much of their time has been dedicated to looking for digital teaching materials, often inefficiently and unsuccessfully (Arispe et al., 2023).

Open educational resources (OER) and OER-enabled pedagogy (OEP) can help solve some of these challenges. The OEP rationale has posited that teachers transform their pedagogy by engaging in the 5Rs of OER (i.e., retain, reuse, revise, remix, redistribute; Wiley & Hilton, 2018) to adopt and adapt high-quality teaching materials. Although sparse, the OER K–12 literature has suggested that teachers value OER because they can modify materials to fit their local needs (Blomgren, 2018; de los Arcos et al., 2016; Kimmons, 2015). However, primary and secondary teachers have needed help accessing materials online (Tang, 2020) and, in many cases lacked knowledge of the existence of OER altogether (Seaman & Seaman, 2023a). Unfortunately, these challenges have prevented teachers from benefiting from what OER and OEP have to offer.

In 2023, an open education (OE) global conference (Open Education Global, 2023) was dedicated to building a sustainable world through open education. One of the greatest threats to equitable and sustainable OE is that K–12 educators have lagged behind in OER awareness and use. The most recent Bayview Analytics report (Seaman & Seaman, 2023b) found that nearly two-thirds (64%) of higher education faculty are aware of OER, compared to 28% of K–12 teachers. Unfortunately, the disparity in awareness of OER between K–12 and higher education practitioners is representative of the attention paid by OER academic researchers and education stakeholders, who have generally focused much more on higher education. For example, a simple comparison of the presentations from 2023 OE global conference revealed that 21 sessions were focused on the K–12 sector compared to 79 on the higher education sector. This present study reflected a long-term partnership between higher education faculty, staff, and undergraduate students with K–12 world language teachers by using the Pathways Project (PP) to foster a community of practice (Arispe & Hoye, 2023b). Importantly, it contributes research findings about the impact of OEP on awareness, use, and perceptions of OER to address the paucity of K–12 OER research, and serves as a call to action for future K–12 OER research as a critical component in the sustainability of OE.

Review of the Literature

One of the most informative findings on K–12 teacher practices and beliefs related to curricula and teaching materials has come from the Bayview Analytics Report by Seaman and Seaman (2023a). This report included responses from 1,205 teachers and 487 administrators from all 50 US states, across 1,109 school districts. Most notably, it was conducted after the COVID-19 pandemic, this reflected the state of teacher beliefs and practices at a critical juncture in the profession. One of the notable findings from their study was that while 72% of K–12 teachers required textbooks, 78% reported they also relied on digital supplemental materials. This suggested that many teachers used a combination of both types of resources to meet their instructional needs rather than relying on a single source. Interestingly, they found a five to six percent decrease in teachers' use of online commercial materials, whereas 77% of teachers said they used digital materials to create supplemental resources themselves. "The high use of self-created materials may be related to their lack of flexibility to fit individual classrooms and the perceptions of poor quality or lack of options for those provided by the curricula creator (commercial or otherwise)" (Seamen & Seamen, 2023, p. 21). This tendency to create one's own teaching materials supported what de los Arcos et al. (2016), Blomgren (2018), and Kimmons (2015) have all found, whereby K–12 teachers particularly valued OER because they allowed teachers to make changes to materials for their local classroom and learner needs. For example, Blomgren explained that differentiation, individualization, and personalization were educational practices K–12 teachers considered when selecting teaching materials because teachers were in a constant state of flux in response to evolving curriculum and teaching standards. It is precisely this challenge that catalyzed the Pathways Project, an OER of ancillary materials to be used and modified to fit within a curriculum for world language teaching and learning.

Blomgren (2018) also addressed the affordance of teacher creativity that came from engaging in OEP, perhaps reflecting a fundamental difference between what K–12 teachers and higher education faculty value. Whereas higher education faculty may not value creating teaching materials or openly licensing textbooks as a critical component of their academic identity, curating and creating teaching materials are critical to the K–12 teacher's role. Interestingly, Seamen and Seamen (2023b) did not ask higher education faculty to select their curricula sources; their assumption was that faculty relied on textbooks and other copyrighted or openly licensed materials. Seamen and Seamen's (2023a) Bayview report for the K–12 sector, on the other hand, asked several questions about teachers' curricula choices, implying that K–12 teachers drew from a variety of teaching materials, including creating their own. This suggests that in the K–12 sector, teacher creativity has been an important feature of the profession, making the disparity in OER awareness between K–12 and higher education all the more concerning; three quarters of K–12 teachers were not tapping into OER even though three quarters of teachers relied on non-textbook classroom material.

Another affordance of OEP has been how it can positively transform one's educational practice. Hegarty (2015) explained that open pedagogy invites teachers to collaborate through peer learning and reflective practices in a participatory culture where teachers can make changes to learning environments and educational practices in the community. While open pedagogical participatory culture has been available to all educators, it has remained largely untapped within K–12 teaching environments. One probable obstacle may have stemmed from digital and information literacy gaps pervasive in K–12 environments. While Seamen and Seamen (2023a) showed a slight, steady increase in OER awareness among K–12 teachers

overall, most of those who were aware of OER still did not know how to use them. One of the principals quoted in the report remarked that "OER can be difficult to navigate. Teachers often struggle to find what they need" (Seamen & Seamen, 2023a, p. 28). PD that helps teachers overcome these barriers is one practical solution but, currently, this is not the case. The report found that a third of teachers give PD effectiveness a failing score.

> Both teachers and administrators do not give high ratings to the current state of professional development. Previous research has shown that professional development, when implemented well, can greatly improve teacher perceptions and implementation of curricula. The post-pandemic K-12 classrooms, while very similar to pre-pandemic, have evolved and will need new professional development to support current and future teachers. (Seamen & Seamen, 2023a, p. 32)

One way PD can improve is to focus on both OER awareness and use; it might not be enough for teachers to know where to find OER. PD should provide teachers with practice applying the 5Rs to their local context. Tang and Bao (2021) identified three key barriers to OER adoption among K–12 teachers—lack of resources, insufficient knowledge, and inadequate institutional support—highlighting the need for targeted PD to address these challenges. They found that only 10% of the teachers in their study actually created OER but that all K–12 teachers were eager to find discipline-specific OER to use in their classroom. Thus, the gap in addressing this need is strategically train K-12 teachers in OEP to create and share OER. However, the value of professional development is more than just helping teachers create and share resources; it has long-lasting impacts. Tang et al. (2021) found that engaging teachers in OEP increased their perceived usefulness of OER and enhanced their self-efficacy and willingness to share resources. Moreover, they noted that the authenticity of the task allowed teachers to practice and hone the very skills they needed to engage in OEP successfully. "We thus speculate that affording a contextualized opportunity for teachers to gain awareness of OER and then implement OER in an authentic context might be an initial step to improve teachers' self-efficacy and readiness of implementing OER" (Tang et al., 2021, p. 3224).

Indeed, one of the greatest appeals for K–12 teachers to engage in OEP has been the snowball effect. OER are designed to be adopted and adapted, and open licenses permit users to make changes to OER they find. Especially when it comes to ancillary OER, the snowball effect is a positive outcome of OEP that grows the breadth of the repository when users adapt and redistribute what they create. Very few OER studies have considered redistribution practices amongst educators which is critical to the sustainability of open pedagogy. Beaven (2018) looked at the barriers, drivers, and enablers that impacted teacher engagement with OER at The Open University. She found that while teachers were engaging with OER at all levels, they were doing so in hidden spaces which made it a challenge to measure such use. For example, teachers shared materials with other teachers in their local or close-knit network. The tendency for teachers to engage in what Beaven called dark reuse was not a threat to the effectiveness or value of OEP as a practice, however, it was a threat to long-term sustainability. If teachers do not know how to share back their materials openly, there is no snowball effect, and other teachers will continue to rely on paying for resources (i.e., teachers paying teachers) or creating their own from scratch. Considering the changes to the profession in a post-pandemic era, teachers have relied heavily on digital materials for their classroom; however, challenges related to OER awareness, use, and sharing back are obstacles to overcome. As another principal remarked in the Bayview Report "it is incredibly important to involve teachers in the decision-making process for

instructional materials. It would be beneficial for my admin team and teachers to learn more about OER, where to access these resources, [and so forth]" (Seamen & Seamen, 2023a, p. 27).

Despite these challenges, there has been momentum rising in the K–12 open education community. Recently, Walz and Farley (2023) published a collaboration toolkit for higher education designed to help faculty, librarians, and instructional designers engage with pre-K–12 to create OER. This toolkit was the first of its kind, bridging the gap between pre-K–12 and higher education (see Arispe & Hoye, 2023a) through practical materials and best practices that supported this type of collaboration. Additionally, according to the Institute for the Study of Knowledge Management in Education (ISKME) the #GoOpen National Network has been a driving force for K–12 that aims to grow awareness of OER and "build capacity and elevate OER through collaboration, knowledge sharing, and strategic action" with stakeholders at all levels (ISKME, 2007). Formerly part of the federal #GoOpen initiative from the US Department of Education Office of Ed Tech, ISKME has developed a steering committee with a centralized hub and network to initiate policy, including a robust agenda of OER professional learning webinars designed to impact awareness and use (GoOpen National Network, 2024). This current study joined these initiatives to evaluate strategic engagement via distributed PD with the K–12 community by measuring the gains in awareness, use, and perceptions of OER over time.

About The Pathways Project

In 2018, the PP was created in response to a needs assessment that identified two primary challenges in K–12 world language teaching: (a) lack of high-quality teaching materials, and (b) time to transform one's teaching practice. At the time, a world language resource center at a university in the region was creating hundreds of high-quality digital materials to foster conversational language development for undergraduate students in 10 languages and across multiple levels of proficiency (for more details about the PP activities, see Arispe & Hoye, 2023b). By openly licensing these activities, the PP became a repository of ancillary activities that could be shared with a wider community of language teachers, including those in K–12 teaching similar content. It became clear, however, that sharing the repository via e-mail communication was not enough to support teachers retaining and reusing the materials for their local contexts. PD was needed to help them adopt and adapt the activities so that they could be localized to their teaching and learning environment. This present study reported the research findings that compared the effectiveness of two types of PD administered to K–12 teachers over time.

Methodology

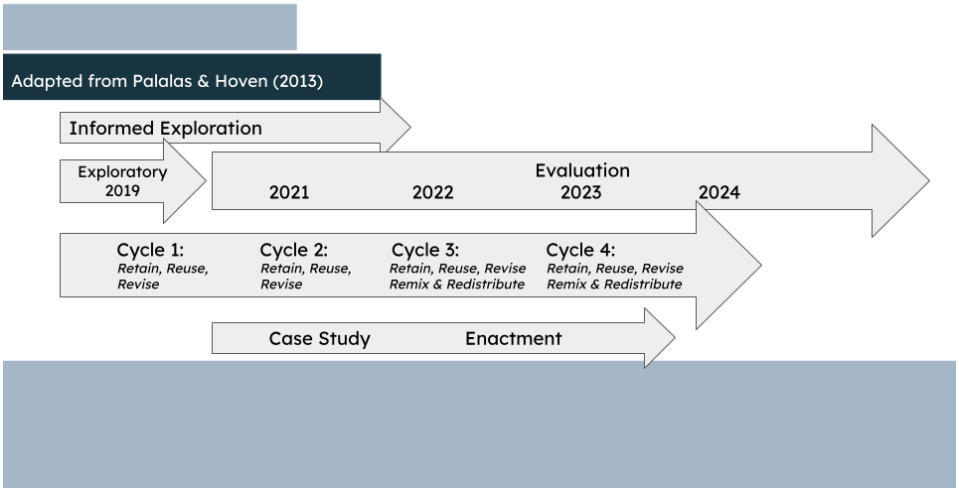
Design-Based Research Framework

The researchers used a design-based research (DBR) framework to engage with the K–12 teachers in the community so that both the tool (the PP OER) and the PD experiences could evolve based on user input. DBR is a method in educational research that is both long-term and cyclical, allowing the study's design to adapt based on emerging insights, thereby influencing teaching methods. Researchers collaborate closely

with educators to assess and refine the interventions to positively enhance the teaching and learning environment. Drawing on the integrative learning design framework from Bannan (2009), adapted from Palalas and Hoven (2013), the DBR framework used in this study had four cycles that were conducted from 2019 to 2023. As is typical with many DBR longitudinal studies, the participants varied over time; however, the iterative nature of the process enabled continuous refinement of both the OER PP tool and the OEP PD experience. Figure 1 below demonstrates the nature of the exploratory and case studies that informed the enactment phase, cycles three and four, which are the focus of this present study.

Figure 1

Design-Based Research Framework



In cycles one and two of the DBR, Arispe et al. (2023) found that transformative OEP did not happen with short-term PD, and certain design features of the PP activities acted as barriers to accessibility (see Hoye & Arispe, n.d.). As a result, the training design was improved and in 2022 the PP research team was awarded a Level II Digital Humanities Advancement Grant (DHAG) from the National Endowment for the Humanities to carry out the enactment phase to measure the impact of longer (four-month asynchronous/synchronous) OER PD on K–12 teacher practices. While the first two cycles informed the structured intervention described in this study, due to space constraints, full details of these cycles will be published separately.

Specifically, this study compared two groups of K–12 teachers who received different PD experiences reflecting different levels of intensity. The following research questions were investigated:

1. Was there an increased awareness of OER and the 5Rs?
2. Was there a perceived increase in the frequency of OEP?
3. Did teachers believe OER materials were effective for learning?

Participants

Since 2018 when it was founded, the PP has built a subscriber base of K–16 world language teachers by collecting information from visitors who navigated to the website that hosted the PP, as well as through the OER Commons where the PP activities have been curated. One of the outcomes of the DHAG award was to initiate a monthly PP newsletter that had three primary objectives: (a) showcase PP activities and their features to promote widespread use, (b) promote PP PD opportunities, and (c) publicize other OER and PD opportunities specific to language teaching. The two groups being compared in this study were a subset of the PP subscriber population. Prior to participating, teacher participants completed an institutional review board protocol in compliance with institutional ethics for research involving human subjects.

The subscribers was the largest group (n =23), representing K–12 teachers who received the monthly *Pathways Post* newsletter; they were invited to attend four, one-hour webinars and complete pre- and post-PD surveys. Attendance for webinars was verified using Zoom meeting reports, which logged participation data and timestamps. The training cohort (n =16) completed the same treatment as the subscribers group as well as a one-day synchronous workshop and three virtual training modules (including asynchronous and synchronous activities) centered on adapting and adopting PP materials for their classroom.

The two groups represented different levels of outreach and PD that might be replicated in other K–12 OER PD in the future. Where the subscribers group required minimal cost and passive engagement, the training cohort took a different approach. Each teacher participant received a $1,000 stipend for attending and completing the training activities, and the facilitators provided high-level feedback in synchronous meetings and through asynchronous assignments.

By comparing the groups, OER researchers and education leaders considered the potential impacts based on the type of OER PD for the future. Table 1 below depicts the differences in OER PD treatment per group.

Table 1

Pathways Project Treatment Offerings

Offerings	Group	
	Subscribers	Training cohort
Received a monthly newsletter	✓	✓
Access to four live or on-demand webinars	✓	✓
Completed pre- and post-PD surveys	✓	✓
Attended full-day workshop	x	✓
Participated in a four-month online cohort	x	✓
Completed three training modules	x	✓

Training Modules

The full-day, hands-on workshop was designed to introduce OER, the PP, and have teachers practice retaining the PP materials for their upcoming units. Based on the findings from the case study described in Arispe et. al (2023), it was important to devote the four-month online cohort activities to those three of the

5Rs with which teachers previously struggled the most: revising, remixing, and redistributing materials back to the PP repository. To create a scaffolded learning environment, two former participants from cycle two were recruited to support participants as teacher mentors in cycles three and four; this enabled participants to receive feedback from peers who had recently completed similar professional development. These teacher mentors attended synchronous meetings, modeled best practices through activity exemplars, and provided high-level feedback on training activities for each of the teacher participants.

Teacher participants were instructed to download and retain PP activities aligned by theme to an upcoming unit. The training strategically guided them through the process of revising, remixing, and redistributing the PP activities they adopted and adapted. Table 2 summarizes the activities by theme as well as learning objectives from both the full-day synchronous workshop and the three modules.

Table 2

Training Modules: Descriptions and Outcomes

Workshop	Module 1: Revise	Module 2: Remix	Module 3: Redistribute
Description: Introduce teachers to OER and PP, with hands-on practice for integrating PP materials into their upcoming units.	Description: Revise an existing PP activity to meet the needs of their classroom and local contexts.	Description: Remix an activity to include authentic materials and digital humanities sites.	Description: Publish the final activity, which was shared back to the PP community.
Outcomes: 1. Explain the benefits of OER to a colleague. 2. Find an interpersonal speaking activity from the PP repository. 3. Describe why I might want to revise an activity. 4. Identify authentic materials and digital humanities (DH) sites.	Outcomes: 1. List a few reasons why I might want to revise an activity. 2. Locate where to revise a PP activity. 3. Apply the principles of revising to an activity of my choice.	Outcomes: 1. Explain to a colleague how DH can support language teaching and learning. 2. Brainstorm and identify DH and authentic materials that will help me enhance the unit I selected. 3. Plan and/or practice remixing DH and/or authentic materials with a PP activity.	Outcomes: 1. Apply a Creative Commons license to my final PP activity. 2. Share back and publish my final PP activity by completing the PP worksheet.

In addition to the treatment, the two comparison groups differed in their geographic demographics. The subscribers (n = 23), a subset of a larger subscriber base, were K–12 teachers in the US. Due to the DHAG funding source that allowed the researchers to stipend teachers from rural and urban districts to participate in the four-month cohort, all members of the training cohort were K–12 language educators in the state of

Idaho. Initially, recruiting teachers was challenging. For this reason, there was a smaller fall cohort (n = 6) and a larger spring cohort (n= 10), however only 12 completed both the pre- and post-PD surveys. Most participants in the first cohort resided in southern Idaho and predominantly in urban districts. Most of those in the second cohort resided in northern and eastern Idaho with a mixture of urban and rural districts. Table 3 shows the combined participant demographics for the training cohort groups. It should be noted that most participants were Spanish teachers because other languages were not commonly taught in rural districts.

Table 3

Participant Demographics for the Pathways Training Cohort

Characteristic	*n*	%
District type		
Rural	5	33
Urban	11	67
Language		
Spanish	12	75
Non-Spanish	4	25
Level		
Primary	2	12
Secondary	12	88
Experience Teaching		
0 to 2 years	2	13
2 to 5 years	3	19
5 to 10 years	1	6
10+ years	10	63

Instruments

Both groups, the subscribers and the training cohort, received a baseline survey prior to their PD in May 2022. The project team designed the survey instrument to measure respondents' awareness, use, beliefs, and perceptions of OER and the PP materials. Questions were grouped according to Wiley's 5Rs (Wiley et al., 2017) because the activities associated with both groups were designed according to OER engagement, where teachers learned to retain, reuse, revise, remix, and redistribute the PP materials. The survey was sent by e-mail to all members of the PP monthly newsletter subscribers list. The list contained both K–12 educators and post-secondary educators across the United States and internationally. However, for the scope of this current study, all post-secondary and international respondents were excluded to focus the study on the PD gains for primary and secondary educators. If members of the training cohort had not completed the baseline survey in May, they were asked to complete it before beginning the PD. After the PD was completed, a post-PD survey was sent to both the subscriber and training cohort groups. This survey instrument measured changes in respondents' awareness, use, and perceptions of OER and the PP over time as a result of the treatment (subscribers vs. training cohort).

To compare individual differences over time, respondents were only included in the analysis if they completed both the pre- and post-PD surveys. In both surveys, respondents were asked to rate their familiarity with each of the 5Rs (i.e., retain, reuse, revise, remix, and redistribute) using a 5-point Likert scale (1 = *not familiar at all*; 5 = *extremely familiar*). Respondents also reported their frequency of OER use for teaching and learning purposes in an average school year; frequency options ranged from never to daily. Similarly, those who reported using OER materials also rated how frequently they revised, remixed, and redistributed materials back to an OER website after retaining (i.e., downloading the activity or bookmarking it) and reusing them. Finally, respondents rated how effective they believed OER was for teaching and learning purposes, specifically for helping students learn classroom content, using a 5-point Likert scale (1 = *strongly disagree*; 5 = *strongly agree*). Comparative analyses were used to identify any significant changes between pre- and post-PD survey scores for each item. Wilcoxon-Signed rank tests for non-parametric and small samples were conducted to account for the minimal sample size within each group to establish if the two scores were statistically different from one another.

Results

Increased Awareness of OER and the 5Rs

After completing an intensive four-month training period, the training cohort demonstrated significant increases in self-reported familiarity with all 5Rs. Conversely, the subscribers group did not report any significant increase in familiarity with these aspects of OER over time. The training cohort indicated a lower average familiarity for all 5Rs in the baseline survey compared to the subscribers (see Table 4). However, by the end of the training period, the training cohort outscored their peers in all aspects, reporting at least an average familiarity level of 4.31 on a five-point scale. While the training cohort demonstrated significant increases in familiarity for each of the 5Rs, the subscribers reported only slight non-significant increases in familiarity for each, with only the retain component slightly decreasing over time. In the baseline survey, both groups reported the least familiarity with redistributing materials but by the end of the training period, the training cohort reported the highest growth in this area. Conversely, the subscribers measured only a slight increase in this area.

Table 4

Participants' Familiarity With OER Components

OER component	Training cohort (n =12)		Subscribers (n =12)	
	Pre-PD M	Post-PD M	Pre-PD M	Post-PD M
Retain	2.08**	4.31**	3.59	3.56
Reuse	2.09**	4.27**	3.59	3.72

Revise	2.18**	4.27**	3.35	3.72
Remix	2.09**	4.27**	3.41	3.61
Redistribute	2.00**	4.27**	3.18	3.28

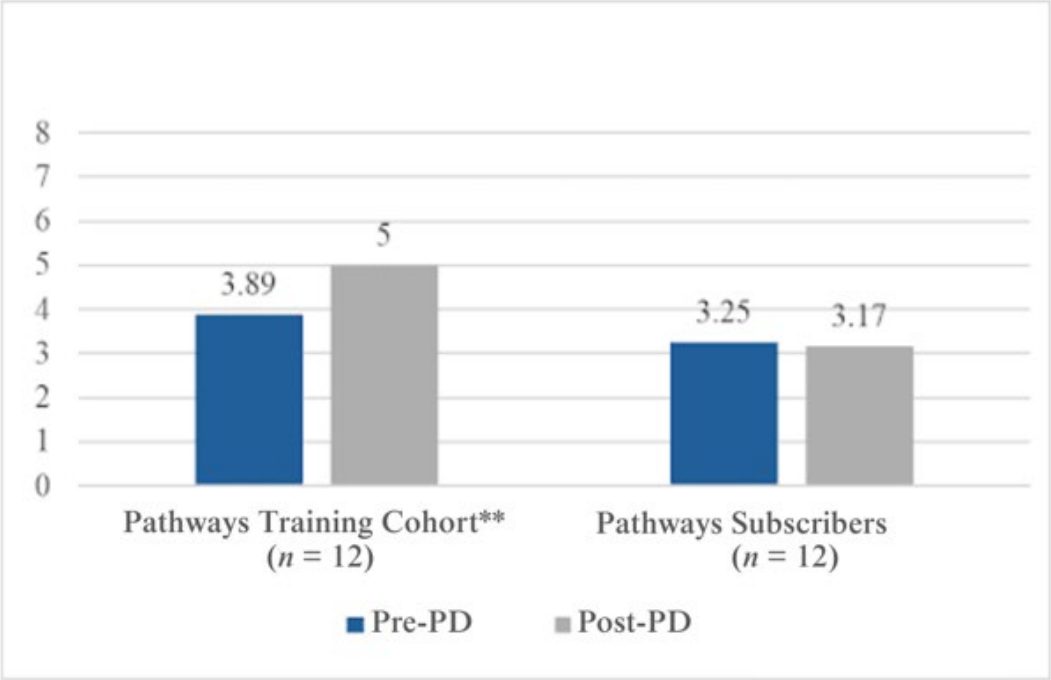
Note. *** indicates statistically significant differences between pre- and post-PD scores ($p < .005$)

Perceived Increase in the Frequency of OEP

The webinars and training modules (described in Table 2) focused on the components of OEP that have been most challenging for teachers in the past. For this reason, to address the second research question, researchers were interested in measuring both general OER use over time as well as the frequency of revising, remixing, and redistributing OER, specifically. The training cohort experienced significant increases in their self-reported frequency of OER use between pre- and post-PD survey (pre-PD $M = 3.8$, post-PD $M = 5.0$; $z = 2.04$, $p = .04$). The subscribers, on the other hand, reported a slight insignificant decrease over time (pre-PD $M = 3.25$; post-PD $M = 3.17$; $z = -1.49$, $p = .14$). Figure 2 illustrates the average frequency of participants' OER use.

Figure 2

Participants' Frequency of OER Use

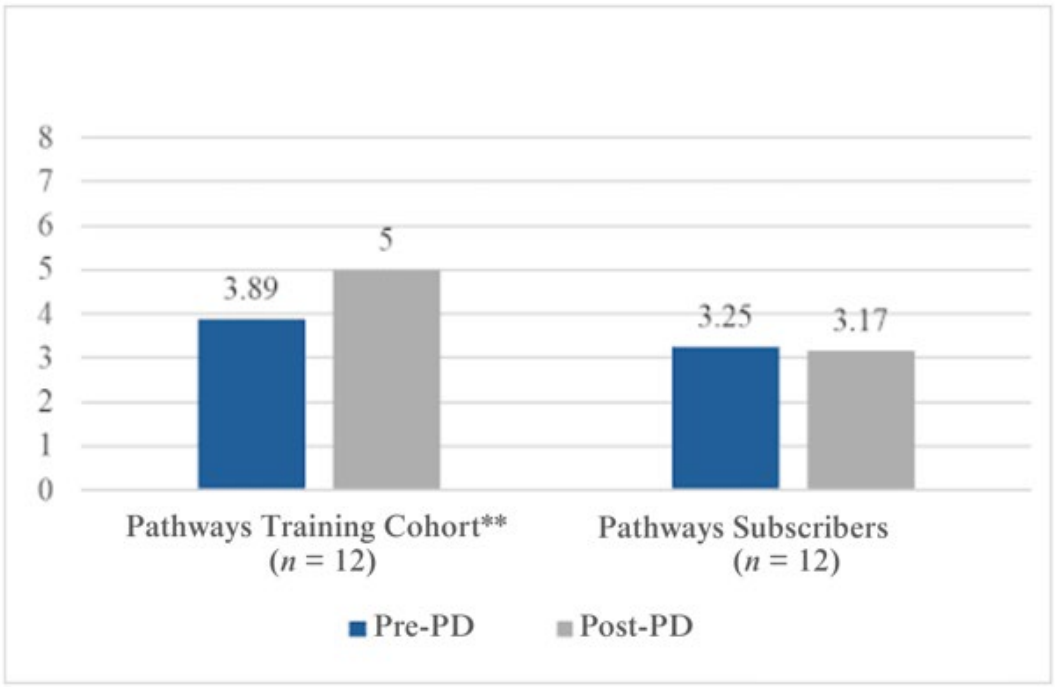


Note. **Indicates a significant difference between pre- and post-PD survey scores ($p < .05$). Response scale: 1 = *never*, 8 = *daily*.

As illustrated in Figure 3, frequency scores for revising OER also significantly increased for the training cohort (pre-PD M = 2.89, post-PD M = 4.11; z = -2.29, p = .027), while slightly decreasing for those in the subscribers group (pre-PD M = 3.25, post-PD M = 3.17; z = -.98; p = .38). The training cohort reported lower levels for revising in the pre-PD survey compared to their peers. However, by the end of the training, they reported a higher average frequency for revising than did the subscriber group.

Figure 3

Participants' Frequency of Revising OER Materials

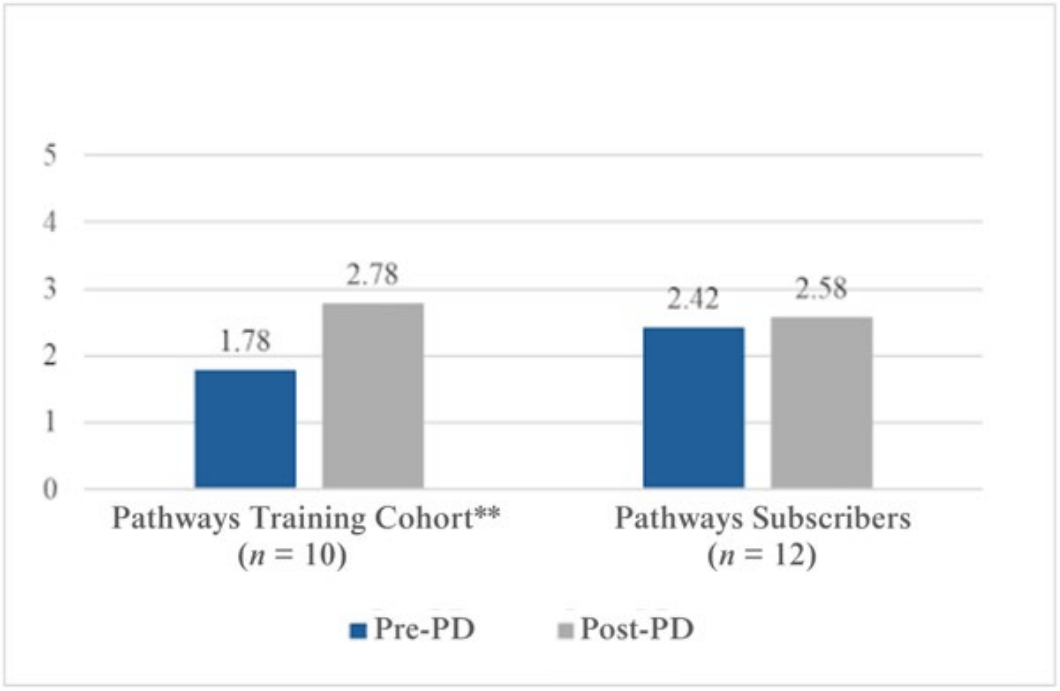


Note. **Indicates a significant difference between pre- and post-PD survey scores (p < .05). Response scale: 1 = *never*, 5 = *always*.

For the training cohort, frequency scores for remixing increased significantly increased from pre-to post-PD survey (M =1.78, M = 2.78; z = -2.04, p = .041), while the subscriber group reported only reported slight non-significant increases over time (pre-PD M = 2.42, ; post-PD M = 2.58; z = -.57; p = .56). See Figure 4. Similar to the results for revising above, the training cohort reported lower frequencies for remixing in the pre-PD survey compared to their peers but reported remixing more frequently by the end of the period.

Figure 4

Participants' Frequency of Remixing OER Materials

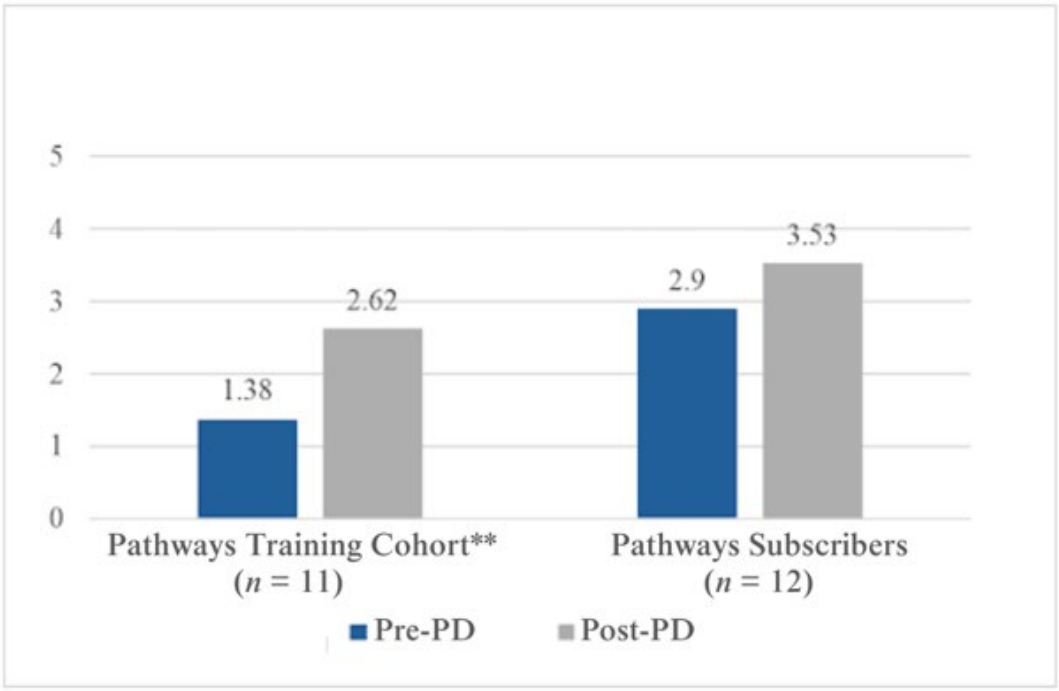


Note. **Indicates a significant difference between pre- and post-PD survey scores ($p < .05$). Response scale: 1 = *never*, 5 = *always*.

Finally, frequency scores for redistributing did not significantly change for either group from pre- to post-PD survey (see Figure 5).

Figure 5

Participants' Frequency of Redistributing OER Materials



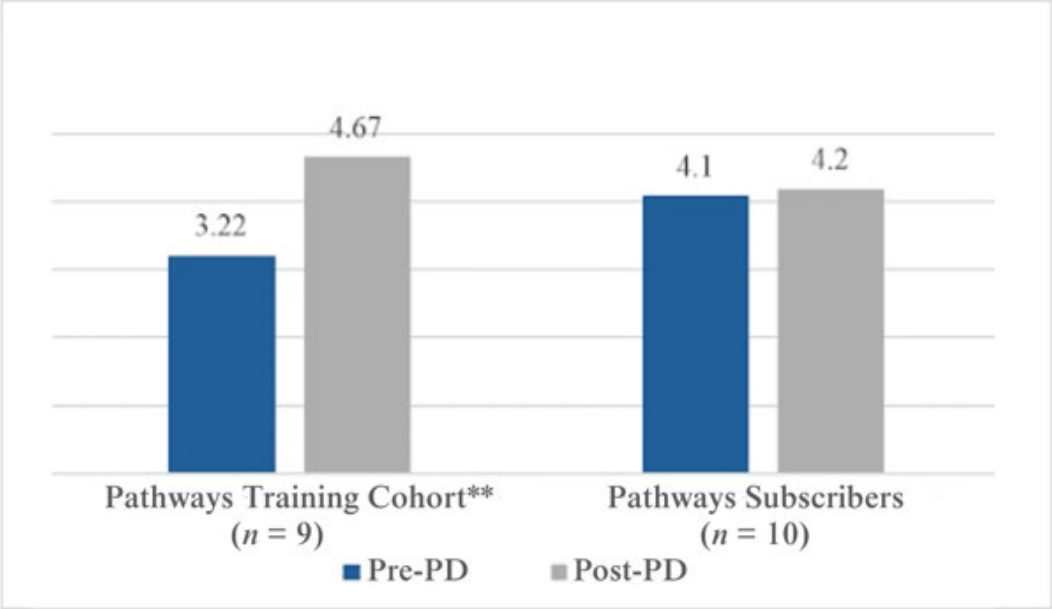
Note. **Indicates a significant difference between pre- and post-PD survey scores ($p < .05$). Response scale: 1 = *never*, 5 = *always*.

Teachers' Beliefs That OER Materials Are Effective for Learning

In addition to evaluating awareness and use, the third research question addressed researchers' interest in how the participants perceived OER materials for learning over time. The training cohort indicated significant increases in their agreement that OER materials were effective in helping students learn classroom content (pre-PD $M = 4.0$, post-PD $M = 4.78$; $z = -2.64$; $p = .008$). Conversely, the subscriber group did not differ significantly in this belief over time (see Figure 6).

Figure 6

Participants' Perspectives on OER Effectiveness for Learning



Note. **Indicates a significant difference between pre- and post-PD survey scores ($p < .05$). Response scale: 1 = *strongly disagree*, 5 = *strongly agree*.

Discussion

This study has reported the findings from the enactment (final) phase of a DBR framework that explored teacher awareness, use, and perceptions when using the PP OER, and compared different levels of PD engagement over time. Previous literature suggested that most K–12 teachers did not know about OER as a tool for teaching and learning and, if they did, they did not know how to use it. PD can be a critical solution to grow OER awareness in the K–12 sector and to bridge the gap between awareness and use. Importantly, the findings in this study indicated that passive OER PD was not enough to create change. Whereas webinars and newsletters have provided equitable distributed learning to K–12 teachers everywhere, effective PD holds participants accountable to do something with what they have learned. While this finding alone might not be surprising, the results from this research have provided evidence that can compel stakeholders to invest in OER PD opportunities that are strategic, long-term, and require active engagement. This also has important implications for what equitable PD entails. While the findings that compared rural and urban OEP practices were beyond the scope of this paper, the study was designed to impact equitable access to OEP by offering PD opportunities to teachers who were geographically isolated. The pandemic changed the nature of PD by normalizing distributed PD for teachers everywhere, regardless of their geographic location. However, access to knowledge alone has not been enough to help teachers transform their pedagogy, an intended outcome of OEP. This study revealed the difference in passive versus

active PD engagement and has important implications for how OER training is implemented, especially for K–12 teaching communities in the humanities located in rural districts where isolation is a given.

The PD provided to the training cohort had two critical ingredients that positively impacted their awareness, use, and perceptions of OER. First, in every module of the PD training, teachers had to apply their knowledge of OER to their local context through OEP activities. Second, feedback from the mentor teachers allowed participants to reflect on their learning process in the community, enacting what Hegarty (2015) referred to as participatory culture. Whereas the webinars and newsletters highlighted OEP best practices, including teacher exemplars, and encouraged teachers to apply what they learned to their local context, the teacher participants in this study only benefited when there was an accountability measure in their PD experience. This accountability was experienced by the training cohort when participants turned in assignments and received timely feedback on the evidence of their learning.

However, one component of OEP remained a challenge for K–12 teachers, namely, redistribution. Interestingly, the familiarity of redistributing was where the training cohort had the highest increase in awareness, but it was also the only category in which there was not a significant increase in use over time. Teachers gained familiarity with redistributing as a concept (i.e., OER invites users to share back material they have revised or remixed), but the PD did not influence them to redistribute more frequently.

There are several possible interpretations of this finding that must be explored, especially as the OER field considers its sustainability and growth in the K–12 sector. One possible explanation is that teachers came to OER expecting a product they could use, not necessarily something they created or adapted. K–12 teachers may not have known that their creativity and expertise was of value to the open community, to be shared easily. Another possible explanation is that teachers lacked digital competence to redistribute their materials effectively and efficiently, perhaps falling back on dark reuse tendencies by only sharing what they adapted locally and informally. Similarly, they may have felt insecure about open licensing and lacked practice applying open licenses to material they revised or remixed. While the training provided to both groups included an overview and access to interactive tools to navigate open and fair-use licensing, teachers in the training cohort required more support from mentor teachers in this module compared to the other two modules. This suggests that redistribution was the more complex of the 5Rs, requiring time and practice for mastery, especially with K–12 teachers less familiar with publishing compared to higher education faculty. In sum, this finding may spark future researchers to investigate what motivates K–12 instructors to redistribute and elucidate the barriers that prevent them from sharing back, as well as to consider sustainable incentives to encourage redistribution as an educational practice in K-12 contexts.

Conclusion

This study aimed to spark further discussion and action surrounding the sustainability of OEP by addressing a major component of the educational ecosystem that is underrepresented in the OER literature. The results suggested that the more teachers were exposed to OER and given the chance to practice engaging in OEP, the more they used OER and valued it in their practice, corroborating Tang et. al (2021). Return on investment contributed to the snowball effect wherein OER grow in breadth and depth and

teachers can access materials more effectively without having to reinvent the wheel. Whereas previous literature has indicated a knowledge-use gap for K-12 teachers, the results from this research pointed to the effectiveness of OER PD to help teachers learn about the 5Rs of OER and apply them to their practice. In addition to findings from Bayview Analytics (Seaman & Seaman, 2023a, 2023b), initiatives like the #GoOpen National Network and ISKME's efforts have sought to expand OER awareness among K–12 educators. These initiatives, along with growing state policies on OER adoption, have highlighted the increasing momentum in integrating open practices in K-12 settings. Future research should explore how these efforts intersect with professional development strategies similar to those studied here.

Limitations

One limitation of this study was the small sample size and the fact that not all respondents completed every question in the surveys. A larger sample size would increase the reliability and validity of findings and allow for further exploration of PD effects on individual respondents. Non-parametric tests were used when comparing data to account for these uneven distributions and low sample sizes; however, future research could expand the scope to include participants on a national scale. Another limitation of this study was related to the nature of measuring active versus passive PD engagement. The subscriber group was drawn from the larger subscriber population which included K–12 teacher participants across the US compared to the training cohort which included K–12 teacher participants in the region only. In many instances, the subscriber base had a higher awareness of OER and the 5Rs at the beginning of the study as measured by the pre-PD survey. This may have been due to other types of OER PD exposure supported by state or national initiatives and/or OER policies which have varied greatly across the nation. Unfortunately, this variance was not considered, and the researchers could not control other types of OER exposure that may have impacted subscribers' base level knowledge. While the scope of this paper was to elucidate the quantitative findings from the final cycles of the DBR, qualitative analysis was also conducted and will be discussed in a future paper.

The increased engagement among the training cohort participants may be attributed to their extended time on task. Longer training durations that allowed for deeper understanding and more hands-on practice in OEP, may explain the significant gains in awareness and frequency of use in this group. Finally, another limitation of this study was the financial incentive of $1,000 that was provided to each participant in the training cohort. This stipend may have positively influenced engagement levels, making the findings less replicable in contexts without such funding. As well, the study did not assess whether engagement would continue to be sustained once the financial incentive and structure support were removed.

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Virtual Concerts in Learning Oboe-Played Chinese Folk Music: Impact on Performance Proficiency, Perceived Aesthetic Qualities, and Students' Motivation

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Abstract

This study compares the effectiveness of video communication technologies and group chats in virtual reality (VR) as platforms for practising musical skills among students. Additionally, it examines the capacity to convey aesthetic characteristics of musical performance through these two forms of remote communication and the influence of these technologies on student motivation. The research involved 106 senior students from two higher educational institutions in China. Zoom and VRChat served as the instructional platforms for the two experimental groups. The findings did not reveal significant differences in performance mastery. Specifically, the perception of task value demonstrated the most substantial increase, scoring 5.65 compared to 4.81 out of a possible 7; all three pairs of values exhibited significant differences between the groups based on the results of the student's *t*-test. Furthermore, a significantly higher sense of immersion and quality of aesthetic experience was observed within the VR group, scoring 4.81 compared to 3.70 out of a possible 5 in the videoconferencing group. Additionally, VR's greater capability to convey characteristic emotional nuances of music was confirmed by the fact that within the VR group, two out of six distinctive features of Chinese folk music (lyrical, highly artistic aspects and intonation subtlety) were more pronounced than in the videoconferencing group. These results indicate the potential of VR technology to enhance the quality of aesthetic experience as well as the motivation for learning among students in music education, including those studying wind instruments.

Keywords: intonation subtlety, musical values, performance expressiveness, sound sharpness, upper register

Introduction

The instruction of musical instrument playing constitutes a significant component of education capable not only of preparing individuals for professional endeavors in music but also of enhancing the quality of life, fostering a sense of creative self-realization, and promoting emotional development. However, music education is one of the most challenging disciplines, as it necessitates the simultaneous development of fine motor skills, auditory acuity, and the concurrent processing of various forms of information (Adamyan, 2018). Due to the absence of rapid progress, a considerable number of students may lose motivation and prematurely discontinue their studies. Conversely, the integration of digital technologies in education can streamline the learning process, rendering it more engaging and motivating for students. Such technologies encompass the use of mobile applications, remote communication technologies, and specialized software capable of providing prompts or feedback in real time. Currently, the majority of research is devoted to the development of various technologies for piano instruction, with comparatively fewer studies focusing on string instruments and notably scant attention directed toward wind instruments (Apaydınlı, 2023). Meanwhile, instruction in wind instrument playing may pose the greatest challenge and prove less intuitive for students due to the nature of sound production (Hallam et al., 2020).

Due to its intricate design, the oboe is one of the most challenging wind instruments to master. The most common challenges include mis-fingering, poor blowing skills, and incorrect assembly (Han, 2023). Using a double reed to create the sound gives it a unique and subtle quality (Bowen et al., 2019). The tiny opening in the reed allows the musician to breathe in a way that sustains the sound, creating a continuous melody (Zhang & Lam, 2022). During deep or prolonged breathing, inhaling through the nose can cause the cheeks to expand as they hold more air (Li, 2022). The oboe can be used in traditional and contemporary music, which is connected to the potential for expanding the realm of sound (Bucur, 2019). In solo performances and as a solo instrument in orchestras, the oboe can enhance the expressive presentation of folk music (Tang, 2020). This instrument has a wide range of sounds, distinguished by including notes from the small octave (B flat) to the 3rd octave (A). The air passage creates the soprano sound produced by the oboe through a conical tube and the use of valves with a double reed (Miller, 2013). A sharp timbre characterizes the upper register sound of the oboe. The nasal sound of the oboe is also distinctive (Paquier et al., 2016).

When selecting approaches for performing melodies on the oboe, it is essential to preserve the uniqueness of the musical compositions, which is particularly significant for folk music. The distinctiveness of Chinese folk music is maintained through the pentatonic scale and the presence of a soft timbre (Xiao, 2025). The emotional component in its interpretation plays a crucial role, which should be reflected in the articulation of musical nuances and the expressiveness of musical experiences (Lee & Mazzola, 2025).

Changing circumstances in the modern world have spurred a noticeable shift towards remote learning across various educational domains, including music. However, this shift often occurs out of necessity, lacking adequate preparation and thorough analysis to select the best methodologies. Consequently, teachers, students, and parents report a decline in students' theoretical knowledge and practical skills (Zhang, 2024). Equally significant is the adverse impact on the mental well-being of both teachers and students, manifesting in feelings of social isolation and a lack of live interaction (Tivendale, 2022). An intriguing question also arises regarding the influence of remote communication on the aesthetic perception of music. Audiences often perceive live concerts as a distinct and emotionally immersive

experience, whereas digital communication or playback reproduction requires more effort to achieve a comparable effect (Merrill et al., 2023). At the same time, digital technologies in education have an impact on student motivation, which ensures a deeper level of learning. As a result, students strive to develop a unique performance style, which encourages them to overcome challenges (Chen, 2025). Continuous improvement of knowledge fosters confidence in musical interpretation and contributes to creative growth.

Although networked music has become prevalent in education and professional music creation and performance, its implementation is still associated with technical limitations, such as latency issues (Wilson, 2023). These problems contribute to additional frustration in an already complex process of music creation and may pose a significant threat to motivation for students still acquiring skills. Furthermore, if the transmission of aesthetic qualities of musical performance through virtual environments is incomplete, it may devalue students' efforts and diminish the perceived utility of their education. Therefore, further research is necessary to determine which forms of organizing remote music training and concerts are optimal.

Literature Review

Characteristics of Chinese Folk Music

Chinese folk music is known for its lyrical, highly creative elements, often added as lyrical windings — a style that involves graceful, flowing ornamentation and expressive pitch bends — and which would be measured in the beauty of a distinctive performing style. Sound improvisation on the oboe can be heard in the instrument's rhythm, windings, and symbolism. The ability to perform and play the oboe proficiently is linked to highly artistic characteristics. Intonation subtlety is valued in Chinese music because it is related to the performer's emotional investment in the music. Folk melodies can be performed vocally while accompanied by an instrument, allowing pitch manipulation and enhancing speech intonation nuances. The visibility of the musical is influenced by the prominence of high-pitched sounds, which have spiritual importance in China. This method can be seen in a flexible performance that includes a variety of sound layers. Chinese spirituality is imparted through a system of embedded tones and use of a pentatonic scale which have a distinctive sound when performed on the oboe.

The oboe's sound arises from vibrations in the column in the instrument's barrel. Combining long and short notes allows for creating sharp sounds, which can lead to novel virtuosic possibilities. The musical piece's artistic theme is revealed through the rhythm expression speed. Sound speed changes are evident in the aesthetics of performance, which are associated with folk music's peculiarities.

Playing the Oboe: Features of Sound and Learning to Play

The oboe sound's unique characteristics, which resemble those of the human voice, are related to sound expressiveness (Li & Zhang, 2022). Controlling the acoustic balance will produce an aesthetically pleasing sound for oboe melodies. It is possible for musicians to exercise self-control during rehearsals. The oboe playing technique is interconnected by knowledge of the oboe's unique timbre, the relationship between cultural preservation and musical perception, and the degree of hearing development (Wang et al., 2022). With the aid of carefully chosen music, the oboe can amplify the

emotionality of literary folk pieces. This strategy encourages the appreciation of folk materials' aesthetic qualities based on their emotional resonance and technical inspiration (Pong, 2020).

Several studies have been devoted to the development of mobile applications aimed at assisting in learning to play wind instruments. Specifically, the Fingering and Tuning Charts application allows users to select one of 10 different wind instruments. Its functionality includes displaying a moving musical staff that indicates the next notes, a visual representation of how a note should be played on the instrument, and some visual explanations of music theory. However, the application does not provide real-time feedback and is primarily intended for initial familiarization with playing principles (Priyadarshani, 2021). There are also applications designed to assist beginners in tuning their instruments by providing graphical representations of pitch (Peterson Tuners, 2023). The application examined in the study by Pamidi (2018) offers slightly broader functionality, allowing real-time analysis of student performance, providing feedback on the accuracy of note intonation, and presenting fingering and tuning information graphically. Another application, Suiview, recognizes and displays intensity, pitch, and timbre in real time as graphical representations (Watanabe et al., 2023). However, the functionality and user interface of such applications are often somewhat limited in enhancing the student's learning experience (Watanabe et al., 2023).

A popular trend in the development and research within music education is the use of augmented and virtual reality (VR). These technologies enable the creation of fully virtual representations of instruments, with "playing" facilitated through human motion tracking technologies. Examples of such applications include Music Room and Soundstage VR (Gao & Li, 2024). Their advantages may include increased student engagement and a reduction in performance anxiety through appropriate simulations. However, a current limitation of the technology lies in its suitability for simulating musical instruments played through hand movements. The specific nature of wind instruments complicates their realization as virtual interactive objects (Serafin et al., 2017). Furthermore, digital sound simulation of wind instruments is more complex due to their physical characteristics. Nevertheless, this issue may soon be addressed as researchers develop devices capable of using information about the intensity of airflow from human breathing to interact with virtual environments (Tatzgern et al., 2022). Additionally, playing a musical instrument in VR can be facilitated through the use of a specially designed substitute for a real instrument, known as a digital musical instrument, a physical instrument constructed specifically for interaction with VR. These instruments can be adapted for learning various real instruments (Costa et al., 2019).

The development of software products capable of serving as guides for students in understanding the theory and practice of playing wind instruments, such as the oboe, is complex, and the role of the instructor in this process remains indispensable. However, it is equally important to organize high-quality remote learning experiences, increase student motivation, and foster social interaction. The use of VR is often considered in organizing virtual training sessions and concerts, wherein motion and facial expression recognition technologies allow for the creation of corresponding avatars in virtual space whose movements mirror those of the real participants (Chen, 2022). This technology creates a sense of the presence of performers in the same venue. Yet, they play on real physical instruments rather than virtual ones, with the instrument's representation in VR serving merely as a graphical reproduction. Immersive technologies are proposed for developing communication skills among performers during group performances (Orman et al., 2017; Yan & Xia, 2024). Further refinement of these technologies may enhance the distance learning by increasing social interaction and better preparing students for real musical performances.

Problem Statement

VR technology is relatively new to contemporary education and is still underused. Challenges include the need for additional resources, time for prior familiarization with the technology, and insufficient understanding among instructors of the effectiveness of such technologies (García Gil et al., 2022). The aim of this study was to investigate further the impact of using remote communication technologies with VR for organizing distance concerts on the performance quality of music students, their motivation for learning, and their subjective aesthetic perception of music compared to videoconferencing technologies.

The research objectives were to

- develop an educational program that includes regular mini-concerts for practicing students' technical and expressive skills, organized using videoconferencing and VR technologies, and
- identify and compare the performance outcomes achieved by students who practiced using videoconferencing and VR technologies.

Methodology

Sample

Participants in the study included 106 future musicians. One of the conditions for participating in the research was the achievement of oboe theoretical playing skills sufficient for performing musical compositions from beginning to end, which was necessary for participation in the mini-concerts. Therefore, for the study, graduates of senior courses—4th and 5th year students from Lishui University, Nanjing Arts Institute, and senior classes of music schools in Lishui and Nanjing—were selected. The sample consisted of students with varying levels of oboe performance skills: below average (15%), average (23%), sufficient (35%), and high (27%). This allowed for a stratified approach to sampling based on the presence of different levels of practical skills. All students had completed a theoretical course in oboe performance but lacked sufficient practical skills. The assessment of practical skills was conducted based on the evaluation of academic results and additional verification of oboe performance skills in accordance with the research program. Adobe Audition software (Version 1.6.4) was used for acoustic analysis. This program enabled the use of various tools for sound analysis (e.g., phase analyzer, spectral analysis), which allowed for the evaluation of the accuracy and purity of instrumental interpretation of melodies. This made it possible to select students with varying levels of practical skills. Participants were randomly assigned to two groups, with the first group participating in virtual concerts using videoconferencing technology (videoconference group) and the second group using VR technology (VR group). Each group comprised 53 participants. Four instructors, two from each participating institution, all with 10 to 15 years of experience in teaching the oboe, were invited to evaluate the students' performances.

Research Design

The research spanned a period of 5 months and was integrated into the existing educational process at the two participating institutions. In addition to the standard curriculum adopted by the institutions, which included the study of music theory and group and individual practical sessions, students

participated monthly in virtual mini-concerts involving a total of 15 to 25 students from different academic groups and instructors who assessed the performances. Students from the videoconference group participated in conferences organized using the Zoom platform, while students from the VR group used the VRChat virtual reality platform.

The Zoom platform offers advanced capabilities for engaging participants in videoconferences. Joining the videoconference was facilitated through the generation of an identifier, which allowed for the pre-scheduling of the conference and provided participants with an opportunity to prepare in advance. This ensured collaborative interaction among all participants and was designed to facilitate responses to surveys regarding the quality of performances. The high image quality was aimed at enabling the visibility of necessary elements of the demonstration, including the presented melodies. The Zoom platform enabled collaborative musical interaction with students, focusing on the accuracy of the performed sounds. The use of recordings from conducted videoconferences and interactive whiteboards provided timely access to essential musical information.

The platform VRChat was chosen for its extensive customization capabilities. This platform allows each participant to create their avatar based on Unity SDK technology, and interactivity occurs through eye- and body-tracking mechanisms. The range of choices encompasses both the external appearance of the avatar and the features of its movements and animations. Additionally, the platform enables the construction of custom virtual worlds, adjusting the appearance of the environment in which the virtual embodiments of participants will interact.

For the implementation of this research, the virtual environment and avatars were created with the assistance of two staff members from each educational institution who had experience in three-dimensional modeling and voluntarily assisted in the research. They developed a virtual three-dimensional concert hall and also aided students in creating their avatars. Students could choose the characteristics of their avatars themselves; however, a condition was that their appearance should correspond to the circumstances of a musical concert and should not contain sharply contrasting elements to the external environment.

To conduct sessions in VR, Meta Oculus Quest 2 VR glasses were used. The technological process of working with the VRChat platform involved the creation of a virtual space tailored for a specific group to perform oboe melodies. This included configuring the platform according to the genres of music being studied and providing virtual practical approaches to oboe performance. Interaction through avatars was implemented based on the platform's technical capabilities, using natural approaches to performance. Interaction among students also occurred through 3D models of sheet music and musical diagrams, enabling their performance through animation. Virtual reality allows for the creation of necessary settings to improve instrumental playing techniques. This is achievable through gamification elements, which motivate students to achieve higher results during concert-level instrumental interpretation. The technical capabilities of VRChat are also expanded, allowing for the use of regular computers with a VR headset connection. The creation of avatars is possible based on predefined text or animation parameters. Interaction between avatars occurs through virtual buttons, musical instruments, and other elements.

Students from both groups participated in virtual concerts from their own homes, and the necessary instruments were provided by the educational institutions. Considering the limited amount of VR equipment, concerts in the VR group were held on different days with a 1 to 2 day displacement.

The initial participation for students in both groups was characterized by discomfort and a lack of skills in using the platforms despite being familiar with their theoretical features. The group of students who initially used the Zoom platform interacted more confidently with instructors and other participants, as the simple functionality did not require additional actions. The use of the VRChat platform before the creation of avatars was characterized by students' lack of confidence in learning the designated functionality and performing the required actions.

However, the first lessons revealed an increase in the confidence of students using VRChat and a decrease in confidence among students using Zoom. This was related to the clarity of sound provided by the first platform and the distortion of sound that occurred during the use of Zoom. This resulted in more positive assessments regarding the use of VRChat. Additionally, psychological indicators among students were considered, as these could have influenced the quality of the concerts. The assessment was linked to the determination of self-efficacy, as physical classrooms allow students to be directly under the teacher's supervision and focus on the educational atmosphere, whereas home-based lessons require additional self-discipline. The assessment of self-efficacy before and after the study among students in both groups was conducted using the method of Schwarzer and Jerusalem, adapted by Romek (Scholz et al., 2002). The results showed that the use of Zoom before the study indicated a self-efficacy level of 28 points among students, corresponding to an average level; after the study, the score was 31 points, still corresponding to an average level. The use of the VRChat platform before the study reflected a self-efficacy level of 27 points, corresponding to a low level; after the study, the score increased to 38 points, corresponding to a high level.

During the virtual concerts, students took turns performing solo renditions of musical adaptations of Chinese folk songs on the oboe. The final concert served as an assessment of the effectiveness of the educational interventions employed. Instructors evaluated each student's performance based on the accuracy of musical elements, instrument mastery, and artistic expressiveness. Additionally, upon completing the final concert, students were required to complete three questionnaires. The first aimed to evaluate the overall aesthetic experience of the concert, the second was aimed at determining the level of educational motivation, and the third expanded the data on the quality of aesthetic characteristics conveyed through digital environments, assessing to what extent students in each group were able to perceive the distinctive features of Chinese folk music. The questionnaires were provided in the form of online surveys on the Airtable platform.

Measurements

Instructors evaluated the quality of students' musical performances at the end of the experimental period based on three parameters: accuracy of musical elements (pitch sequence, rhythm, and pitch), mastery of musical instrument control, and artistic expressiveness. Each parameter was assessed on a scale of 1 to 5, guided by criteria provided by the assessment rubric presented in the study (Ciorba & Smith, 2009). To determine the final score for each participant for each of the three parameters, the average of the scores assigned independently by the four instructors was calculated.

The Value Components section of the Motivated Strategies for Learning Questionnaire (Pintrich & De Groot, 1990) was used to assess the level of academic motivation. These components included: intrinsic goal orientation, which pertains to internal reasons why a student engages in a task, such as a challenge, interest, and skill acquisition; extrinsic goal orientation, reflecting the level of motivation by external indicators, such as grades or rewards; and task value, which reflects the student's perception of the usefulness and value of the task. Each component consisted of several statements, rated on a Likert

scale from 1 to 7, with the final score for each scale determined as the average value. The assessment of performance mastery involved two approaches with a weekly frequency, which allowed for the collection of longitudinal results.

To compare the quality of students' aesthetic experience in perceiving music in a VR environment, a questionnaire on the sense of absorption was employed based on statements developed by Vroegh (2018). The questionnaire included the following statements:

1. I felt completely absorbed in the music.
2. Time passed quickly.
3. I did not notice the surrounding environment.
4. I forgot that I was at a concert.
5. I was completely focused on the music.
6. My thoughts wandered.
7. I was completely bored.

Each of these statements was rated from 1 to 5 on a Likert scale, with the last two statements using an inverted scale. The final score was computed as the mean of the ratings across all statements. This test was chosen to focus on feelings of engagement and absorption in the musical presentation. Metrics from this test would be able to effectively reflect the emotional atmosphere transmission of the musical presentation in digital environments, which might suffer the most due to the limited capabilities of certain technologies.

I developed a questionnaire to assess the quality of conveying the aesthetic characteristics of Chinese folk music. For its development, I initially analyzed 200 folk music compositions using a comparison method to determine the expressiveness parameters. This analysis identified several distinctive and prominent elements. These included the following:

- lyrical, highly artistic aspects
- intonation subtlety
- the high-pitched sound, significant for Chinese spirituality
- sound reproduction uniqueness
- the rhythm expression speed

The quality of transmitting the aesthetic aspects of music during the performances was assessed by independent experts. This involved the participation of four instructors who teach the performance of folk music on various instruments (oboe, pipa, piano, etc.), each with a minimum of 10 to 15 years of experience. The instructors were able to evaluate not only the elements of expressiveness but also the

ways in which additional nuances were conveyed. These nuances were related to the ease of interpreting these indicators and the possibility of reflecting symbolic Chinese elements.

The connection between these elements is essential for manifesting the characteristic features of Chinese folk music. The link to these indicators of intonational subtlety is based on conveying the delicacy of emotional performance, reflecting the depth of expression. The significance of high-pitched sounds for Chinese spirituality should be based on elevated performance, using symbolic high sounds interconnected with meditation. The uniqueness of sound reproduction is characterized by conveying subtle nuances that influence the overall tone of the performance. The speed of rhythm expression implies the use of expressive movements that impact emotional intensity, aligning with cultural symbolism and interpretative nuances. The level of transmission of these parameters depends on the multilayered nature of the performance and the ability to convey the internal experiences of the performer.

The questionnaire regarding the assessment of the possibility of conveying aesthetic aspects of music is presented in the Appendix. The questions are related to student perception of individual aesthetic aspects of Chinese music in the performances of their own groups.

Students were asked to rate on a scale of 1 to 5 how much they perceived these characteristics while listening to performances by their peers at the educational mini-concert organized using one of the distance communication technologies.

Statistical Processing

For the convenience of data collection and initial processing, Airtable software (Version 1.6.4) was used, which enables the creation of electronic spreadsheets. For statistical data processing, including the calculation of the independent samples *t*-test, IBM SPSS Statistics (Version 1.6.4) was employed. Calculations were based on the inclusion of normal distribution between the groups.

Ethical Issues

Participants in the study were engaged on a voluntary basis and were informed about the option of withdrawing their participation at any time without any negative consequences. The data collected were anonymized for the purpose of analysis and were not used for any other purposes. Additionally, all borrowed materials reference relevant literature sources (COPE, 2025).

Limitations

This study exclusively used the VRChat platform, and the developed virtual environment resembled a typical concert hall during a performance of classical music. Many other VR platforms, specifically designed for music concerts, offer various vivid special effects, which may elicit a completely different experience and affect the quality of musical performances. This research focused on VR as a communication environment and aimed to create a more realistic experience rather than employing gamification or enhancing entertainment effects. Also, limitations apply to studying the performance of folk music on the oboe; performances of contemporary music genres were not included. However, the limitations are not obvious, as this article reveals the relationship between technical and aesthetic parameters of musical performance and parameters that affect folk music's expressiveness.

Results

During the fifth and final mini-concert, instructors assessed the two groups of students for (a) mastery of musical pieces based on criteria including accuracy of musical elements (score accuracy, musical notation, rhythm, and pitch), (b) proficiency in instrument control, and (c) artistic expressiveness. The results are presented in Table 1.

Table 1

Results of the Assessment of Student Performances in the VR Group and Videoconferencing Group

Performance parameter	VR			Videoconferencing			*t*
	Score	*M*	*SD*	Score	*M*	*SD*	
Proficiency with and accuracy of musical elements, including pitch, rhythm, and score accuracy	5.9	4.13	0.76	6.0	4.22	0.80	1.654*
Ability to control his or her instrument with musical intent	6.4	3.51	0.65	6.2	3.47	0.76	1.585*
Ability to be expressive with regard to inflection and style	6.8	3.88	1.11	6.5	3.75	1.09	1.442*

Note. The assessment was based on the evaluation rubric found in "Measurement of Instrumental and Vocal Undergraduate Performance Juries Using a Multidimensional Assessment Rubric," by C. R. Ciorba and N. Y. Smith, 2009, *Journal of Research in Music Education, 57*(1), p. 9 (https://doi.org/10.1177/0022429409333405). VR = virtual reality.
*$p < .05$.

There was no significant difference between the groups, although the accuracy of musical elements was slightly lower in the VR group. Since the *t*-test did not reveal significant differences, this slight reduction may be attributed to the randomness and inaccuracy of some assessments or to the fact that students may not have sufficiently adapted to the new technology. As the VRChat platform was being used for practicing and demonstrating already-acquired skills rather than for initial skill acquisition, the lack of significant difference may indicate that both platforms equally facilitated the students' ability to realize their skills without many impediments.

A lower level of accuracy in the interpretation of musical elements, although not significant, was observed in the use of VRChat, resulting from students being distracted by additional functional features. Students indicated that this affected their initial concentration to some extent. The ability of the students to control their instruments with musical intent was higher when using VRChat, as it maintained an enhanced level of interaction with all participants in the learning process. The performance of melodies occurred in a more natural atmosphere, which enabled students to achieve high results. This allowed for the integration of possible virtual cues with playing techniques. For the same reason, expressiveness in the manifestation of intonation and musical style was achieved. Respondents noted that the flexibility of the virtual settings also had an impact, as it allowed for adjustments to the performance in accordance with the proposed musical works.

Upon completing the final mini-concert, students completed a questionnaire on learning motivation. Table 2 presents the results.

Table 2

Results From a Questionnaire on Learning Motivation Comparing the VR Group and Videoconferencing Group

Learning motivation parameter	VR		Videoconferencing		*t*
	M	*SD*	*M*	*SD*	
Intrinsic goal orientation	5.49	1.21	4.89	1.13	2.753*
Extrinsic goal orientation	5.58	1.17	5.01	1.05	2.267*
Task value	5.65	1.03	4.81	1.21	2.978*

Note. The learning motivation strategies were drawn from "Motivational and Self-Regulated Learning Components of Classroom Academic Performance," by P. R. Pintrich and E. V. De Groot, 1990, *Journal of Educational Psychology*, *82*(1), p. 33-40 (https://doi.org/10.1037/0022-0663.82.1.33). VR = virtual reality.
*$p < .05$.

Motivation indicators across all three components were higher in the VR group compared to the videoconferencing group. The most significant positive difference in the VR group was observed regarding task value, signifying the perception by students of the usefulness and importance, and their interest in the content of their learning.

Intrinsic goal orientation was based on responses to questions related to the willingness of students to voluntarily exert more effort in learning activities for a specific internalized goal. The internal goal orientation among students in the VR group was higher, and motivation was expressed through the unconventional use of approaches to instrumental interpretation. That motivated students to work more precisely on the artistic elements of Chinese music and to develop confidence in conveying Chinese folk music's values. This motivation arose among students from the original listening experience of compositions, ensuring the perception of sound purity through VR. The pedagogical aspect of this motivation was reflected in the individualized approach to teaching, which was evident in the possibility of progressive learning.

Extrinsic goal orientation denoted motivation associated with approval from elders and parents, and competitive feelings between peers. These allowed the learning process to be perceived as more meaningful and enabled the achievement of new musical goals. External motivation is typically manifested in the increased confidence of students and the connection between dedication to learning and the attainment of a corresponding level of practical skills. It is also reflected in a student's ability to achieve educational goals and in the exchange of musical experiences with other students.

The final aspect of this study involved determining students' subjective perceptions of the aesthetic experience during the virtual mini-concerts. See Table 3.

Table 3

Results From a Questionnaire on the Quality of the Aesthetic Experience Comparing the VR Group and Videoconferencing Group of Students

Quality of the aesthetic experience	VR		Videoconferencing		*t*
	M	*SD*	*M*	*SD*	
Absorption and positive emotional experience	4.81	1.07	3.70	1.15	2.112*

Note. Students ranked the quality of the experience on a scale of 1 to 5. The questionnaire was based on statements found in "The Pleasures of Getting Into the Music: Absorption, and Its Role in the Aesthetic Appreciation of Music," by T. P. Vroegh, 2018, doctoral dissertation, Johann Wolfgang Goethe-Universität (https://publikationen.ub.uni-frankfurt.de/frontdoor/index/index/docId/47549). VR = virtual reality.
*$p < .05$.

The students' experience of absorption and positive emotional perception of the performance was significantly higher in the VR group. When examining students' responses to individual questionnaire items, the greatest difference between the groups was observed in the ratings of three statements: (a) "I felt completely absorbed in the music" (4.70 in the VR group compared to 3.21 in the videoconferencing group); (b) "I did not notice the surrounding environment" (4.87 compared to 3.05); and, (c) "My thoughts wandered" (4.67 compared to 3.52, using an inverted scale).

The final part of the study involved an analysis of how effectively the two different digital environments facilitated the conveyance of characteristic aesthetic features of Chinese folk music using the oboe. In the preliminary phase of the research, I identified the specific expressiveness parameters of Chinese folk music.

These expressive parameters were presented to the students in the form of a questionnaire. The results of students assessing the effectiveness of two digital environments in conveying the characteristic features of Chinese folk music are presented in Table 4.

Table 4

Students' Views on the Effectiveness of Conveying the Aesthetic Features of Chinese Folk Music in Two Digital Environments—VR and Videoconferencing

Aesthetic feature of Chinese Folk Music	VR		Videoconferencing		*t*
	M	*SD*	*M*	*SD*	
Lyrical, highly artistic aspects	4.58	0.94	4.22	1.02	2.012*
Intonation subtlety	4.71	1.02	4.35	1.13	2.109*
High-pitched sound significance for Chinese spirituality	3.72	1.13	3.55	1.24	1.714
Sound reproduction uniqueness	2.98	1.26	3.17	1.31	1.512
Rhythm expression speed	3.55	1.32	3.38	1.21	1.615

Note. VR = virtual reality.
*$p < .05$.

Participants in the VR group demonstrated a significantly higher level of recognition of the melodies performed by peers in such characteristic features of Chinese folk music as lyrical, highly artistic aspects and intonation subtlety. Although there were no significant differences between the groups in recognizing the rest of the characteristic features, the overall tendency towards better recognition of

these features in musical pieces in the VR environment once again speaks to the effectiveness of this digital environment in conveying the aesthetic characteristics of musical performances.

The subtlety of intonation takes precedence over other parameters, as it is closely related to the emotionality of the instrumental interpretation, conveying personal experiences. This criterion influences the potential for altering approaches to performance, which is manifested in the creation of additional nuances.

The prominence of lyrical, highly artistic aspects over other indicators is linked to the transformation of the primary sound and the ability to use additional melodic embellishments. This expressive parameter is associated with partial modifications of the melody, allowing for the use of unconventional approaches to its interpretation.

The relationship between pitch sounds and Chinese spirituality is linked to musical traditions, which allow for the performance of inherent sounds and orientation towards multi-layered sounds. The student's understanding of the principles of conveying the pentatonic scale component of music enables them to reflect a high degree of spiritual depth in their performance. The speed of rhythm expression is also associated with the relationship between pitch sounds and Chinese spirituality, as it holds particular significance in Chinese music. During the instrumental interpretation, the respondents were able to achieve harmony in alternating sounds and intervallic performance, which influenced the expressiveness of the sound.

The originality of reproduced sounds parameter had a lower level of expression, as students were required to possess more professional skills in melody interpretation. Some difficulties were observed in combining long and short notes, which was reflected in the virtuosity of respondents from both groups.

Discussion

This study is not the first to examine the effectiveness of VR technologies for organizing remote communication in the education of future musicians. Specifically, several studies have explored the effectiveness of applying this technology in the training of future conductors. Improvements in nonverbal communication through eye contact, body posture, and gestures have been identified. In this case, the technology increased the amount of potential training time, overcoming the time constraints of face-to-face sessions (Orman et al., 2017). However, the sense of social presence may vary, depending on the ability of the virtual environment to simultaneously accommodate multiple streams of information from the real world, such as facial expressions, movements, and environmental features (Van Kerrebroeck et al., 2021). In one study aimed at testing a VR platform specially developed to support interaction among professional musicians, open interviews with participants demonstrated the platform's potential to foster creative activity. It is worth noting that researchers implemented appropriate audio and visual tools to facilitate music creation (Ppali et al., 2022). Another study investigated the effectiveness of using VR in training future vocalists (Doganyigit & Islim, 2021).

The reviewed studies were based on the analysis of the overall impact of VR effectiveness. In my study, however, an assessment was conducted on the mastery of oboe melody performance using VR and videoconferencing. Although the results show only slight differences, they provide an opportunity to

evaluate the advantages of VR in education. This is related to the ability to achieve more precise sound processing, which allows for the consideration of cultural and aesthetic aspects of Chinese folk music.

Studies examining the effectiveness of distance communication in music education have often yielded ambiguous results. For instance, a study comparing the effectiveness of face-to-face and online music composition education using the sonata form found that the quality of compositions was higher in the group using the online platforms Playground Sessions and Soundation Studio. The former provides diverse educational materials, communication opportunities, and assessment, whereas the latter focuses on technical aspects of music creation, such as audio editing and beat addition (Han, 2023). Meanwhile, another study investigating the effectiveness of face-to-face and blended learning in gobo playing revealed a decrease in practical and theoretical knowledge among students in the blended form compared to face-to-face. However, the results only reflected the subjective perception of skill levels by students and teachers (Zhang, 2024). Similar results were obtained in a study examining the effectiveness of distance learning in choral singing; however, in that case, students' perception was slightly more positive in terms of the convenience of such a format (Li, 2024).

The current study complements the findings of previous research by providing an assessment of whether VR technology is more effective for training future oboe players than conventional videoconferencing. Despite the absence of a noticeable difference in the quality of acquired skills, the virtual environment contributed to an increase in the quality of aesthetic perception of music during performances and motivation for engagement, which is a significant advantage. Motivation plays a crucial role in the continuous improvement of students' skills and allows for the regulation of their desire to acquire new knowledge. A prominent advantage of virtual technologies is their ability to create an individualized learning environment and adjust the pace and duration of working on specific musical parameters.

Additionally, a somewhat greater effectiveness of the virtual environment in conveying folk music's lyrical and aesthetic characteristics was demonstrated. The evolution of folk music compositions can be linked to regional shifts impacting contemporary music. A change in playing tempo, connected to a change in intonation and modern forms, allows a performance to be more harmonious. It was found that the right way to breathe and changes in sound pitch and volume affect how expressive a performance is (Xu, 2022). The wind instrument's characteristics mean that it should produce an expressive sound (Li & Yuan, 2023).

Folk music has a unique style, evoking light, dark, rich, and vibrant emotions. The interplay of different rhythms in folk compositions is another feature that contributes to their expressive power (Yantian et al., 2021). The study of the characteristics of traditional Chinese music allowed us to conclude that it is primarily composed in pentatonic scales, has monophonic sound, and contains a significant amount of percussion. Traditional music is an excellent tool for expressing a wide range of feelings, and one song can encompass serenity, complexity, mystery, and calmness (Chai, 2022). Folk music is distinguished by a special musical charm that shows in the performance aesthetics. Since different melodic windings have varying effects on the scale system and tonal-harmonic structures, using them contributes to performance authenticity (Chai, 2022).

Augmented reality technology that allows learning to play classic musical instruments, such as the oboe, can be used to maintain national cultural art. It is known that the aesthetic qualities of musical composition performance are based not only on a musical technique but also on the ability to add extra

musical windings. It has been proven that using augmented reality technologies helps people learn more about their culture and traditions and gets students more interested in learning new things (Hong & Wu, 2022).

Using an oboe is a great way to convey the metaphorical tone of musical works. The oboe contributes bright tones, creates varied harmonies, and helps maintain the pentatonic scale, which is characteristic of folk music. The oboe is a musical instrument that allows the user to concentrate on sound waves and add attenuation or saturation effects that enhance the musician's freedom of expression. The sharpness produced by the sound intensity of the instrument appears in the sound dynamics (Larson, 2020).

Despite the debate surrounding the equivalence of live and virtual music in conveying subtle aesthetic elements, in this study, the levels of recognition of characteristic features of Chinese folk music were quite high, and there was a tendency towards improvement observed in the group participating in mini-concerts using VR. The use of virtual technologies enables a more precise adherence to the sequence of task execution and eliminates extraneous sounds, ensuring an accurate perception of melodies. Consequently, it allows for a deeper analysis of musical works, which impacts the quality of subsequent performances. Additionally, the virtual space provides an expanded set of tools for sound correction, in contrast to traditional teaching methods.

Conclusions

This study aimed to compare the effectiveness of using videoconferencing and VR technologies in teaching oboe playing, particularly in organizing remote mini-concerts aimed at practicing the technical and expressive skills of students. The oboe is a challenging instrument to teach, particularly when fully translated into a distance format. Due to its inherent complexity, there is a risk of losing its effectiveness. However, incorporating elements of distance learning can complement and enrich traditional teaching methods. This approach allows for increased practice opportunities, which entail more organizational complexities in face-to-face settings and pose higher risks in the event of infectious disease outbreaks. The capabilities of the technology employed play a crucial role in this context.

In this study, no differences were observed in the technical and expressive characteristics of students' performances between groups regularly participating in mini-concerts using videoconferencing and VR technologies. However, higher levels of academic motivation were noted in the VR group according to the Value Components section of the Motivated Strategies for Learning Questionnaire. Specifically, the perception of task value scored 5.65 compared to 4.81 out of 7 possible points, intrinsic goal orientation scored 5.49 compared to 4.89, and extrinsic goal orientation scored 5.58 compared to 5.01; all three pairs of values showed significant differences between the groups. Motivation among students using VR was linked to the provision of immersive presence through avatars. This facilitated closer interaction between students, promoting the development of practical oboe-playing skills. Sensory integration enabled a more comprehensive understanding of performance approaches using experimental learning methods, allowing for the identification of a clear connection between the performance of musical elements.

Additionally, a significantly higher sense of immersion and quality of aesthetic experience was reported in the VR group, scoring 4.81 compared to 3.70 out of 5 possible points in the videoconferencing group.

The use of VR provided a greater sense of immersion, which was related to the quality of transmitted sounds and the elimination of surrounding noises from the real environment. Furthermore, VR demonstrated a greater ability to convey characteristic emotional nuances of music. In the VR group, 2 out of 6 characteristic features of Chinese folk music were more pronounced compared to the videoconferencing group. The findings showed that lyrical highly artistic aspects, intonation subtlety, the high-pitched sound significant in Chinese spirituality, sound reproduction uniqueness, and the rhythm expression speed are the expressiveness parameters in Chinese folk music. After adding melodic windings typically associated with lyrical motifs, it was found that highly artistic lyrical aspects emerged. Intonation subtlety is intertwined with changes in pitch; the high-pitched sound, significant for Chinese spirituality, also promotes awareness of the pentatonic scale. The sharpness of the sound and the contrast between long and short notes are two indicators of a unique sound. Finally, the rhythm expression speed helps to convey the performance artistry.

Based on this study, the VR environment has the potential to provide better levels of immersion and perception of aesthetic value among students, which may, in turn, be one of the reasons for the simultaneous increase in their motivation.

Funding, Conflict of Interest, and Ethical Compliance

This research did not receive any specific grant from funding agencies in the public, commercial, or not-for-profit sectors. The authors declare that there are no conflicts of interest related to this work. Data supporting the findings of this study are available from the corresponding author upon reasonable request.

The study was conducted in accordance with the ethical standards of the World Medical Association's *Declaration of Helsinki*. Ethical approval was obtained from the local ethics committee of Xinyang Normal University (Protocol No. 4993, dated February 2, 2023).

All authors contributed to the study's conception and design. Material preparation, data collection, and analysis were performed by YZ. The first draft of the manuscript was written by YZ, and all authors reviewed and approved the final manuscript.

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Appendix

Survey: "Evaluation of the Possibility of Conveying Aesthetic Aspects of Chinese Folk Music Through the Platforms Used in Education

- Is it possible to perceive musical nuances during the performance of instrumental compositions?
- Does the perception of cultural nuances occur based on listening to melodies performed by students from your group?
- Does the perception of artistic nuances occur based on listening to melodies performed by students from your group?
- While listening to melodies performed on the oboe by students from your group, do you perceive lyrical motifs?
- Does the perception of intonational subtlety occur as a result of listening to melodies performed by students from your group?
- Is the spiritual component of the music perceived during the listening of melodies performed by students from your group?
- Is the high-pitched sound clearly expressed during the listening of melodies?
- Is it possible to trace unique sound characteristics while listening to melodies performed by students from your group?
- Is it possible to perceive the speed of rhythmic changes during the listening of musical works?
- Does the perception of oboe melodies, as heard through the platforms, leave a positive impression?
- Does the perception of oboe melodies, as heard through the platforms, leave a negative impression?

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Comparing Academic and Non-Academic Support Services: Mechanisms Impacting Academic Performance

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Abstract

Learning support services, categorized into academic and non-academic support, have been demonstrated to positively influence student development. However, the distinct mechanisms by which academic and non-academic support services impact academic performance remain underexplored in China. This study seeks to provide comprehensive insights into these mechanisms. A survey was conducted with a sample of 1,234 students to gather data on learning support services, student engagement, and learning performance. Structural equation modeling (SEM) was employed to analyze the conceptual model derived from the survey data. Results revealed that student engagement played a partial mediating role between academic support services and learning performance, while it played a complete mediating role between non-academic support services and learning performance. Furthermore, the analysis of standardized coefficient values reveals that academic support services have a lesser impact on student engagement and learning performance compared to the influence of non-academic support services on these same outcomes. It is suggested that distance education institutions need to pay more attention to non-academic support services and optimize resource allocation to achieve more efficient and rational resource distribution. As numerous traditional face-to-face educational institutions in China expand into online education, they encounter challenges due to isolation between teachers and students. Consequently, the concept of learning support services in distance education has become a significant concern. The findings of this study could provide valuable insights for these institutions.

Keywords: learning support services, student engagement, academic support services, non-academic support services

Introduction

Since 2012, online education in China has experienced exponential growth. The number of massive open online courses (MOOCs) in the country surged from a mere 5 in 2013 to 18,555 by 2019. Following the COVID-19 pandemic, the number of MOOCs skyrocketed to 61,990 by 2022 (Wu, 2022). As a result, online education has emerged as a viable alternative for universities in China.

The transition to online learning poses significant challenges for both lecturers and students, as noted by Kristiana et al. (2023). Wu and Li (2020) discovered numerous obstacles in the online education realm of traditional universities, including the inability of teachers to assess students' immediate status, monitor their learning progress, and provide on-site guidance and supervision, as well as the relaxation of classroom discipline. These challenges are largely attributed to the physical separation between teachers and students. Consequently, some Chinese researchers, such as Han (2019) and Zheng et al. (2020), have suggested that adopting the concept of learning support services from distance education may mitigate these issues.

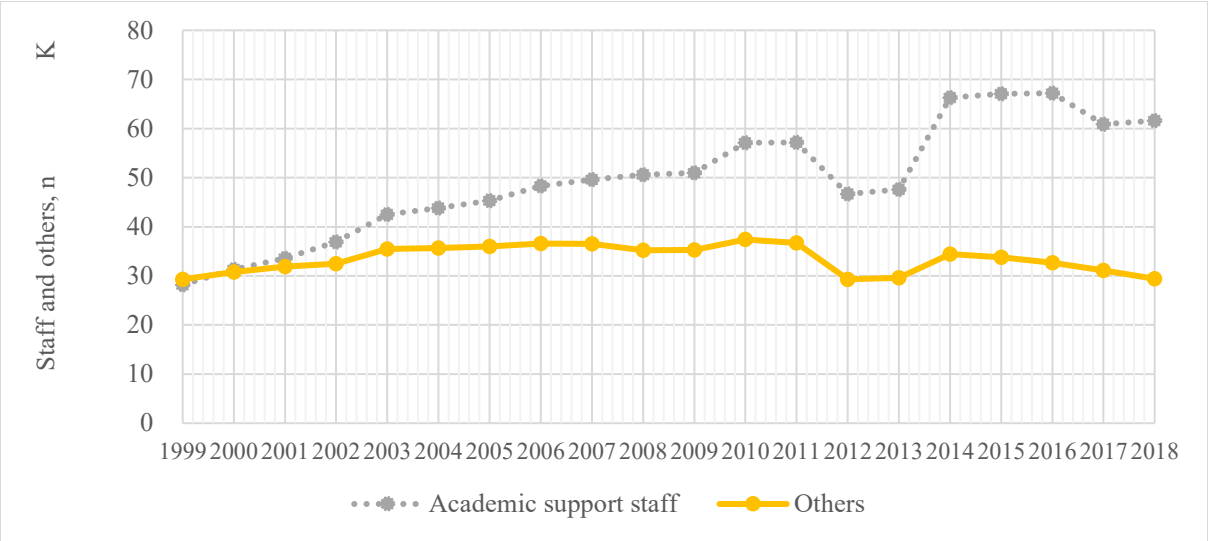
In the realm of distance and online education, researchers have established the pivotal role of learning support services in enhancing student performance and retention rates (Ludwig-Hardman & Dunlap, 2003). Simpson (2002) distinguished these services into academic and non-academic categories, a framework that has been widely adopted in China's open universities. Academic support services mainly refer to the support services provided to students in terms of cognition, intelligence, and knowledge within specific courses. Non-academic support services mainly refer to the help and support provided to students for issues or difficulties outside their professional studies, such as emotional and managerial support services.

The Open University of China (OUC) is the largest institution dedicated to distance and open education in China, comprising the OUC headquarters and 45 branches and thousands of study centers across the country. The entire educational system (including the headquarters, branches, and study centers) currently has nearly 4.57 million students. Informed by these theories, OUC has established separate teams for academic and non-academic support services. The faculty team including both full-time and part-time faculty members takes the responsibility for providing academic support services. Meanwhile, non-academic support services are mainly carried out by tutorial instructors (class advisors), technical staff, and other administrative personnel. These two roles of faculty and staff collaboratively work together to fulfill the task of delivering comprehensive learning support services to students.

Figure 1 presents data extracted from the Open University of China's (OUC) education statistical yearbooks spanning 1999 to 2018. The figure illustrates the imbalance in the growth of full-time teaching staff and other administrative personnel. Over this period, student enrollment surged from tens of thousands to nearly 4.57 million, and the number of full-time teachers rose to almost 61,600 by 2018—2.18 times the figure in 1999. In contrast, the number of administrative and technical staff remained virtually unchanged at approximately 29,400.

Figure 1

Number of Academic Support Staff and Others in Open University of China From 1999 to 2018



Due to data limitations, the academic support staff in Figure 1 refers only to full-time academic staff. Many part-time teachers who provide academic support are not included in the figure's data. Conversely, some staff members who do not provide non-academic support services, such as the support team, are included in the others category. Additionally, the support services provided by the two categories of personnel in Figure 1 may overlap in practice. For example, faculty members often offer non-academic support (e.g., emotional support) to students. Therefore, these two categories cannot be strictly equated with academic and non-academic support service teams, respectively.

The research questions posed in this study are: What are the actual impacts of the different support services provided by various staff on student development? Which service is more important? Is the personnel structure reasonable?

This study sought to provide an in-depth analysis of the impact mechanisms of learning support services on student development, with a particular focus on uncovering the distinct mechanisms between academic and non-academic support services.

Conceptual Framework

The concept of student development is multifaceted, with theories from sociology, psychology, and ecology contributing to the understanding of how students grow and develop (Astin, 1977, 1984; Bronfenbrenner, 1979; Sanford, 1962). These perspectives have significantly influenced student affairs in American higher education, offering theoretical frameworks for programming and student services (Renn & Li, 2008). Central to this discourse is the concept of student engagement, which explains the impact of external support environments on student development (Astin, 1977, 1984; Finn, 1989). Numerous studies have

since confirmed the link between student engagement and academic success (Mih & Mih, 2013; Pierson & Connell, 1992; Reeve & Tseng, 2011; Skinner & Belmont, 1993).

Student engagement refers to the extent of students' involvement in their learning experiences and their sense of connection to their classes, peers, and institutions (Axelson & Flick, 2010). Fredricks, Blumenfeld, and Paris (2004) highlighted engagement's correlation with positive academic outcomes and delineated three forms of engagement: behavioral, emotional, and cognitive.

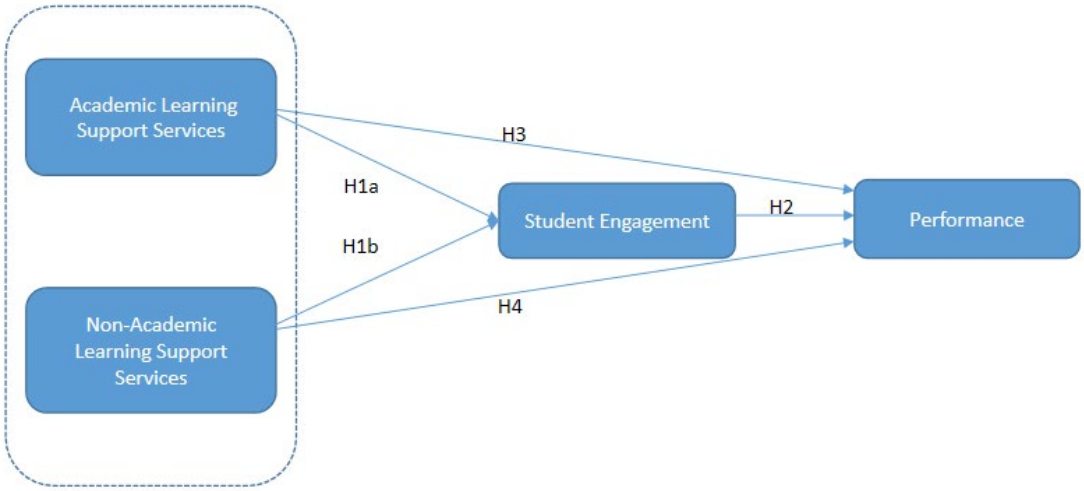
Sun and Rueda (2012) designed the Student Engagement in Distance Education (SEDE) scale, specifically for remote learning contexts. This scale evaluates student engagement across three key dimensions: behavioral, cognitive, and emotional. Behavioral engagement focuses on following online learning rules, submitting assignments on time, and reviewing errors. Cognitive engagement captures activities such as resource exploration, management, and strategic application. Emotional engagement, meanwhile, measures students' affective responses to distance learning, including enjoyment, interest, willingness to share achievements, and feelings of boredom regarding course content.

Zhao, Shao, and Su (2022) assessed online learning support services through three dimensions: cognitive support, emotional support, and management support. Cognitive support was regarded as academic support for learners, while emotional and management support were considered as non-academic support services. The study found that all three dimensions have a positive impact on students' online learning satisfaction.

Building on these theories and findings, a conceptual model and corresponding hypotheses were proposed. Figure 2 illustrates this model, where student engagement is posited as a mediating factor between learning support services—both academic and non-academic—and their impact on academic performance. It should be specifically noted that in measuring the quality of learning support services, the student perspective was adopted in this research. In other words, the term "perceived quality" used in this text means quality as perceived by students.

Figure 2

Conceptual Model and Corresponding Hypotheses



Note. H = hypothesis.

There were four corresponding hypotheses:

> H1: The perceived quality of learning support services, both academic and non-academic, significantly positively affects student engagement (shown as H1a and H1b in Figure 2).
>
> H2: Student engagement has a significant positive effect on learning performance.
>
> H3: The quality of academic learning support services, as perceived by the students, has a significant positive direct effect on learning performance.
>
> H4: The quality of non-academic learning support services, as perceived by the students, has a significant positive direct effect on learning performance.

In summary, this study investigated an integrated model in which the quality of learning support services, assessed solely through students' perceptions captured in a questionnaire, encompasses two dimensions: academic and non-academic support services. Each dimension was posited to positively influence student engagement, which in turn directly and indirectly affected the ultimate outcome—students' academic performance.

Methodology

Sampling and Participants

The Open University of China has study centers across the country, and this survey was conducted at one of these study centers. A deliberate random sampling method was employed to ensure no bias towards particular cases. All willing students were eligible for participation, which was confirmed through informed consent. The research was conducted using an anonymous online questionnaire, administered mid-semester to enrolled students. Questionnaires were distributed by instructors or counselors, either in-class or via groups on the WeChat social media platform.

After thorough data screening and cleaning, a total of 1,234 usable responses were retained for analysis, representing a net response rate of 75.8%. The demographic characteristics of the sample are presented in Table 1.

Table 1

Demographic Characteristics of the Sample

Characteristic	n	%
Gender		
Female	847	68.6
Male	387	31.4
Academic level		
Undergraduate program	440	35.7
Associate degree program	794	64.3
Age		
≤25	265	21.5
26-35	641	51.9
36-45	280	22.7
≥46	48	3.9

Note. N=1234.

Data Collection Procedures

Quantitative data was collected using an online scale adapted from the United Kingdom's National Student Survey (NSS) and Sun and Rueda's (2012) Student Engagement in Distance Education (SEDE) scale, both

translated into Chinese according to Brislin's (1970) translation protocol. Participants completed the 23-item scale online, with informed consent obtained as part of ethical research practices.

The perceived quality of learning support services was measured using nine items that captured two dimensions: academic and non-academic support services, with four and five items respectively. Thus, learning support services are conceptualized as a formative measurement model. Student engagement was assessed with eleven items, while learning performance was measured with three items. See Appendix A for full details of the study scale.

The scale demonstrated strong reliability and validity, with a Kaiser-Meyer-Olkin (KMO) measure of 0.931 and a Cronbach's Alpha of 0.936 for the overall scale. The Cronbach's α coefficients for the academic and non-academic dimensions of learning support services were 0.888 and 0.936, respectively. The factors accounted for a cumulative explained variance of 77.8%. The KMO value and Cronbach's α coefficient are used to assess validity and reliability, respectively. Generally, values above 0.9 are considered very good, while those between 0.8 and 0.9 are regarded as good.

Data Analysis

This study involved the design and revision of scales and questionnaires, testing the reliability and validity of measurement tools, distribution and collection of questionnaires, and statistical analysis of collected data using IBM SPSS Statistics (Version 20.0), including correlation analysis, mean analysis, and regression analysis. Additionally, IBM SPSS Amos (Version 26) was used to construct the structural equation model and test the hypotheses and mediation effects.

Results

The empirical analysis is based on a sample of 1,234 qualified responses from the questionnaire. Following Hair et al. (2017), the measurement models were first evaluated and then the structural equation model was analyzed.

Results of the Measurement Model Analyses

First, convergent validity was evaluated through redundancy analysis for each formative construct. Most of the path coefficients linking the formative constructs with their corresponding single-item global measures exceeded the suggested threshold of 0.70 (see Appendix B), indicating that all formatively measured constructs exhibited convergent validity. Subsequently, the formative measurement models were examined for potential collinearity by reviewing the outer VIF (variance inflation factor) values. All items' outer VIF values fell below the threshold of 5, which suggests that collinearity was not a concern in the formative measurement models. The third step involved assessing the significance and relevance of the formative indicators. The significance of the outer weights was verified, and all formative indicators proved to be significant at the 5% level.

Results of the Structural Model Analyses

Table 2 shows the fit indices of the structural model. The results indicate that the main indicators met the acceptable standards for the model, including SRMR, RMSEA, CFI, IFI, NFI, TLI, GFI, AGFI, and CN. These results demonstrate good fit for the structural equation model. Since the magnitude of the Chi-square (X^2) fluctuates with the sample size (1,234 in this study), the overall model fit judgment should be comprehensively judged based on various model fit indices provided by Amos. On this basis, although the expected *p*-value of the X^2 was significant, it can still be concluded that the theoretical model fits the actual data.

Table 2

Summary of Structural Equation Model Fit Indicators

Indicators	Acceptable Range	Value	Model fit assessment
Model Chi-square(X^2)	$p > .05$	X^2= 769.591 p=0.000	No
Root Mean Square Residual (RMR)	-	.066	Smaller values indicate better fit.
Standardized RMR (SRMR)	< .05	.0303	Indicates good fit.
Root Mean Square Error of Approximation (RMSEA)	< .05	.045	Indicates good fit.
Goodness of Fit Index (GFI)	> .9	.947	Indicates good fit.
Adjusted GFI (AGFI)	> .9	.933	Indicates good fit.
Normed Fit Index (NFI)	> .9	.971	Indicates good fit.
Relative Fit Index (RFI)	> .9	.966	Indicates good fit.
Incremental Fit Index (IFI)	> .9	.979	Indicates good fit.
Tucker Lewis Index (TLI)	> .9	.976	Indicates good fit.
Comparative Fit Index (CFI)	> .9	.979	Indicates good fit.
Parsimonious GFI (PGFI)	> .5	.758	Indicates good fit.
Parsimonious NFI (PNFI)	> .5	.848	Indicates good fit.
Parsimonious CFI (PCFI)	> .5	.855	Indicates good fit.
Critical N (CN)	> 200	412	Indicates good fit.
CMIN/DF	< 5[a]	3.482	Indicates acceptable fit.

Note. [a] = acceptable. Model Chi-Square means the chi-square value and its p-value (a p-value greater than 0.05 indicates acceptable model fit).

Hypothesis Testing Results

Table 3 provides a summary of the path parameter estimates for the model. The table includes standardized estimates of the regression path coefficients, four sets of variables have reached a significant level with small standard errors, indicating that there are significant relationships between the variables and that the structural relationships set by the model are reasonable.

Table 3

Hypothesis Testing Results

Hypothesis:path (X → Y)	Non-standardized loading coefficient	*SE*	Critical ratio	Standardized loading coefficient	Hypothesis supported?
H1a: Academic support services → Student engagement	0.200	0.028	7.034	0.257***	Yes
H1b: Non-academic support services → Student engagement	0.551	0.034	16.252	0.663***	Yes
H2: Student engagement → Learning performance	1.031	0.093	11.131	0.840***	Yes
H3: Academic support services → Learning performance	0.118	0.037	3.167	0.124***	Yes
H4: Non-academic support services → Learning performance	−0.079	0.061	−1.301	−0.077[a]	No

Note. [a] indicates exact *p*-value of .193.
*** $p < .001$.

H1a: The Influence of Academic Support Services on Student Engagement

The results in Table 3 show that academic support services have a significant positive effect on student engagement. H1a is verified by the results.

H1b: The Influence of Non-Academic Support Services on Student Engagement

Table 3 also shows that non-academic support services have a significant positive effect on student engagement. H1b is verified by the results.

H2: The Influence of Student Engagement on Learning Performance

The results shown in Table 3 indicate that student engagement has a significant positive effect on learning performance. H2 is verified by the results.

H3: The Influence of Academic Support Services on Learning Performance

Table 3 shows that academic support services have a significant positive direct effect on learning performance. H3 is verified by the results.

H4: The Influence of Non-Academic Support Services on Learning Performance

Finally, Table 3 suggests there is no direct significant relationship between non-academic support services and learning performance, leading to the rejection of H4.

Comparison of Effect Sizes

Additionally, the results suggest that non-academic support services have a greater influence on student engagement than academic support services.

Assessing Mediation Effects

This study employed latent variable mediation analysis in Amos to explore the mechanisms by which academic and non-academic support services, along with student engagement, influence learning performance. The bootstrap method was used to assess the mediation effects of the model. Table 4 presents the estimated values for the specific path effects within the mediation model.

Table 4

Mediation Effects Testing Results

Effect path	Point estimate	Product of coefficients		Bootstrapping					
				Bias-corrected (95% CI)			Percentile (95% CI)		
		SE	*z*	LL	UL	*p*	LL	UL	*p*
				Total effect					
Academic support services → Performance	0.324 (0.340)	0.042	7.714	0.235	0.405	.001	0.235	0.405	.001**
Non-academic support services → Performance	0.489 (0.480)	0.044	11.114	0.404	0.579	.001	0.401	0.578	.001**
				Indirect effect					
Academic support services → Performance	0.206	0.044	4.682	0.134	0.302	.001	0.133	0.301	.001**
Non-academic support services → Performance	0.568	0.083	6.843	0.431	0.757	.001	0.432	0.758	.001**

Effect path	Point estimate	Product of coefficients		Bootstrapping					
				Bias-corrected (95% CI)			Percentile (95% CI)		
		SE	*z*	LL	UL	*p*	LL	UL	*p*
Direct effect									
Academic support services → Performance	0.118	0.046	2.565	0.027	0.208	.006	0.019	0.201	.020*
Non-academic support services → Performance	−0.079	0.087	-0.908	−0.266	0.068	.341	−0.271	0.066	.323

Note. CI = confidence interval; LL = lower limit; UL = upper limit. Point estimate of total effect includes unstandardized coefficients and standardized coefficients in parentheses. *$p < .05$. **$p < .01$.

Regarding academic support services, the results shown in Table 4 indicate significant direct and indirect effects on learning performance (z value > 1.96), excluding the zero effect. This suggests that student engagement partially mediates the relationship between academic support services and learning performance, with the mediating effect of student engagement accounting for 63.6% of the total effect.

For non-academic support services, the results reveal that their direct impact on learning performance is not significant (z value < 1.96, including zero), suggesting that student engagement fully mediates the relationship between non-academic support services and learning performance. See Table 4.

Additionally, the standardized total effect of academic support services on learning performance is 0.340, whereas that of non-academic support services is 0.480, indicating that non-academic support services have a greater impact on learning performance than academic support services.

Discussion

The quantitative analysis confirmed the theoretical model and supported hypotheses H1 (H1a, H1b), H2, and H3, while H4 was not supported. Academic support services significantly enhance both student engagement and learning performance, whereas non-academic support services influence learning performance indirectly through student engagement.

Second, the study identified distinct mechanisms through which academic and non-academic support services influence learning performance, with two pivotal findings. For one, academic support services' effects on learning performance are partially mediated by student engagement, which accounts for 63.6% of the total effect. In contrast, non-academic support services exert their influence entirely through student engagement, as their direct effect on learning performance is not significant. The second key finding is that non-academic support services have a greater total impact on both student engagement and learning performance compared to academic support services. This suggests that in the context of open education in China, non-academic support services are more critical, with their effects surpassing those of academic support services.

These findings can be interpreted from two perspectives. First, the influence of academic support services may be understated in this study due to the availability of standardized learning resources, which partially replace their role, enabling self-directed learning without direct teacher guidance. These resources include comprehensive explanations of complex and key concepts, integrated with student learning activities. Second, non-academic support services offer personalized support and management, which still require real-time communication and interaction. Although technology allows for some remote interaction, it has not fully satisfied the individualized needs of students, highlighting the continued importance of non-academic support services.

On the other hand, the unique pedagogy and learning framework of distance and open education demand a broad set of competencies from students, including self-directed learning, study techniques, and self-regulation. However, many students lack these essential skills due to enrollment policies, creating a notable gap between the educational system's demands and students' capabilities. This gap highlights the vital role of non-academic support services in bridging the divide.

This study was conducted in the unique context of OUC, which features a distinctive teaching management model and admission policies. The teaching model of OUC prioritizes student self-directed learning, with teacher guidance as a supplementary support. In some extreme cases, such as in remote areas or impoverished regions in China, students may lack access to face-to-face tutoring. To ensure high-quality learning outcomes, course resources are designed to effectively convey knowledge even without substantial teacher support. Therefore, the standardized course resources and meticulous teaching design may partially replace the role of academic support, leading to an underestimation of the role of academic support services. Additionally, the OUC provides learning opportunities for all members of society. Learners can enroll voluntarily without having to take the National College Entrance Examination, resulting in a diverse student body with varying learning abilities. Some students may struggle to adapt at the beginning of their studies, due to insufficient learning abilities. This, combined with high-quality learning resources, increases the demand for and reliance on non-academic support services among students.

Conclusion and Implication

Student development and learning support service theories underscore the critical role of high-quality support services in boosting student engagement and academic performance. This study further explores the impact of various learning support service aspects on student development, aiming to encourage distance education institutions to prioritize and enhance their learning support services, particularly focusing on non-academic aspects.

The study reveals that non-academic support services significantly influence students' academic performance more than academic support services do. It aims to prompt reflection among China's distance education institutions, encouraging a more scientific approach to resource allocation for learning support services. Additionally, it is hoped that insights from this study will benefit traditional universities offering online courses.

As Tian et al. (2023) have pointed out, research studies on learning support services are still predominantly focused on academic learning support services, with very few scholars conducting in-depth studies on non-academic learning support services. Comparative studies on academic and non-academic support services, as undertaken in this research, are currently very rare.

While this study offers valuable insights, it has limitations. Being based on research at the Open University of China, its findings are closely tied to the specific context of Chinese distance education learners and teaching models. Besides, this study was conducted at one specific study center of OUC, and the final valid data obtained met the requirements for empirical analysis. However, the response and return rates of the questionnaire survey were still influenced by students' subjective willingness, potentially introducing self-selection bias. We are looking forward to seeing further in-depth research on this issue by scholars worldwide to explore the nuances of educational practices in their respective countries.

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Appendix A

Measuring Items for Students' Perception of the Learning Support Services, Engagement, and Result

How satisfied are you with … (scale ranged from 1 = *very dissatisfied* to 7 = *very satisfied*)

A. Students' Perception of Learning Support Services

Dimension 1: Students' perception of academic learning support services

Item Code: A1
Item Identifier: Learning resources
Teachers can offer customized learning resources to fit my study needs, enhancing my comprehension of the subject matter.

Item Code: A2
Item Identifier: Teacher's capabilities
The teacher possesses strong professional qualities, adept at tailoring teaching strategies to students' learning needs, effectively explaining course content, and readily answering my questions.

Item Code: A3
Item Identifier: Teacher's tutoring
The teacher offers effective course tutoring and practical guidance with enthusiasm in both online and offline settings, aiding me in understanding the material and enhancing my skills.

Item Code: A4
Item Identifier: Teacher's feedback and evaluation
Teachers offer prompt, detailed feedback on my homework and learning progress, which is enlightening and assists me in identifying and addressing knowledge gaps.

Dimension 2: Students' perception of non-academic learning support services

Item Code: NA1
Item Identifier: Consultation services
I can readily access timely and effective advice when needed, including study skills and enrollment consultations.

Item Code: NA2
Item Identifier: Information services
I consistently receive crucial information like course schedules, exam timings, and grades conveniently and promptly through the school's proactive notifications.

Item Code: NA3
Item Identifier: Management services
The school offers personalized management services, including flexible course schedules and online exam options, and maintains effective communication for adjustments, which supports my self-directed learning.

Item Code: NA4
Item Identifier: Emotional support.
Homeroom teachers and staff regularly reach out to me, proactively checking in on any challenges I might face, which fosters a strong sense of belonging.

Item Code: NA5
Item Identifier: Learning facilities and environment
The school's comprehensive software and hardware facilities significantly aid my studies, including well-maintained classrooms, ample laboratory equipment, intuitive learning platforms, and efficient information management systems. I also receive prompt assistance from support staff whenever issues arise.

B. Students' Engagement

Dimension 1: Behavioral engagement

Item Code: B1
Item Identifier: Self-study
I am able to follow the course requirements, regularly engaging with the provided text, audio, and video materials.

Item Code: B2
Item Identifier: Participation in learning activities
I can promptly complete various learning tasks and actively participate in all activities organized by the teachers.

Item Code: B3
Item Identifier: Active interaction
I frequently engage proactively with questions, requests, and posts from both teachers and classmates.

Dimension 2: Emotional engagement

Item Code: EE1
Item Identifier: Full of interest
I am always very interested in the course content I am about to learn.

Item Code: EE2
Item Identifier: Full of anticipation
I always look forward to the upcoming course activities.

Item Code: EE3
Item Identifier: Enjoyable learning process
I enjoy participating in remote learning activities.

Item Code: EE4
Item Identifier: Willing to share
I am very happy to share my learning achievements with others.

Dimension 3: Cognitive engagement

Item Code: CE1
Item Identifier: Making a study plan
At the beginning of my studies, I usually make a reasonable study plan.

Item Code: CE2
Item Identifier: Proactively searching for information
I will endeavor to seek out additional course-related information from websites, journals, and magazines.

Item Code: CE3
Item Identifier: Good at asking questions
I ask questions to gauge my understanding of the learning material.

Item Code: CE4
Item Identifier: Regular reflection
I regularly evaluate my learning outcomes and diagnose learning issues.

C. Students' Performance

Item Code: R1
Item Identifier: Enhancement of knowledge and skills
Studying at school has significantly enhanced my professional knowledge and skills.

Item Code: R2
Item Identifier: Enhancement of problem-solving abilities
Studying at school has helped me improve my ability to think independently and solve problems.

Item Code: R3
Item Identifier: Increased confidence
I am confident in using the knowledge I have learned to solve real-world problems.

For display convenience, items in Appendix B are labeled using Item Code or Item Identifier.

Appendix B

Summary of Path Parameter Estimates for Measurement Model

Path (X → Y)	Non-standardized loading coefficient	*SE*	Critical ratio	*p*	Standardized loading coefficient
Learning resources (A1) → Academic learning support services	0.841	0.027	30.845	***	0.731
Teacher's capabilities (A2) → Academic learning support services	0.903	0.025	36.232	***	0.804
Teacher's tutoring (A3) → Academic learning support services	0.976	0.024	40.100	***	0.843
Teacher's feedback and evaluation (A4) → Academic learning support services	1.000				0.897
Consultation services (NA1) → Non-academic learning support services	1.025	0.022	46.436	***	0.890
Information services (NA2) → Non-academic learning support services	0.950	0.027	35.429	***	0.779
Management services (NA3) → Non-academic learning support services	0.988	0.023	42.193	***	0.853
Emotional support (NA4) → Non-academic learning support services	1.000				0.889
Learning facilities and environment (NA5) → Non-academic learning support services	1.053	0.021	49.268	***	0.912
Self-study (B1) → Behavioral engagement	1.000				0.863
Participation in learning activities (B2) → Behavioral engagement	0.989	0.029	33.716	***	0.805
Active interaction (B3) → Behavioral engagement	0.981	0.028	34.873	***	0.842

Full of interest (EE1) → Emotional engagement	0.984	0.021	46.795	***	0.882
Full of anticipation (EE2) → Emotional engagement	1.009	0.020	50.468	***	0.910
Enjoyable learning process (EE3) → Emotional engagement	1.011	0.019	51.930	***	0.915
Willing to share (EE4) → Emotional engagement	1.000				0.905
Making a study plan (CE1) → Cognitive engagement	0.739	0.029	25.636	***	0.647
Proactively searching for information (CE2) → Cognitive engagement	1.033	0.024	43.863	***	0.906
Good at asking questions (CE3) → Cognitive engagement	1.009	0.024	42.665	***	0.892
Regular reflection (CE4) → Cognitive engagement	1.000				0.865
Enhancement of knowledge and skills (R1) → Performance	1.000				0.910
Enhancement of problem-solving abilities (R2) → Performance	0.989	0.018	54.087	***	0.928
Increased confidence (R3) → Performance	0.986	0.019	52.045	***	0.914
Behavioral engagement → Students' engagement	1.000				0.838
Emotional engagement → Students' engagement	0.800	0.043	18.757	***	0.592
Cognitive engagement → Students' engagement	1.049	0.042	25.193	***	0.840

Note. ***$p < .001$.

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Flipped Classroom Combined With Group Awareness

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Abstract

This study proposes a teaching model called "flipped classroom combined with group awareness" (FC+GA) to address the challenge of student preparedness in a traditional flipped classroom (FC) model setting. The FC+GA model incorporates group awareness tools, which provide visual information such as statistical tables and graphs, that allow students to see their online learning status along with that of their peers. By using these tools, students can have a better understanding of how well-prepared they are compared with their peers. This knowledge can motivate them to improve their efforts to prepare before class. The study conducted an extended experiment to analyze the effectiveness of the FC+GA model compared with the traditional FC model. The results show that the FC+GA model significantly improves students' preparation efforts before class and enhances students' learning outcomes. The study therefore concludes that the FC+GA model can be used as a practical reference and model for instructors preparing to implement flipped classrooms.

Keyword: flipped classroom, group awareness, preparation efforts, learning effectiveness

Flipped Classroom Combined with Group Awareness

Background

The flipped classroom (FC) model for teaching has gained significant attention in higher education due to its potential for improved learning outcomes and student satisfaction. However, a major challenge flipped classrooms face is a lack of student preparedness, which can significantly hinder their effectiveness. Currently, few studies exist that address this issue or aim to enhance the learning effect of flipped classrooms.

For FC to be successful, students must actively engage in studying and adequately prepare before classes. Unfortunately, not all students are able to meet these requirements. This challenge is also observed in massive open online courses (MOOCs), where students are expected to attend online classes and complete assignments and exams. Completion rates for MOOCs tend to be quite low: studies conducted by Alraimi et al. (2015) indicated that, on average, less than 10% of students who enroll in MOOCs complete them.

To address the challenge of student preparedness in FC, this study introduces a teaching model called "flipped classroom combined with group awareness" (FC+GA). Additionally, we develop an online FC auxiliary platform to support the implementation of the FC+GA model. Incorporating group awareness (GA) tools into the FC+GA model allows students to access visual information about their peers' online learning status. This information enables students to compare their own level of preparedness with that of their peers. By providing students with this awareness, teachers can motivate them to actively engage in pre-class preparation, which is crucial for the success of flipped classrooms.

Flipped Classrooms

Flipped classrooms are known for their emphasis on active learning and student-centered approaches (Lai & Hwang, 2016; Rasheed et al., 2020). In the FC model, students are required to complete preparatory activities before class; and during class, teachers guide problem-solving, group discussions, and interactive activities (Hao, 2016). Pre-class activities in these classrooms typically involve students watching instructional videos, reading learning materials, or completing quizzes (Akçayır & Akçayır, 2018; Howitt & Pegrum, 2015; Wanner & Palmer, 2015). These activities aim to provide students with foundational knowledge and concepts before coming to class, allowing for more meaningful and engaging discussions during face-to-face sessions. In-class activities in FC focus on collaborative discussions, task completion, problem-solving, and project work (Al-Zahrani, 2015; Akçayır & Akçayır, 2018). This active engagement during class time enables students to apply their pre-class knowledge, explore complex topics, and deepen their understanding through interaction with peers and guidance from the teacher. Overall, the FC model encourages students to take responsibility for their learning by engaging in preparatory activities before class and actively participating in collaborative and problem-solving activities during class. This approach promotes a student-centered learning environment and fosters deeper understanding and application of concepts.

Previous research has consistently demonstrated several positive educational outcomes associated with FC. Silverajah et al. (2022) highlighted various advantages of FC, including improved student engagement, satisfaction, and learning performance. Akçayır and Akçayır (2018) conducted a comprehensive analysis of 71 Social Sciences Citation Index journal papers on FC and found that the most commonly reported benefit

was improved student performance compared with conventional learning approaches (Flumerfelt & Green, 2013; Tune et al., 2013). In addition to improved performance, the FC model offers several other advantages. It has been shown to enhance learning satisfaction and motivation (Huang & Hong, 2016) as well as to promote critical thinking skills (van Vliet et al., 2015). FC also fosters creativity and improves problem-solving abilities (Liou et al., 2016). Studies have observed these benefits across various disciplines, including mathematics, social sciences, information science, and the humanities. The FC model has gained popularity and is increasingly implemented in different educational institutions, predominantly at the higher education level, such as in universities (Akçayır & Akçayır, 2018; Al-Samarraie et al., 2020; Divjak et al., 2022).

Compared with traditional teaching methods where the teacher delivers lectures in class, flipped classrooms require students to engage in more thorough pre-class preparation and to manage and monitor their own learning progress (Lai & Hwang, 2016). These requirements are crucial to realizing the benefits of FC. However, numerous studies have pointed out that students' reactions to and readiness for FC are not universally positive (Akçayır & Akçayır, 2018; Hao, 2016; Wilson, 2013). Forsey et al. (2013) even found that while most students hold a neutral attitude toward flipped classrooms, others express negative attitudes. The main challenges of FC include (1) students' limited pre-class preparation (Akçayır & Akçayır, 2018; Al-Zahrani, 2015) and (2) teachers' inability to assess whether students have previewed the learning content, thus hindering effective supervision of student learning (Akçayır & Akçayır, 2018; Fautch, 2015). For instance, Akçayır and Akçayır (2018) highlighted findings from many studies indicating insufficient student preparation, or even lack of preparation, before class. Yoon et al. (2021) further emphasized that while the FC model offers benefits, not all students possess the skills for active and autonomous learning. Consequently, the FC model does not equally benefit all students, presenting a significant challenge (Akçayır & Akçayır, 2018; Sun et al., 2017). As a result, some students may not be adequately prepared for classes, leading to reduced learning efficiency during FC classroom activities (Lai & Hwang, 2016).

Group Awareness

GA refers to the ability of students within an online learning environment to gain insights into the learning context of their peers through visual information, such as statistical tables or graphs (Bodemer & Dehler, 2011; Kimmerle & Cress, 2008). GA information includes details about peers' learning status, effort (e.g., study time), knowledge or expertise, and task or homework outcomes (Lin & Tsai, 2016). By providing objective information about peer learning, GA allows students to observe and compare their progress with others in an unbiased manner (Lin & Tsai, 2016).

Understanding each other's learning context not only positively impacts learning motivation but also guides students in reflecting on their own learning experiences (DiMicco et al., 2007) and overall learning process and enables them to adjust their strategies for subsequent learning activities (Kitsantas & Dabbagh, 2010). Additionally, GA assistance can help keep students motivated to learn and reduce their feeling of loneliness (Lin et al., 2016). Visual representations of GA information can effectively motivate individuals to be more active and responsible because they explicitly highlight individual effort through social evaluations and comparisons (Kwon, 2020), while a lack of GA information can hinder students' engagement (Theophilou et al., 2024).

As a result of these positive effects, educators have made extensive use of GA in online assisted collaborative learning environments (Dehler et al., 2011; Janssen et al., 2007; Lin et al., 2022; Sangin et al., 2011). For instance, Liu et al. (2018) proposed an online collaborative writing system with GA functionality that continuously collects and visualizes the writing behaviors and participation intensity of group members, allowing them to compare their participation levels with those of others.

Research Aims

As mentioned earlier, one of the significant challenges in implementing the FC model is the lack of pre-class preparation by students, which hampers the learning efficiency in the classroom (Akçayır & Akçayır, 2018; Al-Zahrani, 2015; Lai & Hwang, 2016; Yoon et al., 2021). However, existing research on FC focuses primarily on the learning outcomes of these classes in various subjects, neglecting the impact of this issue and failing to propose suitable solutions (Rasheed et al., 2020). Motivating students to dedicate more time to pre-class preparation in FC is, therefore, an important issue to address. Future directions should explore innovative mechanisms or technologies to solve this problem (Lai & Hwang, 2016; Sun et al., 2017).

Therefore, we propose an FC+GA model (Figure 1) and develop a corresponding online FC auxiliary platform to facilitate the implementation of the proposed model. The GA information we provide includes students' online time browsing learning materials, their online assessment scores, and the results of their work. The GA information not only offers students opportunities for self-reflection but also guides their self-regulated learning behavior (Lin et al., 2016; Lin, 2018).

For our study, we selected two classes of students enrolled in the same first-year university course. One of these classes was randomly assigned as the experimental class that would follow the FC+GA process and use the developed system, depicted in Figure 1. The other class served as the control class and followed the traditional FC process using the traditional FC system. Both classes underwent three units of FC teaching, with each unit comprising one FC session per week, resulting in a total of three weeks of repeated FC learning processes. Prior to each session, students in both classes were required to engage in pre-class activities, which included previewing learning materials, completing online assessments, and uploading practice files. During the in-class activities, students in both classes worked on problem-solving tasks provided by the teacher.

This study addressed the following research questions (RQs):

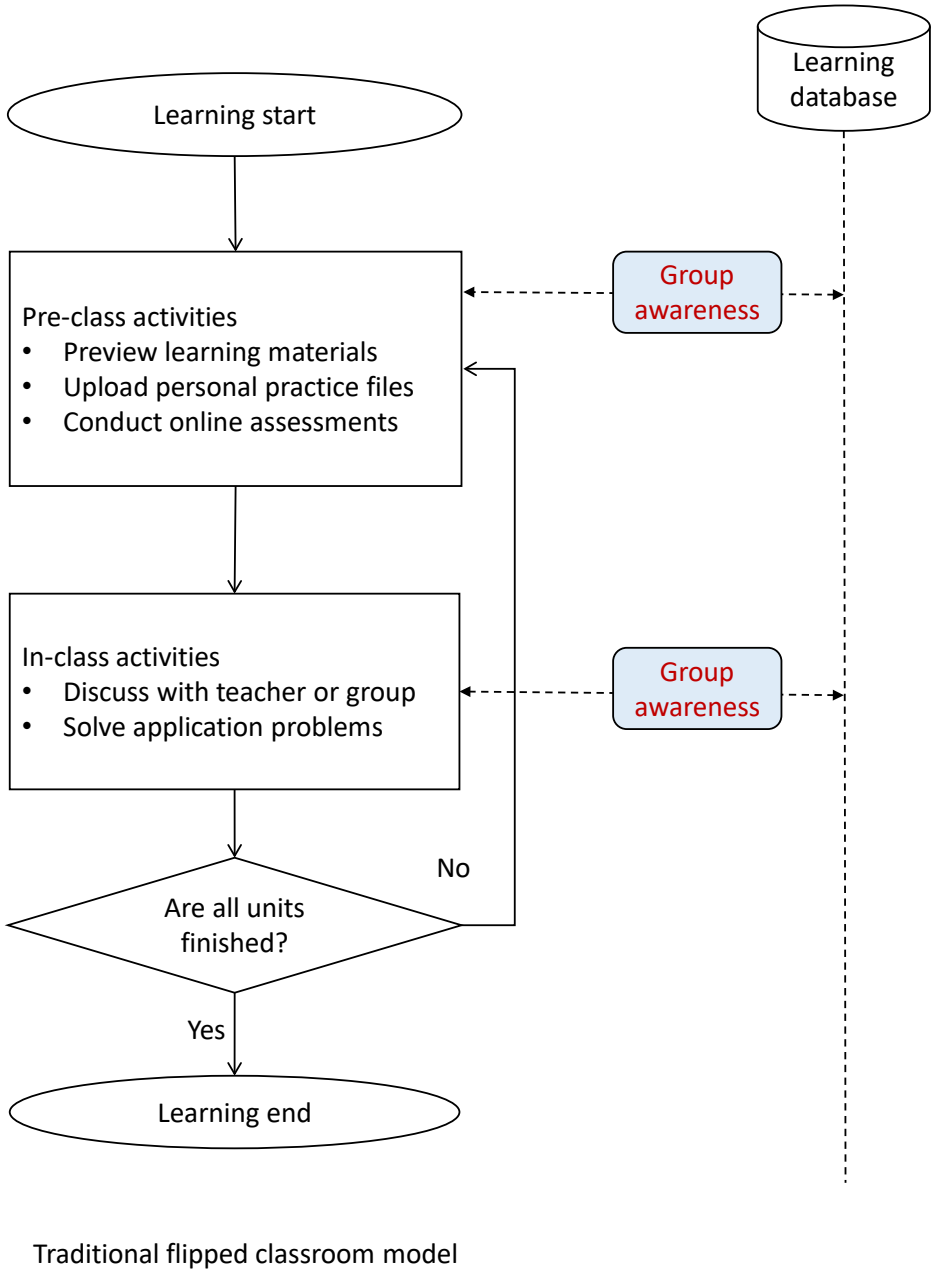
> RQ1: Is there a significant difference between the two classes in terms of pre-class learning activities, including online preview time, online assessment scores, and the number of uploaded practice files?
>
> RQ2: Is there a significant difference between the two classes in learning outcomes (i.e., scores on application questions)?
>
> RQ3: After completing the experiment, do the two classes exhibit any differences in their attitudes or perceptions toward the teaching method employed?

The Proposed Model

Figure 1 depicts the FC+GA model this study proposes. The left side of the figure represents the traditional FC model and the right side represents the integration of GA. The following subsections provide a detailed explanation of the pre-class activities, in-class activities, and the corresponding GA functions provided.

Figure 1

The Proposed Flipped Classroom Combined With Group Awareness (FC+GA) Model



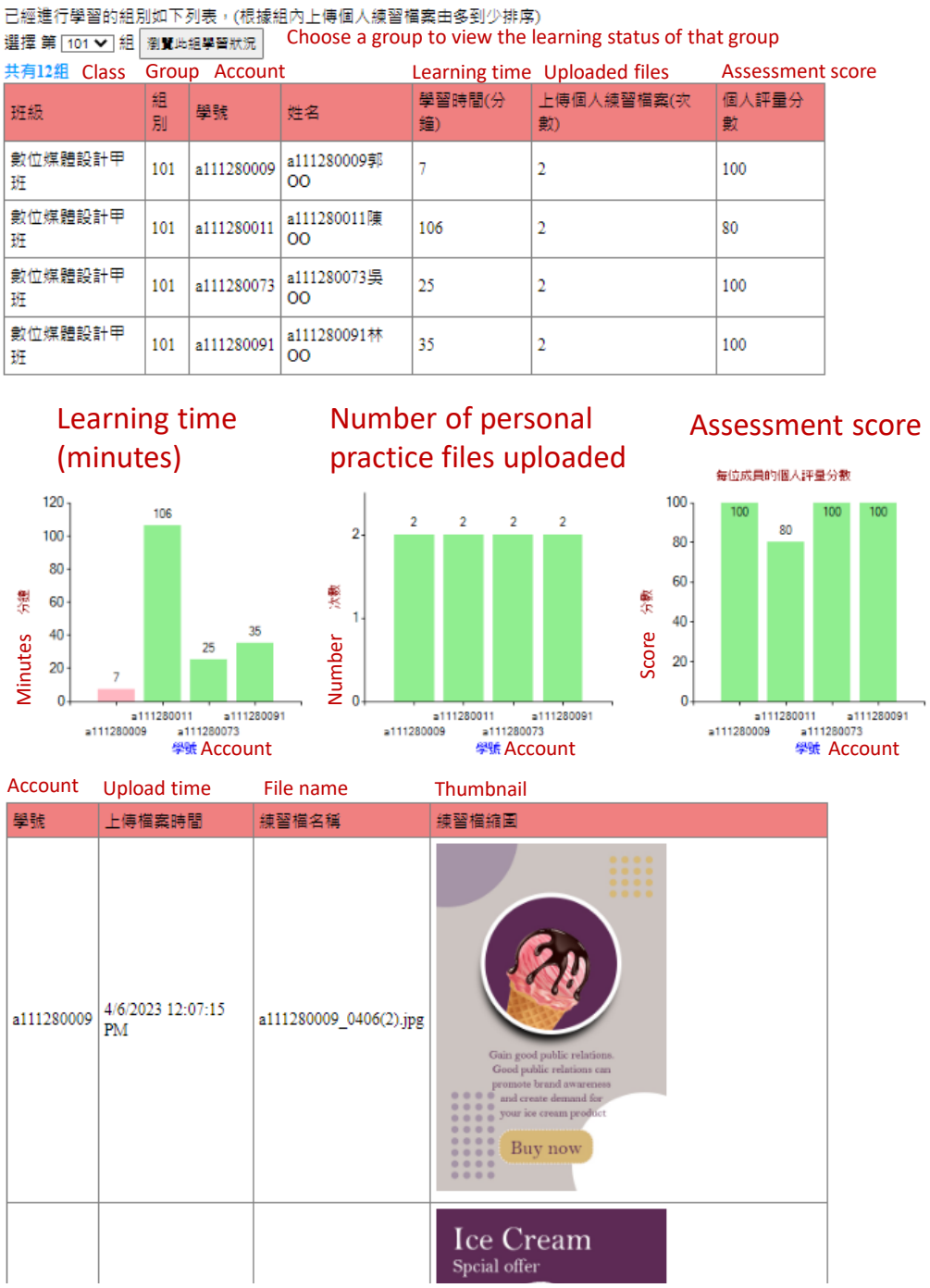
Pre-class Learning Activities

To initiate the learning process for a unit of FC, students are required to engage in pre-class preparation activities, which include previewing learning materials, completing assessments, and uploading practice files. These activities are represented on the left side of Figure 1. Figure 2 illustrates the addition of GA functions, where students can refer to and browse the pre-class learning activities of their group members. The proposed FC+GA system is designed to display information about group members who have completed the pre-class learning tasks for the current unit. This information includes the amount of time they spent on learning, the number of personal practice files they uploaded, and their scores on the online assessment. These GA functions allow students to gain a better understanding of their group members' engagement and efforts in preparing for the upcoming class.

The use of the GA tool raises privacy concerns, as students' online learning status and progress become visible to their peers. To address this concern, the GA system this study implements displays students' accounts without revealing their real names, ensuring that the privacy of individual students is protected while still allowing for the benefits of GA in promoting self-reflection and facilitating peer comparison.

Figure 2

Group Awareness Information About Pre-Class Learning Activities



The table in the top part of Figure 2 provides a detailed overview of each group member's learning activities. This includes information such as (1) the amount of time they spent on learning (in minutes), (2) the

number of practice files they have uploaded, and (3) their scores achieved in the online assessment. This table offers a comprehensive view of the engagement and performance of each group member. The charts in the middle part of Figure 2 display three corresponding learning activities. These charts present graphical representations of the three key aspects of learning, allowing students to easily compare and analyze their progress in relation to that of their group members. The visual nature of the charts makes the data easier to access and interpret, helping the students to identify patterns and trends in their learning activities. The table in the bottom part of Figure 2 provides detailed information about the personal practice files uploaded by group members. This information includes the upload time, file names/types, and thumbnail previews of the practice files. This can facilitate knowledge-sharing within the group, as well as inspire ideas for their own learning practices.

In summary, Figure 2 provides a comprehensive representation of the GA information that supports students in tracking their own progress and comparing their performance with their peers and that facilitates the sharing of knowledge within the learning community.

In-class Learning Activities

During the in-class session, teachers typically assign an application question for students. In this study, the FC+GA model incorporates GA functions that enable students to refer to their group members' learning context during in-class learning activities, as depicted in Figure 3.

Panel A of Figure 3 illustrates the function allowing students to upload their individual work on the application question, allowing students to showcase their solutions. Panel B of Figure 3 presents detailed information about the application work uploaded by group members. This includes the upload time and thumbnail previews of the submitted work.

By displaying this information, students can gain insight into the progress and approaches their group members have taken, facilitating collaborative discussion and knowledge-sharing within the group. This also promotes a deeper understanding of different problem-solving strategies, encourages peer learning, provides peer feedback, and facilitates the identification of alternative perspectives and solutions.

By integrating GA functions into the in-class learning activities, the FC+GA model enhances students' ability to access and leverage their group members' knowledge and expertise. Providing detailed information about the uploaded work fosters a collaborative learning environment, where students can learn from one another and benefit from multiple perspectives and solutions.

Figure 3

Supportive In-Class Group Awareness Information

A. Students upload personal work on the application problem

B. All uploaded student work is displayed for reference

Methodology

Research Design

The course used in the experiment was Digital Image Design. This is a two-credit course, with two lessons scheduled per week. The course primarily covers digital image knowledge and the use of Adobe Photoshop for designing digital images. The first three weeks of the course focus on teaching fundamental image concepts and the operation of Photoshop, providing prerequisite knowledge and skills for the later lessons. These early weeks of the course concentrate on essential concepts and techniques, including image sizing, selection tools, moving and cropping, brightness adjustments, polygonal selections, image deformations, text insertion, stamp tools, layer management, image repair techniques, fill tools, masks, and gradients. During these weeks, both the experimental and the control class followed a traditional teaching approach, with the teacher delivering instructions during class time, followed by students practicing and implementing the learned concepts.

Following the completion of these first three weeks, students taking this course are expected to possess a solid foundation in the subject matter, along with a comprehensive understanding of commonly used functions and special effects necessary for practical applications. Once the students acquire the fundamental knowledge and skills, the subsequent weeks of the course shift to a weekly FC teaching approach, with a specific focus on practical examples, such as the creation of commercial product advertisements.

The experiment was conducted over these subsequent three weeks. One class used the traditional FC model (system), while the other class used the proposed FC+GA model (system). Each week, the course covered one learning unit, focusing on practical design projects. The three practical units covered during the experiment were Designing a Web Banner, Designing a Speech Poster, and Designing an Ice Cream Advertisement. Prior to the start of the experiment, students from both classes registered their accounts and logged into their respective systems. This allowed the systems to store and track students' online learning behaviors throughout the experiment. Recording their activities on the systems provided students with valuable data for analysis and evaluation purposes.

We began by implementing the first unit FC experiment as follows. The teacher instructed students in both the experimental and control classes to engage in various learning activities prior to the class session. These activities included previewing the learning materials and teaching videos, uploading personal practice files, and completing an online assessment. The content of the online learning videos and teaching materials was identical for both classes. The videos consisted of recordings of the teacher's screen operations accompanied by audio explanations. Additionally, students were provided with relevant teaching slides that they could download from their respective systems. Students from both classes had the opportunity to practice on their individual computers while they viewed the teaching videos. Upon completion of the self-practice, students from both classes were required to upload their practice files to their respective systems. Students were advised to practice several times to become familiar with the learning content. Subsequently, they had to complete an online assessment of around 10 multiple-choice questions. If a student answered a question incorrectly, the correct answer was provided. Importantly, during this stage, the experimental class had access to the GA function (Figure 2) while the control class did not.

During the in-class session, students in both the experimental class and control class had the opportunity to raise any difficulties or challenges they encountered during the pre-class learning activities and discuss them with the teacher. The teacher provided guidance and clarification to help students overcome these challenges. After the discussion, the teacher presented an advanced practical application question and provided raw materials (such as pictures or text) for the question that were different than the materials used during the pre-class learning. Each student was required to incorporate these specified materials into their application work, showcasing their creativity and imagination. For example, in the Designing a Web Banner unit, the teacher provided specific pictures and texts that students were to include in their application work. Students were encouraged to use these materials as a starting point and then add their own creative elements to design diverse and unique web banners.

Both classes were given approximately 90 minutes to complete the application question. In the FC+GA class, students had the advantage of being able to browse the uploaded work of their group members, as shown in Figure 3. This feature allowed them to learn from and be inspired by their peers and to gain insights from observing different design approaches. In contrast, the students in the FC class did not have access to this feature and relied solely on their own creativity and problem-solving skills. If they were dissatisfied with their work, students in both classes could refine it and re-upload a revised version, replacing the previous submission. In this way, students could continuously improve their design and strive for a better outcome. Before the end of the session, students in both classes had to upload their final work to be graded by the teacher. This marked the completion of the FC teaching for one learning unit.

The FC teaching process for the second and third learning units followed the same structure as described for the first unit above. It is worth noting that some research has suggested that while computer-assisted learning may initially have positive effects, these effects can diminish over time as students become more familiar with the learning system (Wang, 2011; Wang, 2015). To address this concern, this study's parameters—conducting a three-week experiment consisting of three learning units—allowed for a comprehensive analysis of the learning behavior and its trend changes in both classes under different FC teaching modes (Lin & Tsai, 2016).

Upon completion of the experiment, students of both classes were asked to fill out a questionnaire. The questionnaire, adapted from Lin (2019) with moderate modifications, included four questions that required participants to rate their agreement on a 5-point scale ranging from strongly agree (5) to strongly disagree (1).

Participants and Grouping

A quasi experiment was conducted using approximately 100 students from two first-year classes majoring in information management in an urban university located in northern Taiwan. The students in both classes were aged between 18 and 20 years, had participated in computer courses, and were familiar with computers and the Internet. Each class comprised approximately 50 students. One class was randomly assigned as the experimental class, where the proposed FC+GA model (Figure 1) and online FC+GA system, incorporating all the functions shown in Figure 2 to Figure 3, were implemented. The other class served as the control class and followed traditional FC teaching methods using a traditional online FC system.

Prior to the start of the experiment, both classes were informed that they would undergo three weeks of FC

teaching, covering three learning units. The classes were also introduced to their systems. Additionally, the students were instructed to form their own groups, with each group consisting of four to five students.

Throughout the experiment, both classes had unrestricted access to their respective learning systems, and students could analyze each others' anonymized data. This ensured the privacy of the students and allowed the researchers to collect and examine relevant data to evaluate the effectiveness of the proposed FC+GA model.

Measurement and Data Analysis

The study used normal statistical tests (Kolmogorov–Smirnov test) to determine whether the data were normally distributed (Adalier, 2012); the null hypothesis was that the obtained data were normal. If the null hypothesis was accepted, a *t*-test was performed. Otherwise, a nonparametric Mann–Whitney U test was performed. SPSS software was used for all data analyses.

For RQ1, the study used two FC systems to record students' online learning behavior and participation, which encompassed activities such as login frequency, learning duration, uploaded practice files, and assessment results. The necessary data for analyzing RQ1 were extracted from the databases of these systems.

For RQ2, two relevant experts graded the application work submitted by students in both classes. The grading criteria for the student work, with a maximum score of 100, primarily considered the following aspects: (1) overall presentation of the final work (weighted 30%); (2) use of the materials specified by the teacher (35%); and (3) application of the learned methods and techniques (35%), such as image effects, layer styles, and text effects. The final score was determined by averaging the scores given by the two experts. In cases where the difference in final scores exceeded 10 points, the two experts engaged in further discussions to reach a consensus. To ensure students took the assignments seriously, the teacher announced that the assignment grades would be parts of the final grade of the course.

Results

Results for RQ1 and RQ2

The Kolmogorov–Smirnov test showed that these data were normally distributed ($p > 0.05$); *t*-tests were therefore performed. Table 1 presents the statistical results for learning Unit 1. The analysis indicated no significant differences between the FC+GA class and the FC class in terms of the learning preparation activities conducted before class, such as total learning time and the number of logins. Furthermore, the results showed no significant differences in the application scores obtained by the two classes during the in-class activities. Overall, based on the statistical analysis of learning Unit 1, we found no significant differences between the experimental and control classes in terms of learning preparation activities and application scores.

However, in learning Unit 2, the statistical analysis revealed significant differences between the FC+GA class and the FC class in various learning preparation activities. Specifically, compared with the FC class,

the FC+GA class demonstrated superior performance in terms of total learning time, the number of logins, the number of practice files uploaded, and assessment scores. Additionally, the FC+GA class achieved a significantly higher application score than that of the FC class during the in-class activities. This suggests that the incorporation of the FC+GA system had a positive impact on students' engagement and performance in learning preparation activities as well as their ability to apply the learned concepts and skills in the practical application tasks.

Similarly, in learning Unit 3, we observed significant differences between the FC+GA class and the FC class across five learning preparation activities, even including "advance preparation days." This suggests that the FC+GA class had a higher level of engagement and participation in the learning activities than the FC class. Additionally, the application score in class showed a significant difference between the FC+GA class and the FC class. The FC+GA class achieved a higher score, indicating better performance in applying the learned concepts and skills during the in-class activities.

These results demonstrate that the use of the FC+GA system has a sustained and positive impact on student learning. The FC+GA class consistently outperformed the FC class in terms of learning preparation activities and application scores in learning units 2 and 3. Overall, these findings emphasize the continuous and positive effects of using the FC+GA system on student learning outcomes.

Table 1

Comparison of the Two Classes

Learning Unit	Learning stage	Variables (learning activities)	Class	N[a]	*M*	*SD*	*t*-value	*p*-value
Unit 1	Before class	Total learning (retention) time	FC+GA	29	35.79	37.14	-0.85	0.19
			FC	36	43.33	37.85		
		Number of logins	FC+GA	29	1.48	0.87	-0.99	0.16
			FC	36	1.69	0.82		
		Advance preparation days	FC+GA	29	1.17	0.46	-1.62	0.06
			FC	36	1.83	2.02		
		Number of practice files uploaded	FC+GA	29	0.42	0.08	-0.43	0.33
			FC	36	0.49	0.75		
		Assessment score	FC+GA	29	26.68	38.23	-0.05	0.48
			FC	36	27.12	38.13		
	In class	Application score	FC+GA	36	59.90	41.18	-1.03	0.15
			FC	43	67.45	32.02		
Unit 2	Before class	Total learning (retention) time	FC+GA	44	99.06	92.46	2.06*	0.02
			FC	39	63.39	82.41		
		Number of logins	FC+GA	44	2.52	1.88	2.29*	0.01

			FC	39	1.75	1.52		
		Advance preparation days	FC+GA	44	3.10	3.79	0.56	0.28
			FC	39	2.71	3.16		
		Number of practice files uploaded	FC+GA	44	1.13	1.08	2.10*	0.02
			FC	39	0.65	1.26		
		Assessment score	FC+GA	44	44.61	37.02	2.24*	0.01
			FC	39	28.61	35.30		
	In class	Application score	FC+GA	47	87.77	4.14	2.53*	0.01
			FC	46	83.80	9.84		
Unit 3	Before class	Total learning (retention) time	FC+GA	50	74.71	65.51	2.18*	0.02
			FC	38	43.98	77.05		
		Number of logins	FC+GA	50	1.94	1.21	2.31*	0.01
			FC	38	1.39	1.20		
		Advance preparation days	FC+GA	50	1.98	1.33	3.62*	0.00
			FC	38	1.14	1.00		
		Number of practice files uploaded	FC+GA	50	1.98	1.60	3.03*	0.00
			FC	38	1.04	1.54		
		Assessment score	FC+GA	50	63.20	39.07	2.78*	0.00
			FC	38	40.01	45.32		
	In class	Application score	FC+GA	46	90.26	4.67	2.21*	0.01
			FC	45	88.11	4.68		

[a] N represents the number of students who used their systems; the FC+GA class had a total of 52 students and the FC class had a total of 51 students, but not all of the students used their systems.

Results for RQ3

The Kolmogorov–Smirnov test showed that these data were normally distributed ($p > 0.05$), and *t*-tests were therefore performed. Table 2 presents the results of the questionnaire. In regard to questions 1 and 2, the findings show that students in both classes shared the perspective that the FC approach is more effective than traditional learning, but they also acknowledged that it induces more stress.

Concerning questions 3 and 4, the findings show that students in the FC+GA class had a better understanding of their group members' learning progress and were more influenced by group members than students in the FC class were. This suggests that the FC+GA approach improved comprehension of group dynamics and increased influence from peers in the learning process, as reported by students in the FC+GA class.

Table 2

Questionnaire Results

	Class	N[a]	M	SD	*t*-value	*p*-value
Was flipped learning more effective than traditional learning?	FC+GA	48	4.15	0.74	0.28	0.39
	FC	43	4.09	1.04		
Did you feel more stress with flipping learning than with traditional learning?	FC+GA	48	3.63	1.16	0.74	0.23
	FC	43	3.44	1.18		
Did flipped learning online system help you understand internal members' learning status?	FC+GA	48	4.06	0.83	3.69*	0.00
	FC	43	3.33	1.06		
During flipped learning, were you more likely to be influenced by group members?	FC+GA	48	3.71	0.96	2.16*	0.02
	FC	43	3.21	1.22		

[a] N represents the number of valid questionnaires.

Discussion and Implications

In Unit 1, students in both classes were novices at using their respective systems. Both classes were physically exploring their systems for the first time. Notably, only 29 of 52 students (55%; Table 1) in the FC+GA class and 36 of 51 (70%) in the FC class participated in the preparation activities offered by their respective systems. Therefore, it is very likely that less than 55% of the students in the FC+GA class had access to the information provided by GA. Consequently, no significant differences are seen between the two classes in terms of all pre-class learning activities (Unit 1 in Table 1), such as total learning time and number of practice files uploaded.

However, after Unit 1, students became aware that they could see the preparation efforts of other members and that their own efforts were also visible to others (as shown in Figure 2). This awareness likely spread through word-of-mouth or social media messages shared among peers in the class. As a result, in Unit 2, 44 out of 52 (85%; Table 1) of students in the FC+GA class participated in preparation activities, while 39 out of 51 (76%) of students in the FC class participated in preparation activities. The participation rate in the FC+GA class increased from 55% to 85%, while in the FC class it increased from 70% to 76%. This indicates that the boost in participation in the FC+GA class was greater than that in the FC class. In addition, the two classes in Unit 2 show significant differences in terms of pre-class learning preparation activities, with the exception of "advance preparation days." Specifically, the FC+GA class exhibits significantly higher total learning time, number of logins, number of practice files uploaded, and assessment scores compared with the FC class (Unit 2 in Table 1). Because the students in the FC+GA class engaged in more comprehensive learning preparation before class than the students the FC class, the FC+GA class also achieved significantly higher "application scores" than the FC class.

The phenomenon observed in Unit 2, as described above, continued into Unit 3. Additionally, during Unit 3, we observed significant differences between the two classes in terms of all learning preparation activities

conducted before class, including "advance preparation days." Specifically, in the FC+GA class, the participation rate remained high, with an increased awareness of the visibility of preparation efforts among peers. This led to continued active engagement, as evidenced by higher total learning time, number of logins, number of practice files uploaded, and assessment scores compared with the FC class (Unit 3 in Table 1). These differences are statistically significant, indicating a consistent pattern of more thorough learning preparation in the FC+GA class throughout Unit 3.

In a previous study, Lin and Lai (2019) emphasized the significance of extended experiments in uncovering users' evolving patterns of hands-on behavior as they become more acquainted with the system's functions. In our study, a similar pattern emerges as students in the FC+GA class gradually familiarized themselves with the system, resulting in an increased inclination to engage in learning preparation activities for units 2 and 3. Notably, the students in the FC+GA class also expressed agreement with the notion that they gained a better understanding of their peers' learning context and acknowledged being influenced by it (Table 2). This suggests that the introduction of GA tools allows for a more comprehensive understanding of the collective learning progress within the class, fostering a positive impact on individual students' learning behaviors and outcomes. Therefore, our research findings support the viewpoint proposed by Lin and Lai (2019), emphasizing the importance of conducting extended experiments to capture users' evolving behavior over time.

The availability of GA information allows students to view the impressive work of their peers, which potentially triggers social comparison among them. In other words, students are motivated to outperform their peers and strive for excellence (Lin et al., 2022). This creates a positive cycle where students are inspired by their peers' achievements, leading them to diligently prepare for the subsequent FC learning sessions. The motivation to outperform and the drive to excel fosters healthy competition and a continuous cycle of improvement in class. Students become motivated to put in more effort and dedication, driven by the desire to surpass their peers and achieve their own academic goals (Lin & Tsai, 2016).

In contrast, students who are ill-prepared and do not engage in sufficient learning preparation activities become aware that their lack of preparation is noticeable to their peers (Lin et al., 2016). During the class, they often find themselves needing to seek help from others to solve application questions. These experiences of relying heavily on others and experiencing feelings of awkwardness should serve as a catalyst for them to recognize the importance of adequately preparing for the next FC learning session. The realization that their peers are more prepared and capable can create a sense of discomfort and the desire to avoid similar situations in the future. This discomfort can motivate students to reflect on their own learning habits and take the necessary steps to improve their preparation, ensuring that they are better equipped to actively participate in the next FC learning session.

Thus, integrating GA into MOOCs is expected to boost learner preparedness, motivation, and collaboration while reducing dropout rates. GA visualizations (e.g., forum participation, quiz completion) help learners find study partners, fostering knowledge-sharing and group participation. GA-based reminders (e.g., "You are behind X% of your peers") keep learners on track, creating more interactive and effective large-scale online learning experiences.

Notably, GA tools provide students with insight into their peers' achievements, fostering motivation and

healthy competition. However, this transparency may also lead to stress, particularly for those who feel they are falling behind. Struggling students may experience increased anxiety due to performance pressures and constant peer comparisons, which can undermine self-confidence. To mitigate these negative effects, future GA tools can add individualized progress tracking, encourage self-reflection, and provide constructive feedback (e.g., You have improved since last time—keep up the good work!). Creating a supportive and balanced learning environment can help maximize motivation while minimizing stress.

Conclusions and Limitations

This study introduced the FC+GA teaching model, which combines GA tools with the traditional FC approach. To support this model, we developed an online auxiliary platform, also called FC+GA. The GA tools incorporated in FC+GA enable students to gain insights into their peers' online learning progress through visual representations such as statistical tables or graphs.

The results of the extended experiment conducted in this study reveal that the FC+GA model significantly enhances students' level of preparation before class, thereby leading to improved learning outcomes compared with the traditional FC approach. These findings highlight the practical value and efficacy of the proposed FC+GA model, making it a valuable resource for instructors seeking to implement FC in their teaching practices.

However, implementing the proposed FC+GA model and maintaining the online platform may require additional efforts, including time, funding, and technical support. While the FC+GA model and online platform offer several benefits, it is important to acknowledge their limitations. The proposed teaching model is more suitable for courses where the learning process, assessment results, or learning outcomes can be recorded on a computer. It is well-suited for general courses such as information technology (multimedia courses, programming languages), business management courses, and applied foreign language courses. However, it may be less suitable for courses that require specific equipment or instruments, such as culinary arts courses or courses involving electronic or mechanical equipment. This is because the proposed FC+GA model currently cannot record students' hands-on activities and outcomes with actual instruments or equipment. Nevertheless, if, in the future, the possibility arises of integrating the equipment or instruments with computers to record students' hands-on activities and outcomes, and if this data could be seamlessly integrated with the provided FC+GA model, this would warrant further research.

However, it is important to acknowledge that students have diverse learning styles and preferences. Consequently, not all students may thrive in this particular learning environment. Future research can explore how the FC+GA model impacts students with diverse learning styles and preferences, enabling further refinements to better support all learners. Additionally, since the experiment covered only three learning units, which may be insufficient to determine the long-term sustainability of its positive effects, further longitudinal research is needed to explore this issue.

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The Past and Present of Instructional Design in Online Learning: Trends and Emerging Directions

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Abstract

With the rapid evolution of online learning, driven by technological advancements and the global transition to distance education during the COVID-19 pandemic, the demand for effective instructional design models has become increasingly critical. This study conducted a systematic mapping analysis of instructional design models tailored for online learning environments to offer a comprehensive classification and evaluation of these models. The analysis delved into the theoretical underpinnings, practical applications, and implications for educators and instructional designers. Models were categorized based on instructional conditions, desired learning outcomes, and theoretical-methodological frameworks, and thus provided a structured approach to understanding their relevance and effectiveness. The findings underscored a paradigm shift from traditional, content-centric frameworks toward adaptive, learner-centered designs that emphasize motivation, social interaction, personalization, and technological integration. Additionally, this study offered practical recommendations for selecting and implementing models that align with the dynamic needs of learners and supported future advancements in instructional design, to foster innovation and effective learning in diverse educational contexts.

Keywords: online learning, instructional design models, systematic review, educational technology

Introduction

Online learning environments have significantly contributed to the rapid rise of distance education, a trend further accelerated by the widespread integration of Internet technologies in education and the transformative impact of the COVID-19 pandemic. The increasing importance and continuous growth of this educational approach have led to the emergence of various expressions, such as e-learning, online education, blended learning, distance education, Web-based learning, and computer-assisted learning. While these expressions emphasize the versatility of online learning, they have also contributed to its conceptual ambiguity. To clarify this, Clark and Mayer (2016) defined online learning as a form of instruction delivered through digital devices to support learning. This definition highlighted the essential role of online learning in modern education and the need for effective instructional design models to optimize its implementation.

As instruction migrates from conventional media to computer-based media, designing online instruction should consider the science of learning, the science of instruction, and the science of assessment (Mayer, 2019). While designing online learning, instructional design and development garners special attention, considering changes in pedagogy, the learning environment, types and levels of courses, student interaction, and course management (Ali, 2003; Carliner, 2004). A pedagogically effective instructional design model for online learning is essential for the development and delivery of engaging online learning environments, otherwise, students will get lost or lose interest. They may not know where to start, what to do, when to communicate, or how to learn. They may be distressed and adrift in poorly designed online learning environments (Chen, 2016).

Instructional Design in Teaching and Learning Processes

Instructional design (ID) is fundamentally the systematic planning of the teaching process using a systems approach. According to Smith and Ragan (2004), it integrates learning and teaching principles into instructional planning, encompassing materials, activities, resources, and assessments. The ultimate goal of instructional design is to enhance and optimize the teaching-learning process. Reigeluth (1983) highlighted the importance of identifying effective methods to achieve desired learning outcomes. ID provides frameworks to align teaching methods with goals. Understanding it requires exploring its theoretical foundations, which have supported its practical application. ID theory has offered guidance to improve learning, emphasizing design principles tailored to different contexts (Reigeluth, 2016).

Prominent ID models include Analysis, Design, Development, Implementation, and Evaluation (ADDIE), Dick and Carey, Assure, Kemp, the Kirkpatrick model, Gerlach-Ely, and Seels and Glasgow model (Şimşek, 2016), each offering unique approaches to instructional processes. Branch and Merrill (2012) noted that these models share common traits, such as being learner-centered, goal-oriented, empirical, and emphasizing teamwork, all aimed at achieving measurable outcomes. In the context of online learning, instructional design must adapt to address the unique challenges and opportunities presented by virtual environments, making it crucial to apply design principles effectively for engaging digital learning experiences.

Issues and Considerations in Instructional Design for Online Learning

Research has highlighted several key concerns in online learning, including insufficient interaction among students, teachers, and content (Falowo, 2007; Li, 2009), lack of feedback (Falowo, 2007), limited administrative support (Bonk, 2001), inadequate student support services (Falowo, 2007;

Galusha, 1997), and ineffective technology use (Falowo, 2007). To address the structural and pedagogical challenges of online learning, instructional design must be specifically adapted to meet its unique demands. Poorly designed online environments can lead to student confusion regarding communication and engagement, resulting in disengagement and reduced interaction (Chen, 2016).

The success of online education programs is closely linked to the application of instructional design principles that cater to specific needs. Therefore, it is essential to adopt ID approaches that fulfill the pedagogical requirements of online education, creating sustainable and engaging learning experiences. Identifying and addressing these challenges proactively, while leveraging new technologies, can minimize issues in the design, implementation, and evaluation of online learning environments, ultimately leading to more effective educational experiences (Chen, 2016; Palloff & Pratt, 2007).

In online teaching contexts, models such as the National Media model, Syracuse model, as well as Gagne-Briggs and Wagner models (Dijkstra et al., 2012) have been more frequently used due to their relevance. However, the structural and pedagogical differences between traditional and online education have necessitated models specifically designed for online learning. Chen (2016) emphasized the importance of effective pedagogical design models for successful online learning environments. Literature reviews have revealed a scarcity of models tailored to online education (Alonso et al., 2005; Chen, 2016; Çınar, 2012; Roblyer, 2015; Siragusa et al., 2007; van Merriënboer & Kirschner, 2018). While these models generally aimed to enhance online learning quality and guide course development, they often overlooked critical elements like student-teacher interaction.

Notable models have included the successive approximation model (SAM; Jung et al. 2019), which simplifies the ADDIE model into three iterative phases: preparation, iterative design, and iterative development, focusing on continuous feedback. The four-component instructional design model (4C/ID) by van Merriënboer and Kirschner (2018) broke down complex skills into four essential components, facilitating effective skill development.

Classification Studies of Instructional Design Models

Instructional design has been fundamentally grounded in two theoretical approaches: the systematic approach and the constructivist approach. The systematic approach viewed instruction as a process with predetermined outcomes, where teaching and learning strategies were designed to achieve specific goals. The constructivist approach emphasized preparing resources and learning processes in real-world contexts, to promote social and experiential learning without strict adherence to predetermined steps (Fardanesh, 2006). Factors such as teacher-centered versus student-centered approaches, the type of educational setting (e.g., school vs. vocational training), the nature of the products being developed (e.g., materials or systems), and the methods employed (e.g., traditional or online education) have been considered.

Numerous instructional design models have been proposed, with several studies comparing and classifying these models: Andrews and Goodson (1980) compared 40 instructional design models across 14 different characteristics, while Edmonds et al. (1994) analyzed several models based on six core features. Beyond studies that explored models according to specific characteristics, there have also been works that categorized ID models into groups, such as Gustafson and Branch (2002) who organized models into three major categories.

As online education expands, refining the models is essential for ensuring effectiveness, engagement, and accessibility while addressing pedagogical and technological concerns. Rapid technological advancements have reshaped online education, introducing tools such as learning analytics, artificial intelligence (AI), and virtual classrooms, which also pose new challenges in maintaining engagement and interactivity. The COVID-19 pandemic accelerated the shift to online learning and highlighted the need for flexible designs that incorporate technological innovations alongside pedagogical strategies supporting self-regulated learning and effective communication. While Abuhassna and Alnawajha (2023) provided a general classification of instructional design models, their work lacked a specific focus on online learning environments. Similarly, Spatioti et al. (2022) examined the ADDIE model but did not deeply explore online dynamics.

Aim of This Study

Instructors in online settings often face challenges in identifying suitable models to guide their planning and teaching processes (Abuhassna & Alnawajha, 2023). This study presented a classification of online instructional design models intended to assist instructors in selecting the most appropriate model for their specific needs. This research was significant as it identified models aligned with the unique requirements of online education and contributed to the existing literature. Unlike previous classification studies, this research categorized instructional design models based on their relevance to instructional situations specific to online learning environments.

To organize the findings systematically, we used Reigeluth's (2016) framework as a roadmap for our research questions. Within this framework, the situational dimension of ID theory consisted of instructional conditions and desired outcomes. Instructional conditions involve the learning environment and materials designed to meet learners' needs (Gagne et al., 2005), and guide the selection of methods to achieve instructional goals (Anderson & Krathwohl, 2001). According to Reigeluth (2016), desired outcomes included effectiveness, efficiency, and appeal—effectiveness measured goal achievement, efficiency assessed resource use, and appeal reflected learner enjoyment. This study addressed these gaps among various ID theories by examining theoretical models and their practical applications. By categorizing models for online contexts and focusing on their application, our intent was to offer a new approach to online instructional design. Thus, this study addressed the following research questions.

1. What instructional conditions do the instructional design models focus on in the context of specific situations?

2. What desired outcomes do the instructional design models focus on in the context of specific situations?

3. What key focus trends have the instructional design models followed over the years?

4. What theories and methods have shaped the development of instructional design models, and how do they differ?

This research aimed to systematically organize knowledge of online ID and enhance understanding of suitable models for online learning environments. The findings offer practical guidance for instructors and designers, while also informing future research, ultimately contributing to the effective design and implementation of online learning environments.

Method

The systematic mapping approach has been used to categorize instructional design models specifically created for online learning environments. Systematic mapping reviews have been increasingly recognized as effective methods for organizing a research area, outlining the breadth of available evidence, and pinpointing gaps in the existing literature (James et al., 2016). In this context, systematic mapping has facilitated the exploration of online instructional design models across a wide spectrum, allowing for the simultaneous evaluation of their theoretical foundations and practical applications. Our mapping review consisted of three key methodological steps.

1. Define search terms and evaluation criteria
2. Select and screen articles based on the evaluation criteria
3. Extract data, then analyze, and map the scope and distribution of the current evidence.

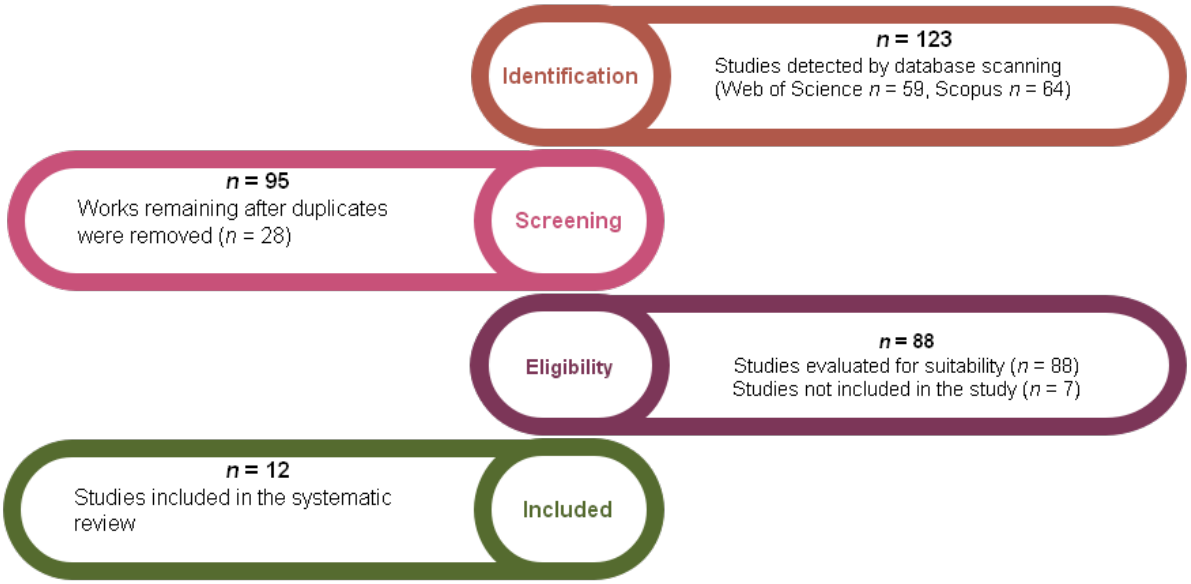
Search Strategy

The inclusion criteria were defined prior to conducting the literature search. Only peer-reviewed full articles written in English, offering a framework for instructional design in online learning, were considered. An iterative scoping process as well as consultation within the author group were conducted to develop the search strategy and identify appropriate search terms relevant to the research question. The following search terms were used: (a) instructional design; (b) online learning; (c) instructional systems; (d) distance learning; (e) instructional design with online learning or distance education or e-learning; (f) instructional design models with online learning or distance education or e-learning; (g) instructional models with online learning or distance education or e-learning; (h) instructional systems with online learning or distance education or e-learning; and (i) systematic mapping.

The literature search was performed in the Web of Science and Scopus electronic databases. Additionally, reference lists from the included studies were reviewed during data extraction to identify any relevant studies missed by the electronic searches. The electronic database search covered the period from 2002 to 2024, while the screening of reference lists continued until the end of January 2024. The studies retrieved were imported into Mendeley reference management software, cataloged with key bibliographic information, and exported to an Excel database. An exhaustive search of all relevant publications was conducted following guidelines based on preferred reporting items for systematic reviews and meta-analyses (PRISMA; Liberati et al., 2009; Moher et al., 2015) as depicted in Figure 1.

Figure 1

An Overview of the Search Protocol Following the PRISMA Guidelines



In the PRISMA flowchart presented in Figure 1, during the initial identification phase, two different databases (Web of Science and Scopus) were searched, resulting in a total of 123 studies. The distribution of the studies was as follows: 59 from Web of Science and 64 from Scopus. During the screening phase, duplicate studies were removed, and after eliminating 28 duplicates, 95 studies remained for evaluation. This process was carried out to prevent the inclusion of the same study multiple times.

Eligibility Criteria and Selection Process

The article selection process was carefully structured, with clear exclusion criteria and an evaluation procedure to ensure that only relevant and high-quality studies were included. Initially, only full-text, peer-reviewed articles published in English journals were considered for inclusion. Conference proceedings, book chapters, reports, and publications that consisted solely of abstracts were excluded from the review. Additionally, studies that did not provide full-text access were excluded, ensuring that only articles with comprehensive details were considered. The defined time restrictions were applied during the selection process. The evaluation was carried out independently by three researchers, each assessing the articles based on the predefined criteria. In cases where there was disagreement among researchers, a fourth researcher's opinion was sought to ensure consensus.

After evaluating a total of 95 studies, 7 were excluded because they did not meet the eligibility criteria. As one of the main selection criteria was that the studies must either propose, classify, or analyze an instructional design model within the context of online learning, articles that focused on general pedagogical approaches or face-to-face education models were excluded. These were deemed irrelevant to the specific focus of the review, resulting in the exclusion of 76 studies.

Finally, 12 studies were selected for inclusion in the systematic mapping process (Appendix 1). These studies were deemed to meet the eligibility criteria and were relevant to the research questions. The eligibility criteria were carefully designed to maintain the focus of the review and ensure that it was

conducted systematically, drawing on the highest quality studies that were most aligned with the objectives of the research.

Findings

This section presents a comprehensive analysis of the findings derived from the systematic mapping of instructional design models within online learning environments. The primary aim of the findings was to address the research questions, elucidating how these models aligned with instructional conditions, desired outcomes, and theoretical trends. Through an in-depth examination of selected models, the findings revealed critical shifts in instructional design paradigms—from rigid, content-driven approaches to adaptive, learner-centered frameworks that prioritize engagement, interaction, and technological integration.

By systematically categorizing and evaluating these models, the findings contributed to a nuanced understanding of the evolving dynamics in online education. This analysis not only highlighted the theoretical underpinnings of each model but also their practical applications, enabling educators and instructional designers to better address the challenges unique to digital learning environments. Furthermore, these insights formed a foundation for advancing theoretical discourse and informing the development of more effective and responsive instructional strategies.

Overview of Eligible Studies

This section provides an overview of various online instructional design models identified through systematic mapping analysis. These models have been developed to meet the diverse needs of online learning environments and offer clear frameworks for effective teaching and learning. Each model was grounded in distinct instructional conditions and theoretical foundations, addressing key elements of the online learning process, such as fostering student engagement and ensuring the efficient use of technology and resources. Our analysis demonstrated how these models used various strategies to enhance learning experiences and meet the evolving needs of modern learners.

The unit-module-topic (U-M-T) approach by Simonson and Schlosser (2004) reviewed best practices in distance education and presented an easy-to-implement framework. It divided a course into units, modules, and topics, each linked to organizational, assessment, content, and teaching guidelines. Similarly, Alonso et al.'s (2005) e-learning instructional design model emphasized individualized learning, guiding educators to create environments that allowed students to progress at their own pace. This model aimed to foster effective learning environments and included seven phases: (a) analysis, (b) design, (c) development, (d) implementation, (e) execution, (f) evaluation, and (g) review.

The T5 model by Salter et al. (2004), which adopted a collaborative-constructivist approach, was intended to help instructors design online courses by incorporating feedback and interaction to encourage active learning. Likewise, the Instructional Design for Online Learning (IDOL) model (Siragusa et al., 2007) included analysis, strategy, development, and evaluation phases, with a focus on developing effective e-learning environments based on surveys of students and teachers. The e-learning system model emphasized the interaction among pedagogy, technology, teaching, and learning, highlighting the importance of feedback and the effective use of technology to enhance learning outcomes (Chen & Chuang, 2008).

The Instructional Design for Electronic Learning (IDEL) model by Zimnas et al. (2009), based on the ADDIE framework, supported educators in creating and managing online courses, focusing on technology and resource reuse to improve both effectiveness and efficiency. The Rapid Instructional Design (RID) model by Kuciapski (2015), in turn, sought to minimize costs and time in developing e-learning courses, promoting resource efficiency while maintaining quality. The E-Learning Engagement Design (ELED) model by Czerkawski and Lyman (2016) was drawn from a comprehensive literature review to enhance student engagement and improve learning performance, linking student engagement directly to effective outcomes.

Models such as Identify, Choose, Create, Engage, Evaluate (ICCEE) by Chen (2016) provided guidance for creating online courseware, emphasizing student engagement and motivation. The Predict, Observe, Explain, Evaluate (POEE) model by Al Mamun et al. (2020), rooted in constructivist learning theories, presented a strategy for self-regulated learning in online environments, with evaluation as a key component. The e-neuroanatomy learning conceptual framework (eNEUROANAT-CF) model by Javaid et al. (2021) offered principles for neuroanatomy e-learning, focusing on cognitive load, motivation, and active learning to improve student comprehension. Lastly, the 6P4C (the 6P's: the participants (learners), platforms used for teaching/learning, a well-developed teaching plan, safe spaces for intellectual play, engaging and inclusive presentations and regular checking of the pulse of learners and the tools being used; 4C's; deliberate fostering of civility, communication, collaboration and community-building) model offered support to nurse educators, addressing communication and interaction issues in e-learning while tackling challenges in collaborative learning and socialization (Byrne, 2023).

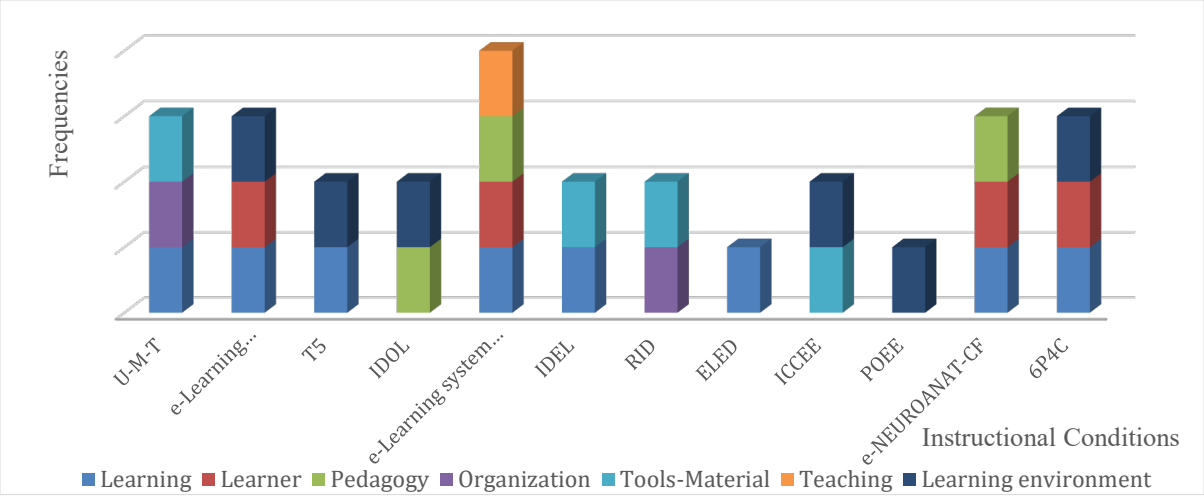
It has been observed that the analysis of the online instructional design models provides valuable insights and practical guidance for course designers, educators, and instructional developers. Each model, with its unique approach and theoretical foundation, offers effective tools and strategies for crafting engaging and successful online learning experiences. Together, these models have contributed to the continuous improvement of online education by addressing various critical aspects of the learning process. This section presents the findings regarding the instructional conditions that each of the online teaching design models examined above is based on, within specific contextual situations. The answers to the research questions are detailed systematically, focusing on each model's instructional conditions, desired outcomes, theoretical foundations, and trends over the years.

Instructional Conditions the ID Models Focus on in the Context of Specific Situations

Figure 2 provides a systematic overview of the key components emphasized in various instructional design models, focusing on teaching conditions such as (a) learning, (b) learner, (c) pedagogy, (d) organization, (e) tools/materials, (f) teacher, and (g) learning environment. These elements play a significant role in shaping the design of each model.

Figure 2

Instructional Conditions Underlying Selected ID Models



Upon reviewing the data, it was clear that many of the models had adopted a learner-centered approach, placing particular emphasis on the learner and the learning process. Models such as the e-learning instructional design model, e-learning system model, e-NEUROANAT-CF, and 6P4C were particularly notable for prioritizing these two fundamental dimensions. Moreover, some models placed a stronger focus on pedagogical and organizational conditions. For instance, the U-M-T, IDOL, e-learning system, RID, and e-NEUROANAT-CF models highlighted these aspects more prominently, while other models did not prioritize them. In terms of tools and materials, the U-M-T, IDEL, RID, and ICCEE models emphasized the importance of these components in the teaching process. Similarly, the e-learning instructional design, IDOL, T5, ICCEE, POEE, and 6P4C models underscored the significance of the learning environment, recognizing its critical role in e-learning. Lastly, the e-learning system model stood out with its comprehensive approach, integrating multiple teaching conditions into its design. This model advocated for a multidimensional perspective in e-learning, addressing various aspects of the instructional process.

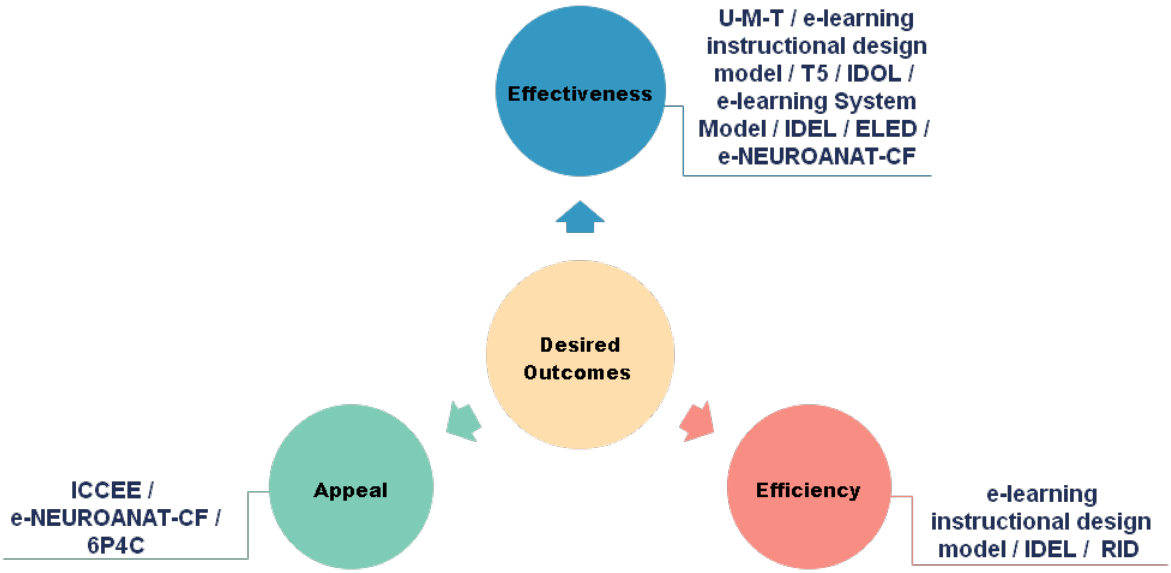
Overall, the analysis of the instructional design models, including the Unit-Module-Topic (U-M-T), e-learning, Tasks, Tools, Tutorials, Topics, Teamwork (T5), IDOL, and others, highlighted a diverse range of approaches and emphases on various teaching conditions. While many models focused on the learner and learning process, others emphasized pedagogical, organizational, and material conditions, underscoring the importance of a comprehensive and multidimensional approach in designing effective e-learning environments. Collectively, these models offered valuable insights for creating engaging and efficient online learning experiences.

Desired Outcomes the ID Models Focused on in the Context of Specific Situations

As presented in Figure 3, all models except RID, ICCEE, POEE, and 6P4C focused on the dimension of effectiveness. Additionally, the e-learning instructional design, IDEL, and RID models emphasized the dimension of efficiency. On the other hand, the dimension of appeal was the focal point of the ICCEE, e-NEUROANAT-CF, and 6P4C models. The desired outcomes that the ID models focused on are depicted in Figure 3.

Figure 3

The Desired Outcomes Targeted by Selected ID Models



Overall, it can be observed that each model prioritized one or more dimensions differently. In particular, the e-learning instructional design, IDEL, and RID models adopted a multidimensional approach, addressing both effectiveness and efficiency, while the e-NEUROANAT-CF model combined effectiveness and appeal. In contrast, other models offered a more specialized structure by focusing on specific objectives.

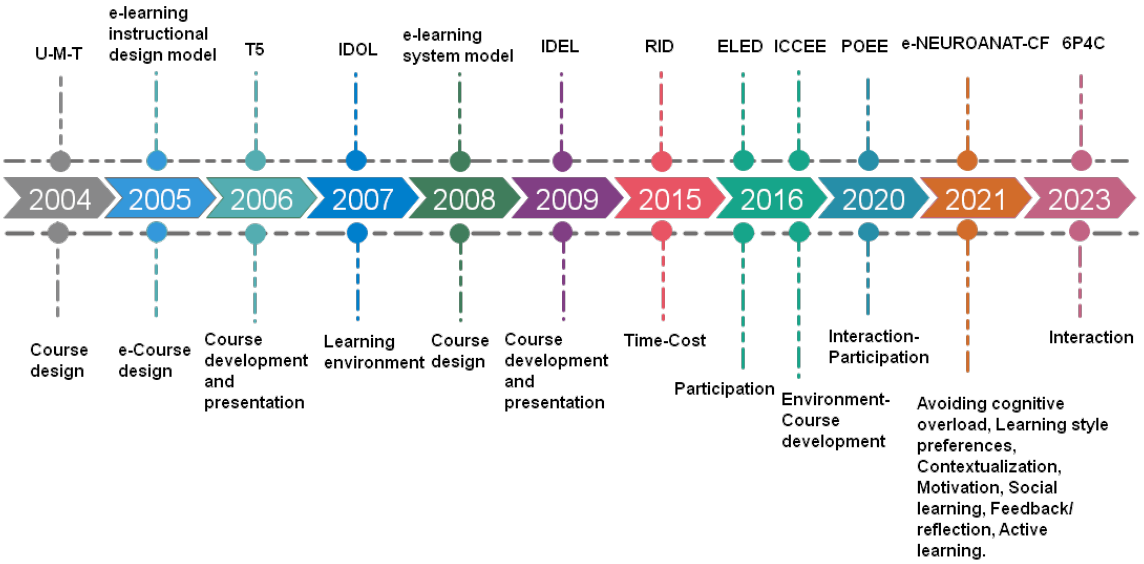
Key Focus Trends the ID Models Have Followed Over the Years

As shown in Figure 4, models developed since 2004 have focused on various areas, such as design, presentation, participation, and interaction within the learning and teaching processes. Early models (U-M-T, e-learning instructional design, T5, and e-learning system) primarily concentrated on course design, e-course development, and delivery. However, later models showed both a broader and deeper focus. Models developed after 2020 not only prioritized instructional design but also emphasized learner-centered approaches and pedagogical-psychological aspects like motivation, social learning, and contextualization. For instance, the e-NEUROANAT-CF model addressed cognitive overload, motivation, social learning, feedback, and active learning, offering a comprehensive perspective. Similarly, the 6P4C model focused on interaction, aligning with modern learning approaches.

Some models, such as IDEL, focused on course development and delivery, while RID emphasized time and cost, and ICCEE and POEE highlighted participation, course development, and interaction. The e-NEUROANAT-CF model, with its broad scope, sought to enhance both instructional design and the learning experience, reflecting a shift from content-centered to more holistic learning approaches in e-learning models. The trends focused on by ID models over the years are shown in Figure 4.

Figure 4

Trends ID Models Have Focused on Over the Years



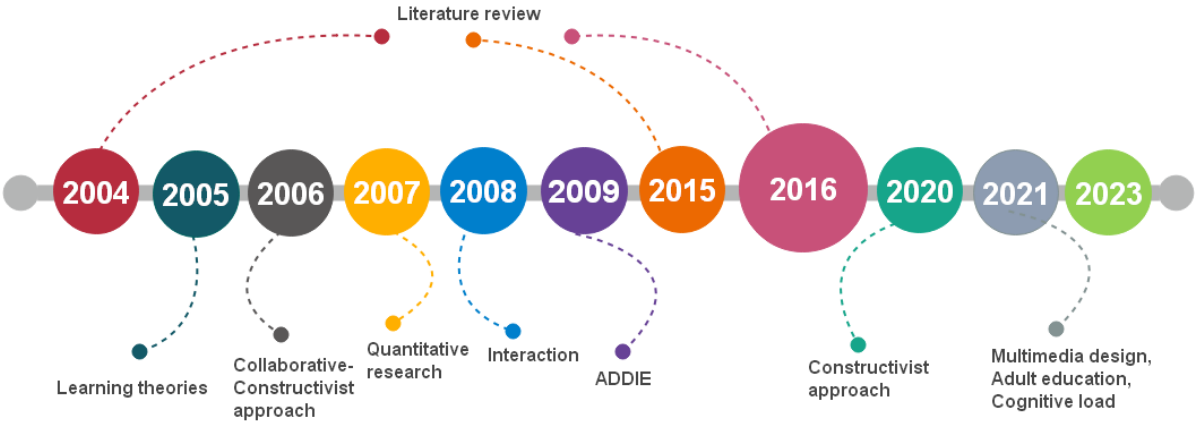
Overall, the data suggested that instructional design models have become more complex and learner-focused over time. Early models concentrated on design and content, while later models placed greater emphasis on aspects like motivation, participation, and social learning.

Theories and Methods That Have Shaped the Development of ID Models

An examination of Figure 5 reveals that since 2004, a more systematic approach to e-learning design has been adopted, leading to the development of significant models based on various theoretical and methodological perspectives. This reflects the rapid rise in the significance of e-learning technologies and applications in both academic and practical domains. In the development of these models, methods like literature reviews and content analysis have been commonly used (e.g., U-M-T, RID, ELEC, ICCEE). Additionally, learning theories, collaborative-constructivist approaches, and frameworks such as interaction and feedback have been foundational in shaping these models, showcasing the integration of both theoretical and empirical strategies in e-learning design.

Figure 5

The Theories and Methods Behind Selected ID Models



Over the years, instructional design models have evolved, drawing on various theories and methods. Initially rooted in behaviorist approaches, the models have shifted towards constructivist and learner-centered frameworks, integrating social learning, motivation, and cognitive theories. These theoretical foundations have shaped how each model structures and implements learning experiences, reflecting an ongoing adaptation to new research and trends in education.

The Evolution of Online Instructional Design Models

An examination of how instructional design models have evolved based on teaching conditions revealed that the e-learning system model stood out for addressing many of these conditions, focusing on both the learner and the environmental and pedagogical aspects of the teaching process. This provides a balanced and flexible structure for instructional processes. Models like T5, IDEL, and RID, which focused on specific conditions such as learner needs, pedagogical structures, or material use, enabled the development of customized solutions. However, this focus may risk neglecting other influencing factors in the learning process. While many models emphasized learning and learning environment conditions, the roles of organization and teachers have been less prominent in some models, suggesting that technology has often taken precedence over human factors in online learning design. The rapid expansion of online learning has made the design of learning environments a critical component. Increased attention to these conditions in models like the e-learning instructional design model, T5, and IDOL supported this trend.

Overall, each model prioritized one or more desired outcomes. Notably, models such as the e-learning system model adopted a multidimensional approach, addressing effectiveness, efficiency, and engagement. In contrast, other models focused on specific objectives, offering more specialized structures. This diversity provides flexibility in selecting instructional design models for various learning and teaching contexts. The findings suggested that instructional design models have become more complex and user-centered over time. Early models focused on design and content development, while later models emphasized learner-centered aspects like motivation, engagement, and social learning, indicating an evolution in response to changing needs in e-learning processes.

The methods used in developing these models showed that a wide range of paradigms have been adopted in e-learning design. For instance, the U-M-T (Simonson & Schlosser, 2004) model was based on literature review within a general framework, while the e-learning instructional design model (Alonso et al., 2005) was directly linked to learning theories. The POEE (Al Mamun et al., 2020) model was built on a constructivist approach, reflecting the increasing emphasis on student-centered learning in recent years. The e-NEUROANAT-CF (Javaid et al., 2021) model represented a multidisciplinary approach, combining multimedia design, adult education, and cognitive load theory to address contemporary learning needs. The 6P4C model (Byrne, 2023) emphasized the continuity of innovative approaches.

The findings indicate that online learning design has integrated various disciplines and is continually evolving. Both theoretical models and practical applications have played a significant role in this process. In particular, constructivist and interaction-based approaches became more dominant after the 2010s, reflecting contemporary e-learning design progresses with a student-centered, technology-supported, and active participation-driven approach.

Discussion

The development of instructional design models has been influenced by changing priorities and evolving pedagogical approaches over time. The theoretical evaluations that have emerged in this process have undoubtedly contributed to the evolution of instructional designs. For instance, Clark and Mayer (2003) emphasized the importance of e-learning tools for effective learning outcomes. Jonassen (2004) highlighted learner-centered environments for better learning. Vygotsky's (1978) theory stressed the teacher's role in guiding collaborative learning. Hattie and Timperley (2007) showed the importance of feedback in learning outcomes. Bates (2014) focused on time and cost efficiency in instructional design. Hrastinski (2009) demonstrated that increased engagement improved learning outcomes. Mayer's (2024) cognitive load theory stressed the need for engaging, interactive learning materials.

Previous review studies on instructional design have predominantly focused on general pedagogical models or traditional educational settings, with limited consideration of the distinct challenges and dynamics of online learning environments (Abuhassna & Alnawajha, 2023; Spatioti et al., 2022). These studies often provided broad categorizations or examined widely recognized frameworks, such as ADDIE, without adequately addressing their adaptation to the complex requirements of virtual learning spaces.

Reigeluth's ID theory emphasized the importance of considering the conditions of instruction, such as learner characteristics, task characteristics, and environmental characteristics, when designing effective instructional strategies (Bannan-Ritland, 2008; Tennyson, 2010). This aligned with the findings from our review, which suggested that instructional design models have become more complex and user-centered over time, shifting from a focus on design and content development to emphasizing learner-centered aspects like motivation, engagement, and social learning (Kulkarni et al., 2013; Majid & Stapa, 2017; Wang et al., 2022). Our study distinguished itself by systematically mapping instructional design models specifically developed for online leaerning and thus integrated contemporary technological advancements and pedagogical trends. Grounded in Reigeluth's (2016) instructional design theory, it has presented a nuanced classification that accounted for instructional

conditions and desired outcomes unique to digital environments. Furthermore, this research not only evaluated theoretical foundations but also incorporated innovative practices, including learner-centered designs, cognitive load management strategies, and mechanisms for fostering social interaction. By addressing these gaps in innovative practices, this study has contributed a comprehensive, practice-oriented framework aligned with the evolving demands of modern online education.

The e-learning system model, which addressed multiple teaching conditions and focused on both the learner and the environmental as well as pedagogical aspects of the teaching process, reflected Reigeluth's emphasis on considering the conditions of instruction (Warburton & Perry, 2020). In contrast, models like T5, IDEL, and RID, which focused on specific conditions such as learner needs, pedagogical structures, or material use, aligned with Reigeluth's (2016) idea of designing instructional strategies based on the specific conditions of the learning environment (Bliuc & Ellis, 2017).

Reigeluth's theory (2016) also highlighted the importance of considering the desired outcomes of instruction, as reflected in our findings that each instructional design model prioritized one or more desired outcomes (Bliuc & Ellis 2017). The e-learning system model's multidimensional approach, which addressed effectiveness, efficiency, and engagement, aligned with Reigeluth's emphasis on considering multiple outcomes (Warburton & Perry, 2022).

The increased attention to learning and learning environment conditions in models like e-learning instructional design, T5, and IDOL supported Reigeluth's (2016) notion that the design of learning environments is a critical component in the digital age (Bliuc & Ellis, 2017; Surahman et al., 2019; Warburton & Perry, 2022). However, our finding that the roles of organization and teachers are less prominent in some models suggested that technology has often taken precedence over human factors, which may not be fully aligned with Reigeluth's emphasis on considering all aspects of the instructional conditions (Adnan & Anwar, 2020).

The diversity of methods used in the development of instructional design models, including constructivist and interaction-based approaches, reflected Reigeluth's (2016) view that instructional design should be informed by a variety of theoretical perspectives and empirical evidence (Ayumba, 2023; Dennick, 2016; Roh, 2015). Staying current with theoretical approaches and integrating new technological advancements, as suggested by the findings, aligned with Reigeluth's emphasis on the continuous evolution of instructional design theory and practice (Kirkwood, 2014).

The findings from the review largely aligned with Reigeluth's ID theory (2016), particularly the importance of considering the conditions of instruction, desired outcomes, and need for a multifaceted and evidence-based approach to instructional design. However, the findings also suggested that the role of human factors in online learning design may be an area that requires further attention in the context of Reigeluth's theory.

In summary, this study examined the diversity and evolution of instructional design models over time, offering a longitudinal perspective rarely explored in prior reviews. By analyzing both foundational and contemporary approaches, it highlighted developmental trajectories and their implications for online learning contexts. Key factors such as (a) learning theories, (b) instructional tools, (c) organizational structures, (d) interaction strategies, and (e) learner motivation were critically evaluated to provide a holistic understanding of instructional design. Moreover, the study integrated emerging pedagogical

innovations, such as constructivist strategies, social learning mechanisms, and multimedia-enhanced designs, reflecting the current state and future directions of the field. In doing so, it advanced beyond earlier works, offering a forward-looking and multifaceted perspective on instructional design for online learning environments.

Limitations

This study's limitations included the scope of the literature reviewed, data source constraints, and the issue of generalization. The analyzed models may not represent all online instructional design models, and some lesser-known or non-English models may have been missed. The methods used (i.e., literature review and content analysis) were dependent on keywords and database coverage, so results may vary with different search terms or databases. Technological advancements might also impact the relevance of the findings as new models emerge. Additionally, while systematic mapping was used, model categorization may have involved subjective interpretation. A more detailed model comparison would require a different methodology. Recognizing these limitations is essential for accurate interpretation and to guide future research.

Recommendations

Future studies could consider rapid changes in technology and the diverse learning needs of students to examine the design of new models integrated with innovative technologies such as artificial intelligence, augmented reality, and virtual reality. Additionally, exploring the impact of existing models across different disciplines could expand the application areas of these models. For example, studies focused on science, social sciences, or vocational education could provide a more comprehensive evaluation of the models. Furthermore, longitudinal studies examining the long-term effects of online instructional design models on learning outcomes could be conducted. Such research would make valuable contributions to assessing the sustainability and retention of learning. Future research has the potential to bring new perspectives to the field of online instructional design from both theoretical and practical standpoints.

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Appendix

Summary of Instructional Design Models: Sources and Characteristics

Source	Online ID Model	Instructional conditions	Desired outcomes
Al Mamun, M. A., Lawrie, G., & Wright, T. (2020). Instructional design of scaffolded online learning modules for self-directed and inquiry-based learning environments.	POEE	Learning environment	
Alonso, F., López, G., Manrique, D., & Viñes, J. M. (2005). An instructional model for Web-based e-learning education with a blended learning process approach.	e-Learning instructional design model	Learning Learner Learning environment	Effectiveness Efficiency
Byrne, M. (2023). The 6P4C model: An instructional design conceptual model for delivery of e-learning.	6P4C	Learning Learner Learning environment	Appeal
Chen, K. C. & Chuang, K. W. (2008). Building an e-learning system model with implications for research and instructional use.	e-Learning system model	Learning Learner Pedagogy Teaching	Effectiveness
Chen, L. L. (2016). A model for effective online instructional design.	ICCEE	Tools/Material Learning environment	Appeal
Czerkawski, B. C., & Lyman, E. W. (2016). An instructional design framework for fostering student engagement in online learning environments.	ELED	Learning	Effectiveness
Javaid, M. A., Schellekens, H., Cryan, J. F., & Toulouse, A. (2021). eNEUROANAT-CF: A conceptual instructional design framework for neuroanatomy e-learning tools.	eNEUROANAT-CF	Learning Learner Pedagogy	Appeal Effectiveness
Kuciapski, M. (2015). Effective management of e-learning projects with limited resources supported by the integration of rapid instructional design concept.	RID	Organization Tools/Material	Efficiency

Salter, D., Richards, L., & Carey, T. (2004). The 'T5'design model: An instructional model and learning environment to support the integration of online and campus-based courses.	T5	Learning Learning environment	Effectiveness
Simonson, M., & Schlosser, C. (2004). We need a plan: An instructional design approach for distance education courses.	U-M-T	Learning Organization Tools/Material	Effectiveness
Siragusa, L., Dixon, K. C., & Dixon, R. (2007). Designing quality e-learning environments in higher education.	IDOL	Pedagogy Learning environment	Effectiveness
Zimnas, A., Kleftouris, D., & Valkanos, N. (2009). IDEL: A simple instructional design tool for e-learning.	IDEL	Learning Tools/Material	Effectiveness Efficiency

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A Systematic Literature Review on Trends in the Use of Science Experiments in Online Learning Environments

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Abstract

Experiments are considered to be essential components of science learning. This research aimed to investigate trends in the use of science experiments in online learning. A systematic literature review was carried out, with data sourced from the Scopus and Google Scholar databases. The reviewed documents were journal articles published between 2015 and 2022, with the keywords "science practicum," "science experiments," "distance learning," "online learning," and "hands-on science." Using Harzing's Publish or Perish software, 970 articles were found but only 32 were reviewed. The literature review followed a procedure adapted from the preferred reporting items for systematic reviews and meta-analyses (PRISMA), with articles reviewed based on predetermined criteria such as the year of publication, article source, practicum topics, research subjects, assessment methods, technology, and experiment design in online learning. In the results, various designs for online learning models, the technology used in science experiments, topics addressed, and appropriate assessment methods were identified. Trends included the extensive use of interactive simulation models in online science experiments, the use of virtual laboratories as a crucial technology, and the use of experiment reports to assess students. The analysis showed a sharp increase in the number of publications since the pandemic (2020) and that online science experiments might be carried out effectively by considering the characteristics of the material, matching the science curriculum, and using assessments that fulfill the objectives of science experiments.

Keywords: experiment report, online learning, science experiment, simulation, virtual laboratory

Introduction

COVID-19 has changed the learning paradigm from face-to-face to online formats (Andrews et al., 2020; Manca et al., 2021; Salta et al., 2022). Research has shown that the pandemic has presented substantial challenges for students in accessing science laboratories at various universities (Marinoni et al., 2020). The challenges include designing science laboratory experiments, maintaining students' motivation, and making efficient use of online learning platforms (Müssig et al., 2020) and technology (Gya & Bjune, 2021). This transition from traditional face-to-face to online formats has required significant adaptation from teachers, particularly in conducting laboratory experiments and engaging students in a virtual environment (Kier & Johnson, 2022).

Experiments are considered to be essential components of science learning (Ha & Kim, 2020; Hofstein & Lunetta, 2004; Mamlok-Naaman & Barnea, 2012). They improve students' confidence, scientific reasoning (Beck & Blumer, 2012), conceptual understanding (Srisawasdi & Kroothkeaw, 2014), scientific argumentation writing (Kapici et al., 2022), experimental design skills (Baker & Cavinato, 2020; Blumer & Beck, 2019), critical thinking, creativity (Malik & Ubaidillah, 2020), collaboration, and communication skills (Malik & Ubaidillah, 2021). Given their importance in developing these skills, science experiments remain a vital aspect of science education.

During COVID-19, science experiments carried out at home improved students' conceptual understanding and laboratory skills, as well as provided meaningful laboratory experiences. Students also showed greater interest in experimental procedure design (Andrews et al., 2020) and problem-solving (Mistry & Shahid, 2021). Home-based experimental activities prioritize inquiry-based learning, allowing students to develop practical skills (Baker & Cavinato, 2020). However, these studies contradict Foo et al., (2021) whose work suggested that the proficiency level of students who engaged in problem-based distance learning was lower than those who participated in problem-based face-to-face learning. While home-based science experiments during the pandemic have shown potential to improve a variety of educational outcomes, the results validate the ongoing debate about the effectiveness of online learning compared to traditional face-to-face learning.

Research related to online learning has explored the use of virtual experiments using augmented reality (AR) within an inquiry and discovery method, which has been proven to increase students' motivation to conduct experiments (Müssig et al., 2020). Virtual laboratory experiments also improve problem-solving skills (Prahani et al., 2020) and can be as effective as face-to-face activities (Hamed & Aljanazrah, 2020). Furthermore, virtual laboratories enable online practicum sessions, improve multiple representation skills, and assist the process of receiving information by students (Widarti et al., 2021). As a result, virtual laboratory activities offer a viable alternative to learning science at home (Gya & Bjune, 2021).

Previous reviews related to online learning have examined a variety of topics, including online teaching and learning (Martin et al., 2020), meaningful learning about e-learning environments (Tsai, Shen, & Chiang, 2013), problem-based learning in e-learning contexts (Tsai & Chiang, 2013), game-based learning in online settings (Tsai & Fan, 2013), and self-regulated learning in online environments (Tsai, Shen, & Fan, 2013). Furthermore, research has examined the use of tools and strategies in online learning (Vijayan, 2021) and the trend in using of platforms such as Google Classroom and WhatsApp in online learning (Nasution, 2022). However, further investigations are needed to examine the design

of science experimental learning, subject matter, technology, and practical assessments in online learning in order to determine best practices in conducting experiments in online learning.

Literature review research has been conducted by Faulconer and Gruss (2018) by analyzing articles from 1999–2017 that discuss aspects of non-traditional laboratory terminology, non-traditional laboratory learning outcomes, and the benefits of traditional and non-traditional laboratories. However, there is a pressing need for systematic review research to provide comprehensive information on the variety of technology, instructional designs offered in non-traditional laboratories, the science materials taught, and the types of non-traditional science laboratory assessments. Our systematic literature review is crucial in filling these gaps and advancing our understanding of science education.

Theoretical Framework

Science Experiments in Online Learning

The COVID-19 pandemic and the development of information technology have changed the learning paradigm from face-to-face to online formats (Hasani et al., 2022). During the pandemic, some laboratory activities were carried out at home by using available materials without special equipment (Andrews et al., 2020). Alternative remote laboratory learning, such as hands-on activities at home, might be beneficial for students when carefully designed (Accettone, 2022). Students could conduct science experiments at a low cost, with the majority choosing hands-on activities over simulators or using experimental data from previous years (Larriba et al., 2021). During the pandemic, students remotely carried out science practicum activities through authentic and inclusive hands-on experiences that could improve scientific research skills (Schnell et al., 2021). Inquiry-based home experiments provided an authentic learning experience, increased practical student engagement, motivated learning, and enhanced curiosity (Gya & Bjune, 2021).

Online science experiments had been implemented before the COVID-19 pandemic as an alternative method for education. One of the important reasons for online learning is to provide flexibility and accessibility for students who cannot attend face-to-face learning. For example, Nandana and de Mel's (2016) study showed that an integrated laboratory experiment setting could strengthen engineering education in the distance mode. Domínguez et al. (2018) found that a virtual experiment setting could complement a traditional laboratory effectively. Through a randomized control study, DeBoer et al. (2019) found that using home laboratory kits in online courses could improve students' attitudes and achievements. At the same time, Seifan et al. (2019) found that virtual visits could be an effective introductory tool before actual visits in chemical engineering education. In addition, Donkin et al. (2019) stated that video feedback and e-learning improved laboratory skills and student engagement in medical laboratories. Based on this evidence, online science learning before the pandemic had shown potential to improve the quality of education by using digital technology. However, implementation challenges and the need for adequate infrastructure remain.

Online learning uses Internet technology that connects teachers and students, enabling learning without being limited to a physical location. Online or digital learning aims to support learning (Mayer, 2019). Teachers and students interact through online learning platforms, including the learning management system (LMS), video conferences, and discussion forums. Technologies used in online learning include multimedia on the Internet, streaming video, streaming audio, push technologies and

data channels, Web whiteboarding, audio chat and voice-over-Internet protocol, and instant messaging (McGreal & Elliott, 2008). Meanwhile, online experimental learning technology can be categorized as augmented reality and virtual reality (Mayer, 2019; Sajka & Rosiek, 2021), remote laboratory (Ma & Nickerson, 2006), virtual laboratory (Ma & Nickerson, 2006; Potkonjak et al., 2016; Wieman et al., 2008), and computer simulation (Oliveira et al., 2019).

Several criteria were important for conducting experiments, including the quality of the experimental results, laboratory logistics, and feasibility, as well as students' learning and achievement (Andrews et al., 2020). Technological integration was required for online practicum activities. For instance, science practicum activities used smartphones (Schmuck et al., 2022) in conjunction with a Google Meet video conference, and assessments based on reports that included headings such as introduction, experimental procedures, results and discussions, conclusions, as well as literature references (Larriba et al., 2021). Online learning of science experiments was carried out through video tutorials and live virtual sessions (Schnell et al., 2021). Research indicated that online experiments might be used efficiently to teach physics (Setiaji & Santoso, 2023). However, students believed that distance practicum learning through videotapes and online simulations was less valuable than direct laboratory experiences (Accettone, 2022).

Assessment is one of the important elements in online experiments since it serves as a benchmark for students' success. The instruments used in online practicums have included practicum reports (Gya & Bjune, 2021), concept-understanding tests (Müssig et al., 2020), pre-laboratory assignments (Brevik et al., 2021), feedback (Donkin et al., 2019), quizzes, and performance assessments (Hamed & Aljanazrah, 2020). A key challenge for teachers has been to develop the right instrument to assess students' abilities in practicums.

Methodology

This research aimed to conduct a systematic review to synthesize the use of online experiments in science learning. The review examined the design of online experimental learning, the technology adopted, and the materials and assessments used in online experiments. The purpose of the literature review was to answer the questions that follow.

1. How were science experiments designed for online learning?
2. What technologies were used in science experiments in online learning?
3. What subject matter is practiced in science experiments in online learning?
4. What was the form of assessment in science experiment activities during online learning?

Inclusion and Exclusion Criteria

The inclusion criteria for the eligible articles included: (a) articles discussing online science experiments; (b) empirical articles using quantitative, mixed, and qualitative methods; (c) articles written in English; (d) articles published in peer-reviewed journals; and (e) articles published between 2015 and 2022. The exclusion criteria were: (a) non-empirical articles such as meta-analyses, literature

reviews, and conceptual papers; (b) conference papers, books, book chapters, technical reports, editorials, and commentaries; and (c) articles not written in English.

Search Databases, Strategies, and Process

The research used data obtained from the Scopus and Google Scholar journal indexing engines. Articles on the indexed database were published between 2015 and 2022, with keywords including "science practicum," "science experiments," "distance learning," "online learning," and "hands-on science." Using the Publish or Perish software (https://harzing.com/resources/publish-or-perish), 970 articles were found, and only 32 were selected for analysis. Data meeting the inclusion criteria were coded for further analysis. The data analysis focused on the design criteria of the science practicum, the technology used, practicum assessment, and practical topics/materials in online learning. Table 1 provides details about the various sources used in our analysis.

Table 1

Distribution of Analyzed Articles by Source and Journal Ranking

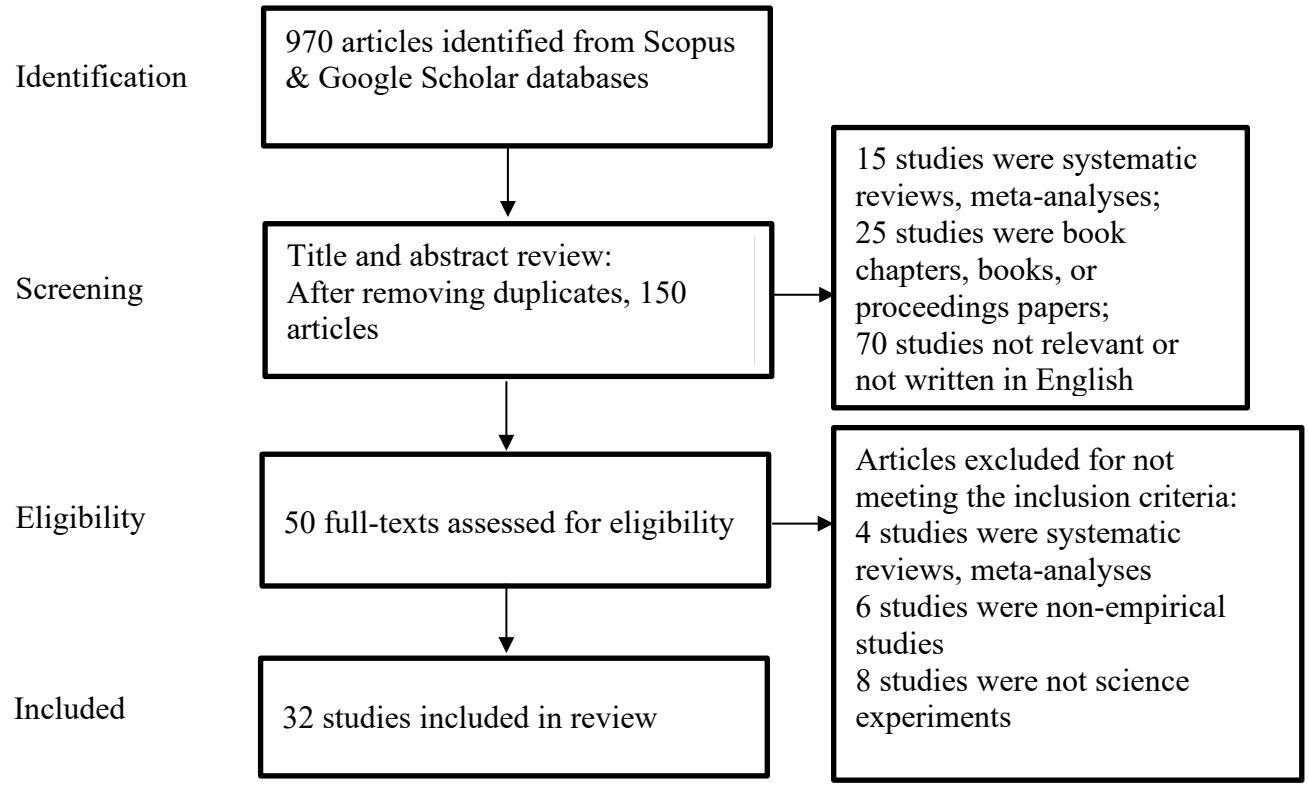
Journal	Quartile (SJR 2023)	*n*
Journal of Chemical Education	Q2 (0.51)	10
Physics Education	Q2 (0.39)	4
Biochemistry and Molecular Biology Education	Q3 (0.38)	3
Education for Chemical Engineers	Q1 (0.93)	3
TEM Journal	Q3 (0.24)	2
Ecology and Evolution	Q1 (0.86)	2
Natural Sciences Education	Q2 (0.39)	1
Journal of Research on Technology in Education	Q1 (0.87)	1
Journal of Information Technology Education: Research	Q1 (0.72)	1
International Journal of Science and Mathematics Education	Q1 (1.04)	1
Education and Information Technologies	Q1 (1.30)	1
European Journal of Engineering Education	Q1 (0.77)	1
BMC Medical Education	Q1 (0.74)	1
Asian Association of Open Universities Journal	Q1 (0.62)	1

Note. SJR = scientific journal ranking.

For our research method, we adopted a literature review combined with a modified systematic review and meta-analysis, following the preferred reporting items for systematic reviews and meta-analyses (PRISMA) guidelines (Page et al., 2021). The procedure consisted of identification, screening, eligibility, and inclusion, as shown in Figure 1.

Figure 1

Research Procedure for a Systematic Literature Review on Science Experiments in Online Learning Environments Using PRISMA Guidelines



Note. PRISMA = preferred reporting items for systematic reviews and meta-analyses.

Results and Discussion

Trends in the Approach to Science Experiments

The analysis of the reviewed articles showed a variety of practicum models. Science practicum that combines hands-on activities with cognitive engagement could still be effectively conducted in online learning. These science experiments activities prioritized the development of scientific knowledge, skills, and attitudes. Students were assigned independent tasks to conduct experiments in their respective homes, and the model for the online learning experiments is presented in Table 2.

Table 2

Pedagogical Approaches to Science Experiments in Online Learning Environments

Study	Pedagogical approach
Ali et al. (2022); Brevik et al. (2021); Damopolii et al. (2022); Domínguez et al. (2018); Hamed & Aljanazrah	Simulations

Study	Pedagogical approach
(2020); Kader et al. (2020); Kapici et al. (2020)	
Baldock et al. (2021)	Problem-solving
Andrews et al. (2020)	Inquiry-based learning, discovery learning at home
Larriba et al. (2021)	Autonomous learning, cooperative learning
Gya & Bjune (2021)	Do-it-yourself (DIY) experiments, inquiry-based laboratories
Nandana & de Mel (2016)	Integrated laboratories experiment setup (ILES)
Schnell et al. (2021)	Course-based research
Müssig et al. (2020)	Inquiry-based learning, discovery learning
Vasiliadou (2020)	Inquiry-based virtual laboratories
Papaneophytou (2020)	Straightforward approach-online delivery
Sherrer (2020)	Discussion, experiments design lab, hybrid learning
Ishafit, Indratno, et al. (2019); Ishafit, Mundilarto, et al. (2020)	Online experiments in remote laboratories
Ametepe & Khan (2020)	Online live demonstration
Accettone (2022)	Chemistry laboratory delivery models
Pratidhina et al. (2022); Schmidt et al. (2021); Schultz et al. (2020); Selco (2020)	Hands-on experiments, video recorded and reported in the LMS
Koretsky (2020)	Re-flipping in the remote classroom, computer-based learning
Seifan et al. (2019)	Virtual field trip
Cesin-AbouAtme et al. (2021)	Demonstration, hands-on practicum at home video recorded
Kapici et al. (2022)	Inquiry-based virtual experiments
Casaburo (2021)	Physics experiments
Donkin et al. (2019)	Blended learning (face-to-face and e-learning)
DeBoer et al. (2019)	DIY "do-it-yourself" remote lab
Schmidt et al. (2021)	Hands-on experiment with remote learning modules

Note. LMS = learning management system.

Online experiments are practical activities carried out through digital platforms to facilitate the distance learning of science. Selco (2020) emphasized direct experiments in online chemistry teaching to improve the fundamental understanding of concepts. Hand-on experiments involved technology; students recorded practical activities in video and reported video recordings on the LMS (Selco, 2020). Schultz et al. (2020) developed a kitchen practicum as a valuable solution for online science learning involving LMS devices and video recordings.

Individual online and traditional laboratory experiments differ significantly in methods, resources, and interactions. The individual online experiment approach is usually conducted at home or through virtual simulations, while traditional laboratory experiments involve complete laboratory facilities and direct interaction with instruments and chemicals. Selco (2020) stated that chemistry experiments conducted from home allow students to gain practical experience even though they are not in the laboratory. Students use materials that are readily available at home to conduct experiments. Schultz et al. (2020) stated that hands-on experiments from home provide practical experience despite limited tools and materials. Meanwhile, Herer (2020) stated that individual practicums using the virtual photosynthesis laboratory module cannot replace more in-depth expertise and the use of actual laboratory equipment. Online individual experiments offer greater flexibility and accessibility in emergencies such as pandemics but have limitations regarding depth of knowledge and interaction with laboratory equipment. In contrast, traditional laboratory experiments provide a more in-depth and comprehensive experience, although they require extensive facilities and resources. The combination of both approaches can provide more holistic and adaptive learning.

Do-it-yourself (DIY) experiments could increase students' interaction with experimental items and systems, develop practical skills, increase motivation and theoretical knowledge, as well as provide authentic experiences (Gya & Bjune, 2021). At-home experiments improved learning results, motivation, and interest in science, as well as provided opportunities for students to develop at their own pace (Zulirfan et al., 2018). The germination experiment with a DIY approach was designed using simple equipment at home and locally accessible plants (Gya & Bjune, 2021). Students completed the modules provided by teachers, submitted hypotheses for testing, designed and carried out experiments, as well as recorded the results on the provided observation sheet. Additionally, they collected and shared observation data online for the benefit of the entire class and wrote a practical report. Students also attached the observational data to the report and discussed the results of the practicum online.

Inquiry-based virtual laboratories learning included conducting virtual experiments using various platforms, particularly Go-Lab (https://premium.golabz.eu/about/projects/go-lab-project.html). Prospective science teachers designed and used experimental activities as well as wrote arguments on an online platform, guided by teachers through online worksheets. Teachers were responsible for carrying out the main task of guiding students on using virtual learning technology. At the end of the activity, students submitted their written results, which were analyzed by teachers (Kapici et al., 2022).

During COVID-19, inquiry-based experiments could be designed and adapted for home settings. Home laboratory designs focused on four main elements, including: (a) avoiding security problems, (b) not requiring special equipment, (c) providing a genuine chemical laboratory experience, and (d) directly interacting with the concepts of pH, acid-base titrations, buffers, solubility, phase equilibria, and thermodynamics (Andrews et al., 2020). Autonomous and cooperative learning was adopted in science practicum activities, with students independently conducting experiments at home (Larriba et al., 2021) and collaboratively writing the practicum report in small groups.

Inquiry-based learning enhanced by AR technology was used to teach chemistry. Students could carry out the learning using this particular technology from home. There were six steps. First, students completed an online test with 10 multiple-choice questions to determine their prior knowledge, with a time limit of 20 minutes. Second, teachers provided multiple-choice test questions related to chemistry. Third, students watched videos provided by the teachers online, which showed step-by-step laboratory activities and how to use AR. Fourth, students were given a brief explanation before experimenting.

Fifth, students downloaded and installed an AR app on an Android or Apple device, conducted experiments, and took pictures of the results. The experimental activities were carried out for a maximum of 2 hours. Finally, students uploaded their experimental reports and accompanying photos to the available platforms (Andrews et al., 2020).

Subject Matter Trends in Science Experiments

The subject matter of practical experiments was quite diverse, covering the fields of physics, chemistry, and biology. In order for any experiment to be conducted in a student's home, suitable materials would have to be easily found around the home or through a virtual laboratory. For instance, in the articles we reviewed, photosynthesis was taught in a virtual laboratory, Ohm's law was practiced through simulation, and acid-base chemistry experiments were easily conducted at home. The trends we discovered in our study are shown in Table 3.

Table 3

Subject Matter of Science Experiments

Subject area	Study	Subject matter
Physics	Kapici et al. (2022)	Electric circuits, Archimedes' principle
	Kapici et al. (2020)	Electric circuits
	Pratidhina et al. (2022)	Ohm's law
	Hamed & Aljanazrah (2020)	Measures the acceleration of gravity (g), the half-life of a draining water column, RC circuit
	Ishafit, Mundilarto, et al. (2020)	Malus law
	Ametepe & Khan (2020)	Principles of physics
	Ishafit, Indratno, et al. (2019)	Magnetic field
	Casaburo (2021)	Gravitational acceleration
	Nandana & de Mel (2016)	Mechanics
Biology	Gya & Bjune (2021); Schnell et al. (2021)	Plant biology
	Damopolii et al. (2022)	Coordination systems
	Brevik et al. (2021)	Microbiology, soil chemistry
	Sherrer (2020)	Photosynthesis
	Baldock et al. (2021)	Biochemistry
	DeBoer et al. (2019)	Neuroscience
	Donkin et al. (2019)	Tissue morphology
Chemistry	Larriba et al. (2021)	Thermal engineering chemistry, separation process
	Andrews et al. (2020)	pH, acid-base titration, buffers, solubility, phase equilibrium, and thermodynamics

Kapici et al. (2022)	Mole, molarity, acid-base, pH
Papaneophytou (2020)	Enzyme test, kinetics laboratories
Müssig et al. (2020)	Crystal structure
Schultz et al. (2020)	Acid-base materials
Kader et al. (2020)	Forensic chemistry
Cesin-AbouAtme et al. (2021); Domínguez et al. (2018)	Electrochemistry
Selco (2020)	Acid–base chemistry, exothermic processes, endothermic
Koretsky (2020)	Chemometrics
Schmidt et al. (2021)	Polymer synthesis, intermolecular interactions, thermomechanical properties, structure-function relationships, and molecular design
Ali et al. (2022)	Oxalic acid solution
Accettone (2022)	Chemical reactions

Note. RC = remote control.

The topics of science experiments had different characteristics and levels of difficulty. In virtual laboratory experiments, the chemical topics explored consisted of mole, molarity, acid-base, pH (Kapici et al., 2022), enzyme tests, kinetics laboratories (Papaneophytou, 2020), and photosynthesis (Sherrer, 2020). Meanwhile, chemical topics related to pH, acid-base titration, buffers, solubility, phase equilibrium, thermodynamics, and electrochemistry were carried out through hands-on experiments (Andrews et al., 2020; Cesin-AbouAtme et al., 2021). Physics topics such as electric circuits, Ohm's law, acceleration of gravity, and Archimedes' law could be simulated using virtual laboratories (Hamed & Aljanazrah, 2020; Kapici et al., 2020, 2022). Biological experiments, including plant biology (Gya & Bjune, 2021) and microbiological materials (Brevik et al., 2021), were conducted using both hands-on activities and virtual laboratories.

Trends of Technology Used in Science Experiments

Technology has played an essential role in the learning process and has been fundamental to online learning. Trends in the articles we analyzed showed that there were various technologies used by teachers to achieve the effectiveness and efficiency of practical learning. Table 4 presents the technologies found in the publications we examined.

Table 4

Technologies Used in Science Experiments in Online Learning Environments

Study	Technology
Domínguez et al. (2018); Kapici et al. (2020, 2022); Papaneophytou (2020); Vasiliadou (2020)	Virtual laboratory

Study	Technology
Ametepe & Khan (2020)	Virtual laboratory, video recording, online live demonstration
Baldock et al. (2021)	iPads apps, video recording, Zoom, quizzes
Damopolii et al. (2022)	Augmented reality
Müssig et al. (2020)	Augmented reality, video tutorial
Accettone (2022); Andrews et al. (2020); Koretsky (2020); Schultz et al. (2020)	Video record
Larriba et al. (2021)	3D printed, Google Meet
Gya & Bjune (2021)	Video conference
Sherrer (2020)	Virtual laboratories, Zoom
Nandana & de Mel (2016)	Multimedia demonstration
Ishafit, Indratno, et al. (2019); Ishafit, Mundilarto, et al. (2020)	Remote laboratory
Selco (2020)	LMS, video
Kader et al. (2020)	Web virtual reality
Seifan et al. (2019)	Virtual field trip
Cesin-AbouAtme et al. (2021)	Real laboratory-kit laboratories
Hamed & Aljanazrah (2020)	Virtual laboratories, online video integrated within Moodle
Pratidhina et al. (2022)	Arduino and block programming language
Casaburo (2021)	Arduino
Brevik et al. (2021)	Video, virtual laboratories
Ali et al. (2022)	Virtual chemistry laboratories
Schmidt et al. (2021)	Remote learning module
Schnell et al. (2021)	Video tutorial, live virtual
Donkin et al. (2019)	LMS, video recording of the practicum
DeBoer et al. (2019)	MOOC conducted RCT

Note. LMS = learning management system; MOOC = massive open online course; RCT = randomized control trial.

AR technology was a trend seen in many science experiments activities. To use the technology, students would first download and install an application on a smartphone. Students would then need to print the available markers and use the AR app to scan the markers with their devices (Müssig et al., 2020). Using the virtual laboratory in a science practicum, learners performed simulations independently according to the instructions on the worksheet (Ametepe & Khan, 2020). Remote laboratory technology, also known as virtual reality, allowed students to perform real, practical work remotely by using Web technology with real practicum equipment (Ishafit et al., 2019; Kader et al., 2020). In practical activities, including video recordings, students watched tutorial videos provided by teachers and then

carried out the experiments independently at home (Andrews et al., 2020). However, distance practicum learning using video recordings and online simulations failed to provide meaningful experiences (Accettone, 2022). The use of practicum activities was followed up by presenting the experimental results through online discussion platforms, particularly on Zoom (Gya & Bjune, 2021). Combining hands-on and virtual laboratories was more effective in increasing students' knowledge and developing inquiry skills (Kapici et al., 2019). The research has not yet shown trends toward integrating artificial intelligence (AI) in online science experiments learning.

AI technology is currently experiencing rapid development and has been used in various levels of education and disciplines. In online science practicum learning, there are AI applications such as ChatGPT with AI Chatbots. Research has shown that AI could be integrated into blended learning environments (Park & Doo, 2024). The technology has the potential to facilitate communication between teachers and students (van Leeuwen, 2019), change learning processes, improve performance (Huang et al., 2023), and develop positive affective results (Troussas et al., 2020).

Trends of Assessment Used in Science Experiments Conducted in Online Learning

Teachers use assessment in science experiments to evaluate the effectiveness of experiments. This assessment assesses aspects of cognition, skills, and attitudes. The literature review identified several assessment methods, including performance assessment, comprehension tests through quizzes, experimental reports, pre-experiment tests, and research papers. Trends in the assessment of science experiments in online learning environments are shown in Table 5.

Table 5

Trends of Assessment in Science Experiments in Online Learning Environments

Study	Assessment method
Andrews et al. (2020); Gya & Bjune (2021); Kader et al. (2020); Larriba et al. (2021); Papaneophytou (2020); Sherrer (2020); Vasiliadou (2020)	Experiment reports assessment
Hamed & Aljanazrah (2020)	Performance assessment, experiment reports, achievement test
Selco (2020)	Performance assessment
Schnell et al. (2021)	Research paper
Brevik et al. (2021)	Online homework assignments (pre-labs)
Müssig et al. (2020)	Concept understanding test
DeBoer et al. (2019)	Survey self-efficacy, self-concept
Kapici et al. (2022)	Scientific argument
Baldock et al. (2021)	Online quiz, homework
Koretsky (2020)	Homework
Ametepe & Khan (2020)	Quiz

Study	Assessment method
Donkin et al. (2019)	Practical examination, feedback from a peer, video feedback
Nandana & de Mel (2016)	Assignments marked by tutors, continuous assessment tests, daily school, and final exams.

The assessment of science experiments generally evaluated cognitive aspects, skills, and attitudes. Cognitive aspects were assessed through multiple-choice questions and essay tests, while skills were assessed using observation sheets. On the other hand, attitude aspects were evaluated using observation sheets and questionnaires. Performance assessment was carried out by recording practicum activities, with video footage submitted through the LMS (Hamed & Aljanazrah, 2020). Furthermore, assessments were carried out before and after the practicum, as evidenced by Baldock et al. (2021) and Brevik et al. (2021). Experiment reports, which were considered a form of product research, were submitted through the LMS platform provided by the institution (Andrews et al., 2020). Specifically, assessment through research papers included students preparing papers based on the results of their experiments. The research paper would consist of an abstract, introduction, methods, results and discussion, conclusion, as well as references (Schnell et al., 2021).

Experiment reports were prepared similarly, adopting a structure containing an introduction, experimental procedure, results and discussion, conclusions, and literature references. Reports were collected 10 days after the completion of the practicum and were weighted at 60% of the assessment (Larriba et al., 2021). Students collaborated on writing these reports, thereby reaching a consensus on the results and conclusions. This group activity in working on experiment reports was intended to enhance students' transversal competence.

Conclusion and Implication

Learning design trends in science experiments was varied, using both hands-on and minds-on methods. Interactive simulations have arisen as a popular trend, and virtual laboratories have become an essential technology in science learning. The topics addressed in science practicums were varied, including a wide range of experimental methods. In terms of assessment, experiment reports were the most common method used in online learning.

The implications of this research suggest that virtual laboratories and interactive simulations could be effectively used and adapted for both online and face-to-face experiments. Online experiments enhance interaction between teachers and students, which tends to improve students' analytical and practical skills while fostering critical and creative skills. Virtual laboratories have significant potential to expand access to conducting science experiments, especially for those with limited opportunities to conduct direct experiments. The use of technology, including AI, could improve the effectiveness and efficiency of science learning.

The variety of practicum materials covered several topics and experimental methods. The predominance of practicum report assessments signifies the importance of teachers designing comprehensive rubrics in accordance with learning objectives. These assessments could provide in-depth information on students' mastery of science concepts and their use of knowledge.

Online science labs cannot wholly replace traditional laboratory-based labs. Online hands-on experiments at home can be an alternative to traditional labs in school laboratories. Traditional science labs in the laboratory provide meaningful learning experiences for students and improve their technical skills while applying theories learned in class. Meanwhile, online science labs do not always provide enough training in essential laboratory skills. Carefully designed online science labs can be an alternative to science lab activities.

The research results for learning theory imply that online science practicums can support constructivist theory, which emphasizes the importance of hands-on experience and minds-on thinking. Curricula that cover various topics and experimental methods must be continuously updated to ensure relevance to the latest developments in science and technology. Research recommendations for policymakers include providing policy support that enables and encourages educational institutions to adopt online science learning by providing adequate funding, teacher training, and infrastructure.

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Which is Better: E-Book or Printed Book? A Meta-Analysis of Educational Materials in Language Learning

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Abstract

This study evaluated the effect of electronic books (e-books) on improving language learning outcomes, particularly in core proficiencies such as speaking, writing, and listening, which are identified as key areas of improvement. Using a meta-analysis approach, this research employed a randomized model with experimental and control groups. Data selection followed the preferred reporting items for systematic reviews and meta-analyses (PRISMA) scheme, based on inclusion and exclusion criteria, using the Scopus database. Statistical analyses included tests for heterogeneity, publication bias, total effect size, and moderator variables using analysis of variance. The findings indicate that e-books positively influence the learning process as compared to printed books, with a medium standardized effect size of 0.5. Among languages, Arabic and Turkish benefitted the most from e-book use, while native language learning showed greater improvements than second-language acquisition. Interactive e-books demonstrated significantly higher effectiveness compared to non-interactive ones, though their impact on reading skills was relatively smaller. These results underscore the value of e-books as tools for enhancing language learning. Future efforts should focus on developing interactive e-books tailored to specific languages and proficiency needs to maximize educational potential.

Keywords: e-book, printed book, language learning, student achievement, meta-analysis

Introduction

Electronic books (e-books) have evolved from being merely an alternative format to printed books to being a mainstream medium in various aspects of life, including education, entertainment, and research. In education, e-books have enabled the distribution of learning materials at a lower cost and faster time than printed books (Alsalhi et al., 2020; Amirtharaj et al., 2023). In addition, increased accessibility through mobile devices such as tablets and smartphones has expanded the reach of e-book users.

In education, e-books offer easy access and distribution that is not limited by geographical location, allowing students and teachers to access educational resources more efficiently (Bradley et al., 2023; Tlili et al., 2022). Previous research shows that using e-books can increase students' motivation, enable more interactive and dynamic learning, and improve learning outcomes (Franco & Bidarra, 2022; Liana Mumrikoh et al., 2023). Interactive features such as hyperlinks, multimedia, and digital annotations allow students to learn more deeply and engage with course material.

E-books equipped with interactive features such as audio, video, and animation can help language learners better understand context and pronunciation. The use of e-books in English as a foreign language (EFL) learning has been shown to improve students' reading and comprehension skills (Hsieh & Huang, 2020). These multimedia features allow learners to hear correct pronunciation, see visualizations of concepts, and interact with the content more deeply.

Other studies have also shown that e-books can enrich vocabulary, improve comprehension, build reading habits, and analyze texts, making them practical for learning foreign languages at various educational levels (Pavlovic & Petrović, 2020). E-books are essential in improving vocabulary in language learning because they have various interactive features and recommendations tailored to students' needs. E-books provide a complete platform for efficient vocabulary learning by assessing students' knowledge based on their activities and giving personalized recommendations (Takii et al., 2021). In addition, e-books can incorporate digital storytelling tools, such as text, audio, and visuals, effectively improving vocabulary, English language skills, and motivation to learn a foreign language (Albishi & Alqiawi, 2022).

Furthermore, integrating visual images into e-books for writing tasks has been shown to significantly increase participants' vocabulary, demonstrating the effectiveness of innovative learning designs in improving vocabulary acquisition through learning using e-books (Sariani et al., 2021). E-books can enhance the quality of learning, student achievement, and classroom atmosphere by providing many learning tools and possibilities (Duvnjak et al., 2022). These studies have shown that since e-books positively impact language learning outcomes, they have become a valuable resource.

Although there are some drawbacks to the use of e-books in language learning, such as the lack of direct interaction between teachers and students, the difficulty of reading on screens, and limitations on some learning content, the effectiveness of e-books depends on how they are structured, their quality, and the learning environment created by teachers (Puric & Sekač, 2022). This study provides a comprehensive understanding of the impact of e-book use, both positive and negative, in various contexts. It also explores how factors such as grade, class size, and reading format preferences can influence the e-book user experience. Thus, the study's results provide more holistic and applicable insights for various stakeholders, including educators, policymakers, and technology developers.

So far, research related to the use of e-books in language learning has focused only on children's reading or literacy skills at an early age (Egert et al., 2022; Furenes et al., 2021; Lee & McKee, 2023; Savva et al., 2022) and reading skills in grades K–12 (Swanson et al., 2020). Meanwhile, meta-analysis research involving studies of all levels and all language skills has yet to be conducted. Therefore, research related to the effect of e-books on language learning that examines a range of variables, including level of education and participants' language abilities (not only reading), is fundamental. In addressing this research gap, this study aimed to examine the effect of e-books on language learning by considering various moderator variables including language, language status, language proficiency, grade, e-book type, domain competencies, the information-base, era, and class size. These variables would be expected to provide new insights into how e-books affected different user groups. Thus, exploring these variables had the potential to significantly contribute to our understanding of e-book usage, especially in language learning.

Material and Methods

This research is a meta-analysis that aimed to summarize various data on the effect of specialized electronic books in English language learning. Meta-analysis research is a technique used to summarize various studies with similar methods and identical themes (Chang et al., 2022). It is a suitable method for synthesizing results from multiple experimental studies. In this study, we used the group contrast model to analyze data from diverse research findings (Fajaruddin et al., 2024). In meta-analysis research, the final result of inference is the total effect size, which represents the general picture, in this case, the difference in the effect of electronic books versus printed books (Mamekova et al., 2021).

Research Data

This study retrieved data from selected articles found in globally reputable publications, which were Scopus-indexed journals. Data collection was carried out through the Scopus database portal (https://www.scopus.com), and several research results owned by researchers. The selection of the Scopus database was intended to allow control of data quality. Researchers assume that every research paper published in Scopus-indexed journals has gone through a rigorous review process so that the quality of the research is guaranteed, at least compared to articles in non-reputable journals.

The data collection process used the keywords "interactive book" OR "e-book" OR "electronic book" OR "audiobook" OR "audio book" OR "digital book" OR "virtual book" AND "language" OR "english" OR "indonesian" OR "arabic" OR "EFL" AND "achievement" OR "outcome" OR "skill" OR "knowledge" OR "attitude" OR "reading" OR "grammar" OR " vocabulary" OR "structure" OR "listening". The use of various Boolean logics was used to obtain a larger but targeted set of articles. From the search results based on keywords, we made a selection with strict inclusion and exclusion criteria. These are shown in Table 1.

Table 1

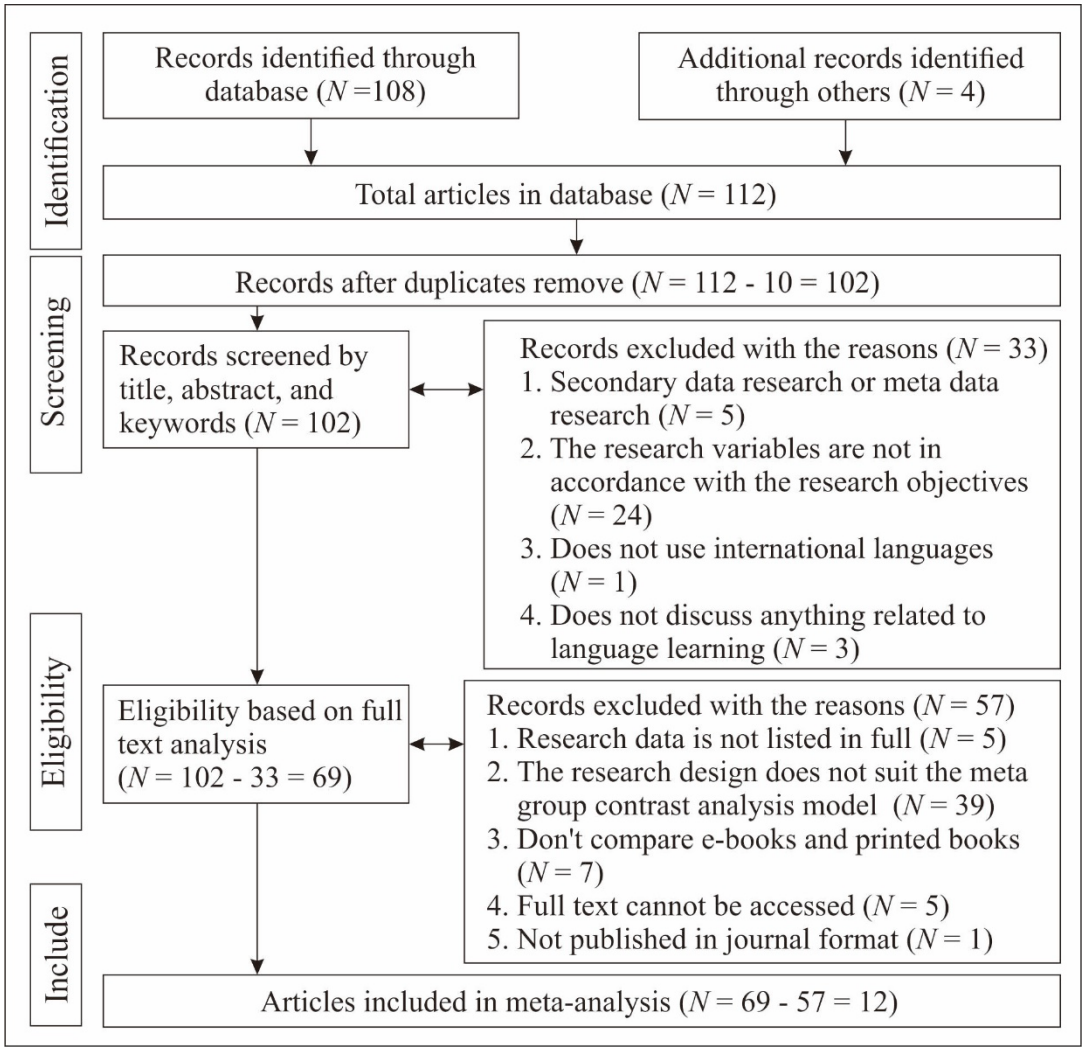
Inclusion and Exclusion Criteria Used to Identify Studies on E-Books and Language Learning

Aspect	Inclusion criteria	Exclusion criteria
Year	2019–2024	Else
Language	English	Else
Article type	Research article	Else
Data type	Quantitative	Qualitative
Research design	Group contrast	Else
Research model	Control and experiment	Does not load either or both
Data component	Sample size, mean, and standard deviation	Does not load one, two, or all three
Analysis data	Quantitative	Qualitative
Theme	The influence of e-books on language learning	Else
Data base	Scopus	Else

The selected data were from articles that met all the inclusion criteria. If a criterion was not met, the data were excluded from the analysis. To control the data search process, this research used the preferred reporting items for systematic reviews and meta-analyses (PRISMA) model. The PRISMA model is used as a data recapitulation procedure so that the data search sequence can be well documented, with all data traced and accounted for (Page et al., 2021). The PRISMA diagram for this study is shown in Figure 1.

Figure 1

Data Selection Flow With PRISMA Model



Note. PRISMA = preferred reporting items for systematic reviews and meta-analyses (https://www.prisma-statement.org/).

In the data selection process, 12 articles were obtained that met all inclusion criteria. These 12 articles each had mostly more than one relevant data point. For example, the article written by Tsuei et al. (2020) had five relevant data to analyze (Research Data section, paragraph 4, page 5), and the research by Phadung and Dueramae (2018) had three relevant data to analyze. The 12 articles contained 43 relevant data points to be analyzed.

Heterogeneity and Publication Bias

The data collected for analysis showed a heterogeneous character indicated by research conducted in various countries, levels, languages, media, and other undefined conditions. Thus, based on the characteristics of the data, the appropriate analysis model would be the random-effect model. However, the identified characteristics needed to be statistically confirmed through heterogeneity tests (Borenstein, 2009). This study used three test models to confirm heterogeneity: the Q statistic, tau-squared (τ^2), and I-squared (I^2) parameter methods. Data is said to be heterogeneous if the probability

value of $Q < .05$ (5% error), $\tau^2 > 0$ (Retnawati et al., 2018), and $I^2 < 75\%$ (Higgins, 2003). Use of three methods can be expected to be accurate because there would be mutual correction between methods.

In the next step, we needed to prove that the data collected were free from publication bias. Although the data collection process had strictly adhered to the robust PRISMA procedures, the quality of the data still needed to be confirmed. To prove that the data were free from publication bias, we used three methods of proof: the funnel plot, Egger's test method, and the fail-safe N formula. A dataset is said to be free from publication bias if the distribution of points in the funnel plot tends to be symmetrical, when the Egger's test probability value exceeds the tolerance of error (Retnawati et al., 2018), and when $N > 5K + 10$ (where N is the fail-safe N value and K is the number of studies; Mullen et al., 2001).

Effect Size Total

In this study, we used a group contrast model with a different group design, namely between the experimental and control groups. In the process of examining the data, we found variations in data intervals that required a standardization process. Therefore, we applied a standardized group difference model (Arlinwibowo et al., 2023). After the data were proportionally standardized, the next step was the calculation to find the total effect size. To minimize the bias of the effect size, the calculation process was transformed with the Hedges formula (Hedges, 1981). The analysis process was assisted by R software (Version R 4.4.1), with meta and metaphor packages. The total effect-sizes were classified according to the recommendations from Sullivan and Feinn (2012) as shown in Table 2.

Table 2

Categories of Effect Sizes Applied in This Meta-Analysis

Effect size	Category
0–0.19	No effect
0.20–0.49	Small
0.50–0.79	Medium
0.80–1.29	Large
More than 1.30	Very large

Moderator Variable Analysis

To understand in greater depth the total effect size, we carried out a moderator variable analysis to explore the variables alleged to influence the main variable. The moderator variables analyzed were expected to enrich the meaning of the findings. In this meta-analysis, there were 9 moderator variables: language, status, proficiency, grade, e-book type, domain, information base, era, and class size. The analysis of moderator variables was based on variant analysis techniques (Arlinwibowo et al., 2023), with inference criteria based on identifying the significance of differences between variables. The identification of significance was based on probability values. If the probability value was below 5%, there would be a significant difference between groups of moderator variables (95% confidence level). Table 3 shows the moderator variables analyzed in this study as well as their categories and frequency.

Table 3

Categories and Frequency of Moderator Variables Analyzed in the Study

Variable	Category	*n*	%
Language	Chinese	15	34.88
	English	21	48.84
	Spanish	1	2.33
	Turkish	2	4.65
	Thai	3	6.98
	Arab	1	2.33
Status	Native language	24	55.81
	Foreign language	19	44.19
Proficiency	Lexical	13	30.23
	Writing	2	4.65
	Reading	20	46.51
	Listening	6	13.95
	Speaking	2	4.65
Grade	Elementary	26	60.47
	Junior High School (JHS)	9	20.93
	Senior High School (SHS)	6	13.95
	University	2	4.65
E-book type	Interactive	13	30.23
	Non-interactive	30	69.77
Domain	Attitude	8	18.60
	Knowledge	22	51.16
	Skill	13	30.23
Information base	Visual	36	83.72
	Audio	7	16.28
Era	Pre COVID (2018–2019)	8	18.60
	COVID (2020–2021)	20	46.52
	Post COVID (2022–2024)	15	34.88
Class Size	Small (n <= 30)	30	69.77
	Large (n < 30)	13	30.23

Results and Discussion

Our analysis began with proving the data used in our study were heterogeneous. Heterogeneity must be proven when a study uses a random-effects model, although in the data collection process, it was already

apparent to us that the data were heterogeneous, as indicated by the highly variable data sources (school level, country of study, time of implementation, e-book type, and various other aspects).

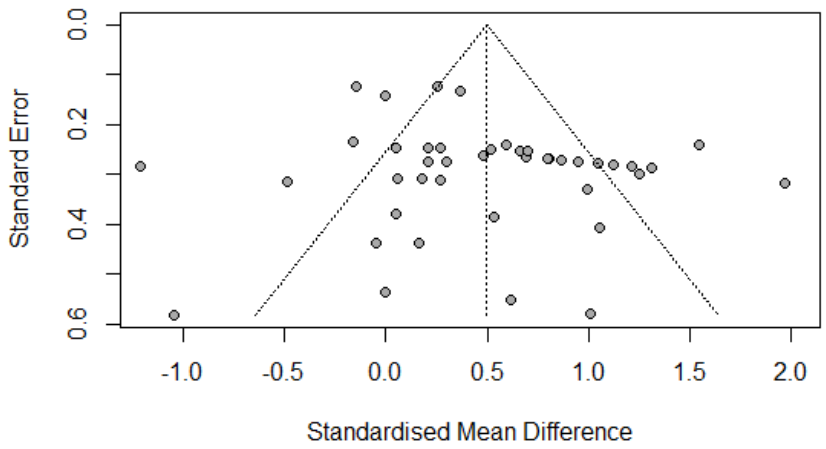
Test Assumptions of Heterogeneity and Freedom From Publication Bias

To assess heterogeneity, three statistical tests were employed: the I^2 statistic, the Q statistic, and the tau-squared (τ^2) estimate. This multi-method approach was adopted to enhance the robustness of the findings. The results indicated significant heterogeneity across studies. The I^2 statistic was 79.3%, with a 95% confidence interval [72.7%, 84.4%], classifying the heterogeneity as substantial. The *Q* statistic yielded a probability value of less than .0001, further supporting the presence of heterogeneity. Additionally, the τ^2 estimate was .2769, with a 95% confidence interval [.1621, .5188], confirming the existence of variability beyond chance. Given these results, a random-effects model was deemed appropriate for the subsequent meta-analysis.

The assumption of freedom from publication bias was assessed using three methods. A visual inspection of the funnel plot (Figure 2) revealed a relatively symmetrical distribution of effect sizes, suggesting no apparent bias. To further quantify this assessment, Egger's test was conducted, yielding a *p*-value of .0771, which exceeded the .05 significance level. Additionally, a fail-safe N analysis was performed, resulting in a value of 2,061, significantly larger than the required threshold of 225. Based on these combined findings, it was confidently concluded that the data used in this meta-analysis were free from publication bias, thereby enhancing the reliability of the overall results.

Figure 2

Funnel Plot Showing the Association of Effect Sizes in the Analyzed Publications



Note. Each dot represents an individual study included in the meta-analysis comparing language learning outcomes using e-books versus printed books. The x-axis displays the standardized mean difference (SMD) for each study, while the y-axis indicates the standard error. The two diagonal lines form a funnel shape, representing the 95% confidence limits within which study results are expected to fall around the overall mean effect. The vertical dashed line in the center shows the summary effect size from the meta-analysis. This plot is used to assess the symmetry of the data and to identify potential publication bias.

Effect Size and Total Effect of E-Book Use on Language Learning Achievement

Having established data heterogeneity and no publication bias, we proceeded to calculate a total effect size to compare e-book and printed book learning. This analysis combined the effect sizes from individual studies to determine the overall effect of e-book use. Table 4 presents this data, summarizing the effect size of each study and showing the total effect size.

Table 4

Effect Sizes of E-Book Versus Printed Book on Langauge Learning in Individual Studies Included in the Meta-Analysis

Article	Study	*n*.e	Mean.e	SD.e	*n*.c	Mean.c	SD.c	SMD	Lower	Upper
Alsalhi et al. (2020)	1	46	16.46	2.14	45	13.93	.82	1.55	1.07	2.02
Aydın & Tunagür (2021)	1	30	83.73	6.91	30	75.27	8.89	1.05	.51	1.59
Aydın & Tunagür (2021)	2	30	75.90	4.54	30	68.70	6.17	1.31	.75	1.87
Chen et al. (2023)	1	30	18.97	2.33	30	16.83	1.30	1.12	.57	1.67
Chen et al. (2023)	2	30	18.97	2.33	30	17.63	1.38	.69	.17	1.21
Chen et al. (2023)	3	30	19.93	1.44	30	18.20	1.38	1.21	.66	1.76
Chen et al. (2023)	4	30	19.93	1.44	30	17.43	1.04	1.96	1.34	2.59
Chen et al. (2023)	5	30	7.53	1.54	30	6.27	1.55	.80	.28	1.33
Chen et al. (2023)	6	30	7.53	1.54	30	6.13	1.38	.95	.41	1.48
Chen et al. (2023)	7	30	6.70	.76	30	6.07	.36	1.05	.50	1.59
Chen et al. (2023)	8	30	6.70	.76	30	6.18	.36	.86	.33	1.39
Chen et al. (2023)	9	30	7.27	1.23	30	6.20	1.42	.80	.27	1.32
Chen et al. (2023)	10	30	7.27	1.23	30	6.63	1.38	.48	-.03	1.00
Hsieh & Huang (2020)	1	7	23.71	3.90	7	18.57	5.50	1.01	-.13	2.14
Hsieh & Huang (2020)	2	7	29.29	4.42	7	24.71	8.75	.62	-.46	1.70
Hsieh & Huang (2020)	3	10	28.00	1.89	11	27.64	2.34	.16	-.70	1.02
Hsieh & Huang (2020)	4	10	41.40	3.41	11	41.55	2.51	-.05	-.90	.81
Hsieh & Huang (2020)	5	7	29.43	.98	7	29.43	.98	.00	-1.05	1.05
Hsieh & Huang (2020)	6	7	47.43	1.51	7	49.14	1.57	-1.04	-2.18	.10
Kartal & Simsek (2017)	1	32	6.53	2.37	34	4.94	2.13	.70	.20	1.20

Moutsinas et al. (2023)	1	21	.94	.47	21	.79	.59	.27	-.34	.88
Moutsinas et al. (2023)	2	21	.67	.62	21	.94	.47	-.48	-1.10	.13
Moutsinas et al. (2023)	3	21	.88	.53	21	.79	.45	.18	-.43	.79
Moutsinas et al. (2023)	4	21	3.79	.58	21	3.76	.45	.06	-.55	.66
Moutsinas et al. (2023)	5	21	4.00	.58	21	3.55	.24	1.00	.35	1.64
Park & Lee (2021)	1	42	73.12	12.96	32	63.81	18.24	.60	.13	1.07
Park & Lee (2021)	2	42	50.45	18.41	32	53.41	17.84	-.16	-.62	.30
Phadung & Dueramae (2018)	1	28	7.29	2.12	26	6.54	2.77	.30	-.24	.84
Phadung & Dueramae (2018)	2	28	6.50	2.02	26	6.00	2.59	.21	-.32	.75
Phadung & Dueramae (2018)	3	28	7.50	1.03	26	5.08	2.54	1.25	.66	1.83
Rahman & Hajar (2020)	1	30	48.80	16.52	30	68.00	14.86	-1.21	-1.76	-.65
Tsuei et al. (2020)	1	48	65.49	16.43	25	64.60	19.41	.05	-.43	.53
Tsuei et al. (2020)	2	48	77.32	16.39	25	73.64	18.95	.21	-.27	.70
Tsuei et al. (2020)	3	48	72.08	17.59	25	66.64	23.51	.27	-.21	.76
Tsuei et al. (2020)	4	48	92.77	15.63	25	81.45	30.03	.52	.03	1.01
Tsuei et al. (2020)	5	48	107.63	18.03	25	91.41	32.93	.67	.17	1.16
Tusmagambet (2020)	1	14	162.92	25.57	14	135.29	25.39	1.05	.25	1.85
Tusmagambet (2020)	2	14	8.64	.93	14	8.00	1.36	.53	-.22	1.29
Tusmagambet (2020)	3	14	2.94	.43	14	2.92	.35	.05	-.69	.79
Wood et al. (2018)	1	108	20.64	7.32	95	20.67	6.79	.00	-.28	.27
Wood et al. (2018)	2	141	18.57	9.96	124	16.23	8.42	.25	.01	.49
Wood et al. (2018)	3	121	86.85	11.46	137	88.71	13.50	-.15	-.39	.10
Wood et al. (2018)	4	112	87.24	18.19	114	80.66	17.26	.37	.11	.63

Note. n = 12 articles included in the meta-analysis summarize individual studies comparing language learning outcomes between e-book and printed book users. Studies are listed alphabetically by first author. Each row pair presents data for the experimental and control groups, including sample size (n), mean score (Mean), and standard deviation (SD). n.e = total sample size for experimental group; n.c = total sample size for control group; Mean.e = mean score of experimental group; Mean.c = mean score of control group; SD.e = standard deviation of experimental group; SD.c = standard deviation of control group; SMD = standardized mean difference. The overall effect size (not shown in the table) based on a random-effects model was SMD = 0.50, 95% CI [0.32, 0.68], $p < .0001$.

This analysis showed a p-value of less than .0001, meaning that there was a significant difference between language learning outcomes when using e-books versus printed books. The total effect size had a value of 0.5, with a lower limit of 0.32 and an upper limit of 0.68 at a 95% confidence interval. Thus, there was a positive effect, indicating that the e-book generally provided a better impact than the printed book on language learning. The value of 0.5 indicates that the effect falls into the medium effect size category.

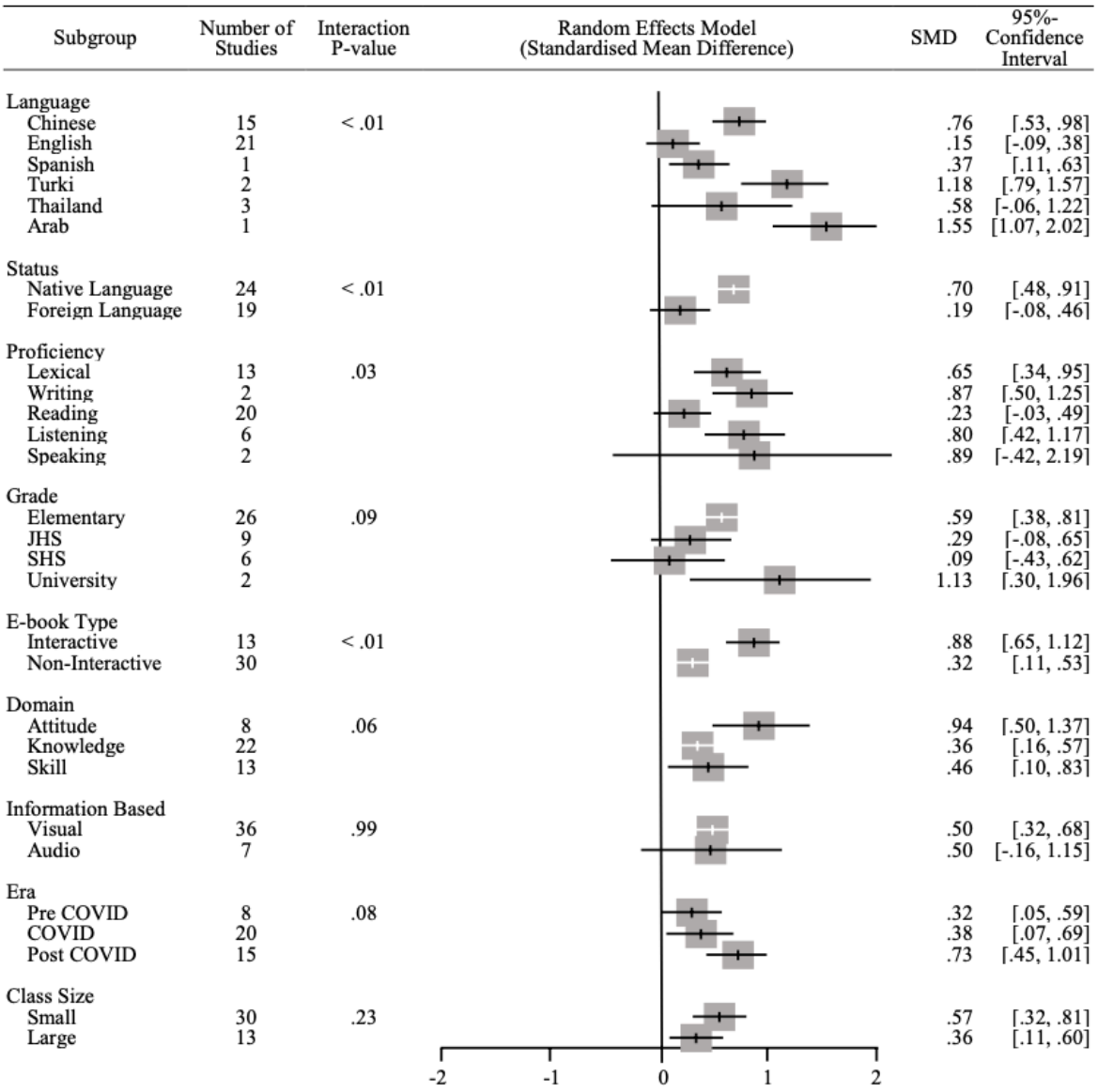
E-books, especially interactive ones, have been shown to increase student engagement, which reinforces language learning (Chen et al., 2023; Wu & Chen, 2018). In line with this, Nasir et al. (2022) mentioned that e-books could support language learning reinforcement because they facilitate students to connect with online dictionaries and Internet resources. However, the effectiveness of e-books for learning will depend on their quality (Liaw & Huang, 2016).

Moderator Variable Analysis

A significant positive effect of e-books on learning was found. To delve deeper, we examined the impact of several moderator variables: language, language status, skill aspects, education level, e-book type, competency domain, audiobook use, implementation period, and class size. The forest plot in Figure 3 illustrates the results of this moderator analysis.

Figure 3

Forest Plot of the Effect of Moderator Variables on Language Learning Using E-Books



Note. Subgroup analysis of the effect of e-books on language learning outcomes. Effect sizes are presented as standardized mean differences (SMDs) with 95% confidence intervals (CI) shown in brackets [lower, upper]. Interaction p values reflect the significance of moderation effects across subgroups. Some squares in the plot lack visible confidence interval lines due to extremely narrow ranges. The shading of the squares reflects study weight: darker (black) lines indicate greater weight, while lighter (white) lines indicate less contribution to the meta-analysis. Categories are spaced to visually separate subgroups for clarity. JHS = Junior High School. SHS = Senior High School. SMD = Standardized Mean Difference.

Language

Based on the analysis of the effect of the moderator variables in the category of language, there was a significant difference in the e-book effect on the language being taught. As presented in Figure 3, Arabic and Turkish showed higher positive effects, albeit based on only one study, when compared to Chinese, Thai, Spanish, and English. In terms of effect size, the highest impact was on Arabic language learning,

indicating a very positive effect. The confidence interval did not include zero, indicating a statistically significant effect. English, with the highest number of studies, had a much smaller effect size. These differences suggest that the target language being learned significantly influence outcomes, possibly due to cultural (Akbar et al., 2015), educational, or methodological differences (Park & Lee, 2021).

Status

The status category compares the impact of interventions on participants using their native language versus a foreign language. The analysis showed significant, solid, and moderate positive effects for e-book interventions in the mother tongue. In contrast, intervention in a foreign language produced a minor and statistically less significant effect. With an interaction *p*-value of less than .01, the difference between the effects in the mother tongue and foreign language contexts was statistically significant. This implies that interventions are substantially more effective when delivered in a student's native language compared to a foreign language. From a language learning point of view, foreign language learning is more difficult than native language learning. This is because cultural and linguistic differences can significantly affect language learning outcomes and understanding these differences is crucial for effective language teaching and learning (Dong, 2024; Tang, 2019).

Proficiency

The proficiency category examines the impact of different language skills on the outcome. It is divided into five subgroups: lexical, writing, reading, listening, and speaking. The results indicate that speaking, writing, and listening have large positive effects, suggesting significant improvements in these skills compared to other proficiencies. Previous research has also found that e-books have an impact on phonological awareness (closely related to speaking and listening) and vocabulary learning (closely related to writing; López-Escribano et al., 2021). These language skills can be improved through e-books equipped with various features such as interactive media including: videos, audio clips, and quizzes (Saddhono et al., 2020; Shamsi & Bozorgian, 2024); authentic materials, meaning real-world resources such as podcasts, videos, and articles created for native speakers (Yazmin & Clara, 2024); and personalized language learning (Yang & Ogata, 2023). The improvement of language can occur because these features allow students to practice, encouraging them to deploy language for meaning and providing them with opportunities to develop a better understanding of the language in its natural context. Lexical proficiency also showed a notable moderate positive impact. In contrast, reading had less pronounced effects, showing the most negligible impact. This is in line with (Lim et al., 2021) who found that there is no significant difference in students' reading ability with e-books or printed books. This may be because it is not the reading medium but how students engage with each medium that affects their understanding of the text. The interaction *p*-value indicates a significant difference among these subgroups, highlighting that the type of language proficiency targeted can substantially influence the outcomes of the interventions studied.

Grade

The grade category examines the impact of different educational levels on the outcome. This category includes four subgroups: elementary, junior high school (JHS), senior high school (SHS), and university. There was a moderate positive effect for the elementary category. Interactive e-books have an impact on children's literacy development compared to printed books (López-Escribano et al., 2021). The university level showed a strong positive effect. In contrast, JHS seemed to have a more minor effect, and SHS indicated no statistically significant effect. The interaction *p*-value suggests no statistically significant difference between the effects observed across these educational levels. This

means that interventions or outcomes being measured may be more effective at the university level compared to junior and senior high school levels. In line with this, Swanson et al. (2020) found that e-books did not have a significant effect on the literacy of K–12 students. Meanwhile, at the university level, e-books have been proven to enhance students' vocabulary and literacy (Jasrial et al., 2022; Xodabande & Hashemi, 2023).

E-book Type

The e-book type variable compares the effects of interactive versus non-interactive e-books on the measured outcome. Studies on interactive e-books have shown a substantial positive effect. In contrast, non-interactive e-books have a much lower effect size, suggesting a more modest benefit. The *p*-value for interaction was less than .01, highlighting a statistically significant difference between the two types of e-books. Interactive e-books, which likely include engaging features such as multimedia, quizzes, and interactive exercises, are more effective in enhancing the desired outcomes than their non-interactive counterparts (Lachner et al., 2022; Lin, 2015). With broad appeal evident across all age groups, interactive books are also linked to positive behavioral changes according to prior studies (Masento et al., 2023; Sahyouni et al., 2017).

Domain

The moderator variable of the domain examines the evolving areas of competence, including attitude, knowledge, and skill, analyzed across multiple studies to determine impact. Attitude had the highest positive effect size, suggesting significant improvement in learners' attitudes due to the e-book interventions studied. Knowledge showed a moderate positive effect, indicating that interventions had a positive but less pronounced impact on knowledge acquisition. Lastly, skill had a moderate effect, suggesting that interventions did enhance practical skills. The interaction *p*-value, just above the conventional significance threshold, implies that there may not be significant differences in how these domains respond to interventions, highlighting the importance of tailored approaches to improving different aspects of competence. The high positive effect size in the attitude category, especially when it came to children, was due to the more interesting content of an e-book, including a variety of pictures and interactive games that would help and motivate students (Chen et al., 2023; Sattar Chaudhry, 2014). The impact on knowledge acquisition could be attributed to the interactive nature of these texts, which in turn influences learner attitudes. As prior research has suggested (Rvachew et al., 2017; Weng et al., 2018), a positive disposition towards learning facilitates knowledge development. This aligns with the observation that children exposed to interactive books demonstrate greater knowledge gains alongside more positive learning attitudes. In addition, using an e-book helps encourage various emerging literacy skills among children as described in previous research (Ihmeideh, 2014; Verhallen & Bus, 2010).

Information

The moderator variable of information compares the effects of primarily visual vs. audio-based e-books. For visual e-books, which rely on text and images, a moderate positive effect was seen in the studies. Meanwhile, audio-based e-books, which emphasize auditory content, showed a similar average effect size but with a wider confidence interval that included zero, indicating that the effect was not statistically significant. The interaction *p*-value of .99 suggests no significant difference between the effects of visual and audio e-books. Since visual and audio-based e-books exhibit the same average effect size, readers can choose the format that best suits their needs and preferences (Adebesin & Pillay, 2022;

Senjam et al., 2022). This highlights the importance of context, user needs, and further research to refine these findings.

Era

The moderator variable of era categorizes studies into three time periods: pre COVID (2018–2019), during COVID (2020–2021), and post COVID (2022–2024). The post COVID era showed the greatest positive impact, followed by the COVID period and the pre-COVID era. According to this trend, the COVID era's development of resilience, adaptability, and technology may have had a long-lasting effect, improving learning outcomes in the years after the pandemic (Rapanta et al., 2021; Williamson et al., 2020). These results emphasize the importance of ongoing innovation and adaptation in educational practices to maintain and enhance language learning outcomes. Although the effect sizes suggest a trend toward increasing impact over time, all three periods reflect a moderate effect. These differences were not statistically significant, according to the interaction p-value of.08. These trends could be a shift in teaching methods, a greater use of technology, or other pandemic-related contextual adjustments. The widespread in digital learning environments are probably a result of the extensive use of remote and hybrid learning during COVID-19 (O'Connor et al., 2023).

Class Size

The moderator variable of class size explores the influence of the number of students per class on the treatment of e-books. Specifically, the analysis distinguished between small and large class sizes. Small classes showed a moderate positive effect. In contrast, the data from large classes indicated a positive but more minor impact. However, the interaction *p*-value implies that the difference in effects between small and large class sizes was not statistically significant. Smaller class sizes may appear to benefit more, but the evidence does not strongly support a significant advantage over larger classes. Differences in how e-books are integrated into the curriculum and the specific teaching strategies used may be more instrumental in influencing outcomes than class size alone (Johnson, 2016; Stirling & Birt, 2014; Wu & Chen, 2018). More research is needed to draw definitive assumptions.

Conclusion

This meta-analysis shows that the use of electronic books has a positive effect on the learning process as compared to the use of printed books. The results demonstrate a total standardized effect size value of 0.5, falling into the medium-effect category. This suggests that electronic books have a positive impact on learning outcomes. Another finding of this study is seen in the description of various moderator variables influencing learning outcomes with e-books in language learning. In terms of the language taught, the e-book showed a positive effect on all languages, but the positive effect on Arabic and Turkish was the greatest. In terms of the status of the language taught, e-books showed more positive effects for native language learning. For proficiency types, e-books have effects on all types, but among them, the smallest effect was seen in the area of improving reading skills. When looking at the type of e-book, the interactive e-book has a much greater effect than the non-interactive e-book. For the other moderator variables, e-books give equally good effects for each grade, domain, information base, era, and class size.

Implications of This Study

This study reveals that e-books have the potential to improve language skills, especially speaking, writing, and listening. As evidenced by this meta-analysis, e-books can be confidently integrated into educational settings. Educators and policymakers should consider optimizing e-book usage to maximize their benefits, particularly by leveraging interactive features that have been shown to be more effective.

Limitations of This Study

Despite these promising findings, this study has several limitations. First, because our analysis relied on existing secondary data, we could not independently verify the quality or consistency of the methodologies used in the included studies, which limits our confidence in how rigorously each study was conducted. Moreover, the study only used articles indexed in the Scopus database. While Scopus is a reputable source of peer-reviewed literature, this choice may have excluded relevant studies from other databases, potentially introducing publication bias. Second, without access to raw data from the original research, we were unable to delve deeper into specific findings. Future work could address these gaps by collecting primary data or partnering with institutions to access richer datasets, ensuring stronger validation of these findings.

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Book Review: Pedagogy Opened: Innovative Theory and Practice

Editor: Tiffani Tijerina (University of North Georgia Press, 2024, 230 pages). ISBN: 978-1-940771-43-4 (paperback, $29.99), ISBN: 978-1-959203-09-4 (HTML: https://ung.edu/university-press/books/pedagogy-opened-innovative-theory-and-practice.php)

Reviewed by: Rajiv Jhangiani, Brock University, Canada

Introduction

As the first volume in a new open access monograph series, *Pedagogy Opened: Innovative Theory and Practice* sets out to weave together strands from the rapidly growing field of open pedagogy while catalyzing critical conversation and challenging further evolution. Refreshingly, this series is edited by an early career scholar, drawing on her significant experience as an open education practitioner and taking seriously the responsibility to amplify diverse and new voices.

Given that open pedagogy is closely related to critical pedagogy and explicitly oriented towards social justice, it is fitting that the advisory board for this series thoughtfully guided the process through these values, drafted a powerful equity statement (which appears in the front matter), and developed equity-focused guidelines for submission review. The result is a collection of seven thought-provoking discussions of theory at the intersection of "teaching and learning practices and environments that promote equity, collaboration, and innovation and invite students to create and share knowledge with future publics, often in association with the use of open educational resources (OER)" (Tijerina, 2024, pp. viii–ix).

In this review I draw attention to some of the most powerful insights in this impressive debut, identify common themes across the seven essays, and offer a few suggestions for the subsequent volumes in this series.

Book Structure

The volume has been organized around seven essays, each of which was collaboratively authored or co-authored by faculty members at post-secondary institutions in the United States. Each chapter is followed by author biographies, four of which include extensive appendices ranging from interview responses and activity design worksheets to course and assignment details as well as links to examples of student work.

The essays are followed by an inspired final chapter showcasing 25 creative cover designs for the book submitted by undergraduate students in a visual design course. This delightful parting gift beautifully illustrates the power of renewable assignments, a popular approach to open pedagogy in which student work has a larger audience, a longer life, and a greater impact than traditional "disposable" assignments (Seraphin et al., 2019).

Key Insights

The opening chapter in the volume, contributed by Elaine Keys and Nicole Wilson, articulates the shared values of critical digital pedagogy and open pedagogy in the form of a values-based framework that guides decision-making across two classroom social justice projects. The framework invites educators and students to go "beyond OER and textbook adoption to see how their own pedagogical and educational goals—including creating more equitable learning spaces—can be realized through open pedagogy" (Tijerina, 2024, pp. 1–2). This values-based framework guides everything from an emphasis on good story stewardship and the amplification of student and faculty voices to the selection of publication venues and tailoring of open-ended reflection questions to invite co-creation of the narrative.

The chapter is enriched by the generous inclusion of excerpts from the reflections of faculty and students that honestly consider tensions, including the vulnerability of working in the open and the challenges of moving away from the banking model of education. Insightful and engaging reflections illustrate how open practices can be transformative for both educators and students. Indeed, having tasted the excerpts, I was strongly motivated to go on to feast on the lengthier reflections included in the Appendix. I was particularly struck by the affective dimension of these reflections, which included references to a feeling of personal responsibility, humility, a sense of reward, and the emotions of lived experience.

The second chapter by Bernd et al. also focuses on the implementation of open pedagogy in higher education, albeit relying on a hybrid digital infrastructure, some of which are open (e.g., Pressbooks, H5P) and some of which are not (e.g., Google Sites, Adobe Photoshop). The chapter includes a detailed overview of the implementation of open pedagogy assignments wherein the emphasis on offering students choice and voice was vindicated in the diverse approaches the students adopted. Once again, the chapter addresses practical concerns and challenges, including, for example, the use of pseudonyms to protect students' identities, whether out of fear of retribution for expressing opinions or when sharing content that is outlawed by state-sanctioned repressive pedagogies.

The essay by Amaya et al. is a break from the higher education assessment context and looks at ways to advance more equitable K–8 education through open educational practices (OEP) and culturally sustaining pedagogy (CSP). The authors helpfully distill seven constructs associated with both OEP and CSP before sharing insights from four case studies. Highlights include reflections on discomfort of using the license to revise or remix open content (bottom-up approach) in the context of a requirement to adhere to standards (top-down approach). The tensions between a prevailing ideology of high stakes testing and the knowledge that fostering greater collaboration (instead of more competition) would lead to better learning are also addressed.

The fourth chapter by Goldoni and Mormino considers the unique advantages of using OER in world language classes where instructors have a "particular duty to focus on diversity and inclusivity" (Tijerina, 2024, p. 100). For example, the importance of gender and sexuality inclusive language not only because "the intimacy entailed in learning a world language requires instructors and learners to engage with a range of identities" (Tijerina, 2024, p. 99) but also because language carries the power to shape perceptions. The authors provide an engaging overview of the evolution of gender inclusive linguistic developments in several gendered European languages and demonstrate how this issue continues to be used as a lightning rod by

far-right groups around the world. A clear-eyed awareness of the challenges of progressive and inclusive approaches to OER help ground the chapter, even as the authors point to the necessity of circumventing the gatekeeping by traditional academies of language around the world.

Ferrier and Graybeal share a detailed case study of an immensely popular community of practice with media innovators and professionals in Ethiopia, as well as the collaborative development of a widely used open educational resource especially valuable in this dynamic field. The chapter demonstrates how grassroots groups can drive open education, create localized solutions, and build regional capacity. In some ways this chapter also serves as an important reminder of the enormous variation of contexts in which open pedagogues are working to advance social justice around the world (Hodgkinson-Williams & Trotter, 2018). In some cases educators are working to redress inequities related to affordability, accessibility, and discrimination, whereas in others, as with the case study presented in this chapter, they are "dancing with uncertainties" (Tijerina, 2024, p. 146) such as planning for rolling blackouts and Internet shutdowns while ensuring the physical safety of participants who may be learning under the threat of persecution.

The sixth chapter by Law and Powell tackles a different dimension of access and equity in higher education by sharing how the development of a hybrid course template and facilitator guide can serve last minute contingent faculty hires. Although this contribution includes valuable guidance concerning effective instructional practices for online hybrid courses, it appears in my reading to have a less direct connection with the central theme of the volume, despite one version of the developed course template utilizing OER and the course template itself being openly licensed and publicly available.

The final chapter shares autoethnographic accounts of working with OER and OEP, from the perspectives of a professor (Bartholomay) and a student (Otter). These are deeply moving accounts that lay bare the impact of high textbook costs on students, as well as how experiences with a university policy requiring textbooks to be procured through the university bookstore coupled with job precarity can shape the values and motivations of faculty members. The chapter is further enriched by an interrogation of assumptions concerning access to digital technologies, the training and labour required to work effectively with OER, the importance of aligning incentives for faculty (e.g., tenure and promotion criteria), and the imperative of enacting justice-based solutions. This chapter serves as a powerful reinforcement of the tone set throughout the book.

Overall Impression

While the volume includes several recurring themes (e.g., theoretical frameworks aligned with social justice, praxis, grassroots communities, cross-disciplinarity, political interference), in my view the two outstanding features of this book are its relentless focus on providing practical tips and guidance and the contributors' desire to engage in honest and critical discussions of the many tension points that encase open pedagogy. It is precisely this openness to self-examination that renders this volume a notable contribution to the field and a valuable addition to the digital or print bookshelf of a new or experienced open pedagogue.

I would love to see future volumes in this series feature perspectives beyond the US post-secondary context (including from K–12 and vocational education and across more of the Global South), some critical analysis of the use of open source versus proprietary tools to support open pedagogy, and a more consistent connection to the theme of open pedagogy. Even so, this impressive debut volume has achieved its goal of deepening existing knowledge and sparking further conversations while setting the stage for the "rich and diverse series of publications" (Tijerina, 2024, p. xi) yet to come.

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Open Educational Resource Policy Development at a Campus of the University of the West Indies

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Abstract

Open educational resources (OER) are critical tools recognized by UNESCO and the Commonwealth of Learning (COL) for achieving the United Nations' Sustainable Development Goals (SDGs), specifically SDG 4: Quality education. The University of the West Indies, St. Augustine Campus (UWISTA), undertook an initiative to formulate an OER policy, aiming to align with the UWI's mission and general OER principles of openness, accessibility, affordability, and innovation. This paper outlines the comprehensive approach adopted, including online research, document review, surveys, focus groups, and a three-day workshop, ensuring diverse staff perspectives. The policy development process commenced with a thorough review of 44 existing OER policies, facilitated by consulting relevant documents and scholarly resources and an online survey. Subsequent stages included two Delphi focus groups and an on-site workshop in which participants actively contributed to drafting a policy. The draft OER policy that emerged from this process reflects a consensus among participants and incorporates best practices gleaned from the examination of other institutional policies.

Key observations from this initiative emphasize the importance of a collaborative approach, the use of existing models, transparency in policy development, continuous support, and addressing copyright issues. Generative artificial intelligence was actively employed by the workshop participants, especially for comparing policy and process items under consideration. UWISTA's OER policy development, supported by the COL, serves as a model for other institutions aiming to embrace open education principles. The draft policy, emerging from this inclusive and transparent process, aligns with UWI's mission and broader OER goals, offering valuable insights for the academic community and policymakers globally.

Keywords: open educational resources, OER, higher education, policy development, collaborative approach, transparency

Background and Introduction

Against the rising cost of traditional textbooks and learning materials, higher education (HE) institutions worldwide are actively discussing and pursuing the increased use of open educational resources (OER) as a crucial step towards making education more accessible and affordable. The use of OER in HE is gaining momentum for several reasons. First, OER have the potential to enhance teaching and learning by providing instructors with a wider range of materials to tailor to their specific courses. Second, students benefit from significant cost reductions compared to traditional textbooks. This financial relief is particularly crucial for students from diverse backgrounds and socioeconomic statuses, creating a more level playing field. Interestingly, the importance of OER is further emphasized by their alignment with the United Nations' Sustainable Development Goals (SDGs), particularly SDG 4: Quality education. Organizations such as UNESCO and the Commonwealth of Learning (COL) recognize the use of OER as a powerful tool to achieve this goal (UNESCO, 2019).

OER are educational materials that are freely accessible and openly licensed. This open licensing allows anyone to use, adapt, and distribute these resources at no cost, fostering creativity and collaboration within the educational community (UNESCO, 2019). OER encompass a vast range of materials, including textbooks, course content, multimedia elements, and even software applications (McKerlich et.al., 2013). This diversity ensures there are resources to foster the universal design of instructional materials and environments to meet a variety of educational needs. As high-quality educational materials that are freely available, OER have the potential to revolutionize HE by promoting accessibility, affordability, and a more equitable learning experience for all students. OER are often categorized based on their level of openness, ranging from openly licensed materials with some restrictons to fully public domain resources (Wiley & Hilton, 2018).

The University of the West Indies (UWI) is a leading institution committed to delivering high-quality education across the Caribbean. The St. Augustine Campus in Trinidad, established in 1960, was originally the Imperial College of Tropical Agriculture. Despite the potential benefits of OER, the adoption and integration of these resources at UWI, St. Augustine Campus (UWISTA) has been inconsistent. An OER policy was lacking, hindering the widespread use of OER and impeding the realization of their full potential. Recognizing the need to enhance teaching quality for all students, the director of the Centre for Excellence in Teaching and Learning (CETL), Dr. Leroy Hill emphasized the importance of faculty affirming teaching excellence as a fundamental right through the creation and use of OER (University of the West Indies, St. Augustine, 2023). The CETL plays a pivotal role in driving educational innovation and excellence at UWI and is at the forefront of UWI's OER initiatives, providing faculty and staff with the necessary resources and support to adopt, adapt, and develop OER. Thus, recognizing the transformative potential of OER, CETL, in partnership with the COL embarked on an initiative to draft an OER policy. The development of OER policies and guidelines is an important aspect of building capacity and the work on developing a policy would only add value in strengthening the capacity of the institution to sustain and encourage OER use. This initiative was aimed to align with UWI's mission, and the general principles of accessibility, affordability, and innovation that underpin the OER movement.

This paper outlines the approach adopted byUWISTA in developing its OER policy. It highlights key observations from the initiative, emphasizing the importance of a collaborative approach, the use of existing

models, transparency in policy development, continuous support, and addressing copyright issues. Additionally, the paper discusses the role of generative artificial intelligence, which was actively employed by workshop participants for comparing policy and process items under consideration. UWISTA's OER policy development, supported by COL, serves as a model for other institutions aiming to embrace open education principles. The draft policy, emerging from this inclusive and transparent process, aligns with UWI's mission and broader OER goals, offering valuable insights for the academic community and policymakers globally.

Exercise Objectives

This initiative was created to draft a comprehensive OER policy for UWISTA. Specifically, the project was designed to:

- Identify the current state of OER adoption and use at UWISTA;
- Explore the perceptions and attitudes of faculty, students, and administrators towards OER;
- Identify key factors influencing OER adoption and implementation; and
- Develop a draft OER policy that aligns with UWI's mission and values.

Literature Review

Several studies have highlighted the benefits of OER. For instance, research by Wiley et al. (2012) demonstrated that the use of OER can lead to significant cost savings for students while maintaining or improving educational outcomes. Similarly, Hilton (2016) found that OER adoption can enhance student engagement and learning by providing educators with the flexibility to adapt and customize materials to meet the specific needs of their students. Faculty members can benefit from OER by saving time and resources on course material development, fostering collaboration with other educators, and promoting innovative teaching practices (Kılıçkaya & Kic-Drgas, 2021). At the institutional level, OER can contribute to organizational cost savings, improve student retention and success, and enhance an institution's reputation as a leader in open education (Weller et al., 2015).

Despite the potential benefits, the widespread adoption of OER faces several challenges and barriers. These include lack of awareness, faculty resistance to change, concerns about quality and copyright, technical infrastructure limitations, and institutional culture (Ramsingh, 2021; Smith, 2013). Addressing these challenges calls for a comprehensive strategy that considers the needs and concerns of various stakeholders. Notwithstanding the comprehensive approach, the implementation of policy can play an important role in advancing the culture of adoption and use of OER within the instructional setting (Farrell et al., 2022). A growing number of higher education institutions have developed OER policies to support the integration of these resources into their teaching and learning environments. Comparative studies have highlighted the diversity of OER policies in terms of scope, objectives, and implementation strategies (Otto et al., 2021).

Some institutions have adopted comprehensive policies that cover various aspects of OER, while others have provided a minimalist framework to give greater flexibility in adoption. Yet others have focused on specific areas, such as copyright, licensing, or funding. To establish OER as a sustainable practice, it is important to develop robust institutional policies (UNESCO, 2019). Effective policy creation involves broad stakeholder engagement, transparent processes, and alignment with institutional goals. For example, the University of Edinburgh's OER policy served as a model, emphasizing openness, collaboration, and continuous improvement in OER development and use (University of Edinburgh, 2021). The literature also highlights the importance of addressing copyright issues in OER policy development. Copyright considerations are paramount in the development of effective OER policies. Restrictions on the use, adaptation, and distribution of educational materials can impede OER adoption. To mitigate these challenges, comprehensive OER policies should incorporate strategies for managing copyright, such as the adoption of Creative Commons licenses. Swettenham (2023) examined the policies of several institutions including the University of Edinburgh, the University of the South Pacific, and the Open University in the UK, which also provided a comprehensive list of OER policies from postsecondary institutions in several countries (Austria, Canada, Germany, Fiji, India, Malaysia, and the UK).

In the context of UWISTA, the development of an OER policy was driven by the need to align with the university's mission and the broader goals of the OER movement. More on this is described in the Methodology section which follows.

Process and Methods

The policy development process at UWISTA involved a comprehensive review of existing OER policies from other institutions, which provided valuable insights and best practices that informed the drafting of the policy. A qualitative research approach was employed to explore the complexities of OER implementation and inform the development of an OER policy. This methodology was selected to provide in-depth insights into stakeholder perspectives and experiences (Creswell & Poth, 2016).

Data Collection Methods

A systematic review of peer-reviewed articles, government reports, and institutional documents was conducted to explore the concept of OER, and its benefits, challenges, and policy frameworks in higher education. There was a total of 44 existing OER policies from HE institutions in several countries. This effort was assisted by consulting a recently completed doctoral thesis on OER policies at Athabasca University (Swettenham, 2023). This policy review provided valuable insights into the different approaches and strategies adopted by other institutions in developing their OER policies. A review of existing related UWI and UWISTA policies and other documents was also included in this review process. This provided valuable information on existing OER policies in higher education, which served as benchmarks and models for the formulation of a specific UWISTA OER policy.

Then, a Google search was conducted using the following keywords "OER Policy" and "Open Educational Resources Policy." No other higher education OER policies were discovered. A search for relevant articles and reports was then conducted using both Google Scholar and the OER Knowledge Cloud

(https://www.oerknowledgecloud.org/). Relevant papers on OER were examined. Documents from UWISTA, UNESCO, and COL that were related to or helpful in understanding the development of an HE OER policy were also consulted. These resources were very helpful in providing direction for developing the OER process at UWISTA. They also contributed to the formulation of questions, which were used in the surveys.

The Survey

An emailed letter with a link to an online survey was sent to more than 40 representative faculty, students, and administrative staff members. This structured questionnaire was intended to gain an understanding of the interest of these staff members and their knowledge of OER, as well as their attitudes, perceptions, and experience with OER. The survey showed that more than 90% of participants had more than ten years of experience in education and that they were familiar with OER. Although few had received any training, some noted that they had experience in using or integrating OER in their teaching or administrative activities. A high proportion (87%) agreed that OER could enhance the quality of the curricula, while believing that the quality and relevance of the OER available was satisfactory. Most also felt that UWI was supportive of OER.

The participants expressed a need for clarity on OER-related terms and how OER aligned with broader institutional goals. The survey included questions on the benefits and challenges of OER and gauged the baseline knowledge and expectations of staff generally. However, it was observed that there was a varied understanding of OER among staff, highlighting the necessity for more OER awareness activities. Concerns regarding copyright issues and potential resistance to change were frequently mentioned, indicating areas that needed special attention during policy development. The responses from the survey provided a foundation for the subsequent stages of the policy development process.

Delphi Focus Groups

In the next stage, UWISTA organized two online Delphi focus groups. The Delphi focus groups were conducted to gather in-depth insights and feedback from university staff. The Delphi method is a structured communication technique that involves a panel of experts who participate in multiple rounds of discussion and feedback. Inclusive online participation was facilitated using Zoom, allowing diverse staff to contribute without geographical constraints. An agenda, along with questions for consideration, was circulated at the meetings. There were 10 participants in the first group and 12 in the second. Participants included a total of 12 women and 7 men.

In the first round, participants were asked to provide their input on key elements of the OER policy, focusing on the potential benefits and challenges. Suggestions were made on staff involvement, integration of OER, and the effect of these both on pedagogy and research. The role of OER in increasing student enrolments and equitable access was also an important consideration raised, focusing on limited Internet connectivity and the needs of students with disabilities.

In the second round, the feedback from the first round was summarized and presented to the participants for further discussion and refinement. There emerged strong support for ensuring that any OER policy must align well with the UWI strategic plan. The importance of understanding copyright law and open licensing

was highlighted. While the focus was on implementing an OER policy in the university environment, participants expressed the importance of exploring partnerships with secondary schools to further increase postsecondary access. The role of AI in creating OER and how this might impact copyright laws was also considered. These further discussions helped build a consensus among the participants and ensure that diverse perspectives were considered.

Thematic analysis was employed to scrutinize the qualitative data. This method allowed for the identification of recurring themes and patterns related to OER implementation and policy development. However, a challenge was observed in achieving a consensus on certain nuanced aspects, pointing to a need for careful facilitation and clarification of policy language. The iterative nature of the Delphi method proved beneficial in refining policy priorities and identifying potential conflicts early in the process.

In-Person Workshop

A three-day, on-site participatory workshop was convened to collaboratively develop a draft OER policy. Key stakeholders, including librarians, faculty, instructional designers, IT staff, students, and administrators were brought together to actively engage in the policy development process. There were 18 participants, all of whom were knowledgeable about OER; most had attended a COL OER workshop earlier. The workshop incorporated a mix of presentations, group discussions, and hands-on activities. Participants were divided into small groups to draft specific policy sections.

OER policy items from a range of other postsecondary institutions were compiled and categorized. On day 1 of the workshop, participants worked together to understand the nature of OER policies and how they might align with the policy environment of UWI. This included agreement on definitions and the purpose of an OER policy for the UWISTA campus. The focus on day 2 was on the development of an appropriate OER policy framework, looking at the policy objectives and agreement on the statements. Copyright and licensing statements were discussed and included in the recommendations along with statements on liability and risk. On day 3, participants developed the procedures to accompany the policy including identifying the responsibilities and accountabilities for policy implementation. Finally, each clause of the draft OER policy was reviewed before acceptance. The meeting concluded with the development of an implementation plan and guidelines.

The first two days were concluded with a quick daily reflections survey in which participants noted their feelings and provided comments, which were universally positive ranging from reflexive and confident to inspired. On the first day, they were overwhelmingly curious and somewhat excited. On day 2 this reversed, and the participants expressed more excitement over curiosity, while showing more confidence and reflection, followed by many positive comments on what they had learnt in the process of developing the policy framework. The final survey showed that participants were mainly very satisfied with the process. None were dissatisfied or neutral. They expressed confidence that the draft policy aligned well with the campus' institutional goals and educational strategies. All agreed that the scope and purpose of the draft OER policy was adequately addressed in the workshop and final draft policy. The majority felt that the guidelines, technical considerations, accessibility, as well as integration of OER into existing institutional systems were all adequately addressed.

This face-to-face workshop fostered a collaborative environment that encouraged active engagement and open discussions. Staff appreciated the opportunity to work collectively on drafting policy sections, promoting a sense of ownership and shared responsibility. Participant insights during the workshop addressed concerns related to OER, copyright, and intellectual property. Through this collaborative process, a draft OER policy emerged that reflected a consensus among participants and incorporated best practices derived from an analysis of other postsecondary institutional policies.

Use of Generative Artificial Intelligence

Artificial intelligence (AI), specifically ChatGPT (Version 4.0), was harnessed to enhance the OER policy framework development process. AI was used to improve the quality of the writing by identifying and correcting errors, increasing readability, and ensuring that the draft policy and procedures were well-structured. To make effective use of AI in the OER policy document, areas were identified where AI could play a role in enriching the content or optimizing the processes.

AI was used to reinforce the consensus arrived at by the participants. Once policy items had been agreed upon, AI was asked to separately and autonomously make recommendations for items that should be included in an OER policy for a university. These AI recommendations were then compared with those produced by the workshop participants. There was a very convincing agreement between them, which helped persuade them of the relevance of their draft policy recommendations. Only minor adjustments were made, using the AI recommendations to improve the clarity of the policy items. AI was used in this way to support the recommendations for both the policy and the procedures, supporting the alignment of both within the policy framework of UWI.

AI was also used to help generate the questionnaire for the survey and provide suggestions for the group meetings and the workshop. It was also helpful in summarizing the data.

Findings and Discussion

The findings from the OER policy development process at UWISTA illuminate a complex landscape of opportunities and challenges. A collaborative approach involving faculty, staff, and administrators proved instrumental in garnering diverse perspectives and aligning the policy with the university's needs. The engagement of stakeholders through surveys, focus groups, and workshops fostered a shared understanding of OER's potential and identified key concerns and priorities.

A comprehensive review of existing OER policies provided valuable benchmarks for policy development. While the literature underscored OER's capacity to enhance teaching, learning, and equity, it also highlighted implementation hurdles such as awareness, faculty resistance, and infrastructure limitations. These insights informed the policy development process and underscored the need for targeted interventions. The implementation of the draft OER policy holds the potential to significantly impact students, faculty, and the institution. For students, the availability of free and openly licensed course materials can reduce financial burdens and improve access to learning resources. Faculty members can benefit from opportunities for professional development, collaboration, and the creation of innovative

teaching materials. At the institutional level, the adoption of OER can contribute to cost savings, enhanced student success, and a stronger reputation as a leader in open education.

Survey results indicated a growing OER awareness but varying levels of knowledge and experience. Positive attitudes towards OER were prevalent, tempered by concerns about quality, accessibility, and sustainability. Focus group discussions deepened this understanding, revealing faculty interest in OER as a pedagogical tool balanced against workload pressures. The culmination of this process was the development of a draft OER policy outlining the university's commitment, defining key terms, and establishing guidelines for OER creation, sharing, and use. The policy also addresses critical issues such as copyright, licensing, quality assurance, and faculty support.

Conclusion and Recommendations

The underuse of OER at the UWISTA presents a significant opportunity to enhance student learning, reduce costs, and promote equity. This study has illuminated the potential of OER while identifying key challenges and opportunities for its adoption. Through a collaborative process involving faculty, staff, and students, a draft OER policy has been developed to address these issues and guide the university towards a more open educational ecosystem. Successful implementation of this policy has the potential to transform teaching and learning, empowering students and faculty while solidifying the university's reputation as a leader in higher education.

To fully realize the benefits of OER, the university must prioritize the following recommendations:

- Invest in faculty development: CETL should continue to provide comprehensive training and support to equip faculty with the necessary skills and knowledge to create and effectively use OER. This includes developing comprehensive OER guidelines, workshops, online resources, and mentorship programs. Additionally, CETL should be resourced to provide technical assistance, copyright guidance, and quality assurance support.

- Build a sustainable OER ecosystem: Foster collaboration among faculty, librarians, and IT departments to create a supportive environment for OER development and sharing. This includes establishing OER repositories, promoting open licensing, and recognizing faculty contributions to OER.

- Evaluate and refine: Implement a continuous evaluation process to assess the impact of the OER policy and make necessary adjustments. This involves collecting data on OER usage, student outcomes, and cost savings to inform future initiatives. By acting on these recommendations, UWISTA can position itself as a pioneer in open education, benefiting students, faculty, and the wider community. As OER continues to gain prominence as a catalyst for democratizing education, UWISTA's commitment to OER can be highlighted and could serve as a resource for the wider academic community and policymakers interested in implementing a similar policy supporting open access to educational content. The description of the process conducted, and the

draft policy that emerged from the consultations can offer insights into the strategies employed and lessons learned.

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