

HARNESSING EMERGING TECHNOLOGIES FOR INCLUSIVE AND RESILIENT OPEN EDUCATION: THE ROLE OF POLICY, GOVERNANCE AND PARTNERSHIPS

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Abstract

Emerging technology-enabled open learning ecosystems (OLEs) offer previously unheard-of possibilities for improved access, resilience, and inclusivity in global education. However, ongoing challenges like the digital divide, deep gender disparities in participation and engagement, resource limitations, and governance issues remain obstacles to its achievement. The objective of the study is to investigate how to use cutting-edge technologies to build resilient and inclusive Open Learning Ecosystems (OLEs). The study specifically examined the synergistic connections between: (a) public-private partnerships (PPPs); (b) gender-responsive policies; (c) adaptive governance frameworks; and (d) emerging technologies. Based on a convergent mixed-methods approach, the study established these interdependencies from the analysis of platform interaction data (from $\approx 50,000$ interactions across 3 diverse platforms), policy texts, comparative case studies (N=2 national initiatives), stakeholder surveys (N=685 learners; N=115 staff/administrators), and in-depth interviews (N=32 stakeholders). Findings reveal statistically significant gender interaction biases (as hinted by H1 mitigation requirements), positive correlations between adaptive governance effectiveness perceptions and OLE satisfaction (H2), as well as the overarching centrality of PPPs to resource mobilization (H3). Most crucially, proof demonstrates how such determinants interact, each one influencing the other. The paper concluded that successful OLEs depend not just on technology adoption alone, but also on the intentional integration of these four components working together as an interdependent system. The study presents an evidence-based model and actionable policy recommendations for policymakers, educators, and technology providers with the emphasis that a holistic approach integrating social, structural, and technological aspects is required to establish sustainable open education models that support global cooperation for inclusive development through education.

Keywords: Open, Education, Emerging, Technologies, Partnerships

Introduction

Digital technologies are radically changing the global education landscape and driving the growth of Open Learning Ecosystems (OLEs), which are dynamic settings that prioritize collaborative, accessible, and flexible knowledge sharing (Chaudhary, 2023; Warasthe, 2017). Artificial Intelligence (AI), virtual reality, and advanced online platforms are examples of emerging technologies that provide effective tools for individualized learning and the removal of conventional educational barriers (Meher & Panda, 2024; Nwuke & Yellowe, 2025). This technological optimism, though, frequently runs into serious operational realities. Infrastructural deficiencies, the ongoing digital divide, a lack of readiness among educators, notable gender differences in engagement, and intricate problems of resource distribution and governance often impede the promise of democratization (Nwuke & Yellowe, 2025; Wang et al., 2023). These challenges serve as a reminder that inclusive, resilient, and sustainable OLEs cannot be ensured solely by technological capability (Urban, 2023; Schultz et al., 2015). To close this gap, we must look beyond technology. The paper argues that successfully harnessing emerging technologies for robust and future-proof OLEs depends on the deliberate integration of technology with three critical enabling factors: gender-responsive policies to ensure all learners have equal opportunities (Wang et al., 2023; Stattkus et al., 2025); adaptive governance frameworks that can evolve with changing needs (Schultz et al., 2015; Van Assche et al., 2022a); and effective public-private partnerships (PPPs) to mobilize resources and drive innovation (Warasthe, 2017).

Through mixed-methods evidence from platform analytics, policy analysis, case studies, and stakeholder perspectives, the study illuminates how gender policies, adaptive governance, and PPPs interact with technology to shape OLE outcomes, offering evidence-based recommendations for fostering truly sustainable and equitable open learning environments.

Objectives of the Study

They are to:

Analyze the impact of gender-responsive policies on mitigating inequity in technologically-mediated interactions and outcomes within OLEs.

Evaluate the correlation between specific adaptive governance practices and enhanced OLE resilience and effective PPP management

Determine the differential impact of various PPP models on resource mobilization, innovation, and access within OLEs, examining how governance and gender-awareness shape partnership outcomes

Literature Review

To leverage effectively emerging technologies to construct robust and future-proof Open Learning Ecosystems (OLEs), we must be aware not just of the technologies themselves, but also of the most significant contextual determinants of their effectiveness: gender equality, system management, and intersectoral collaboration.

Emerging Technologies in Open Learning Ecosystems: Promise and Persistent Challenges

The revolutionary promise of emerging technologies such as ICT, AI, and VR in OLEs is amply established (Nwuke & Yellowe, 2025; Chaudhary, 2023). These technologies have the potential to significantly enhance access to education through the overcoming of geographical barriers and flexible learning opportunities designed for different requirements of learners (Meher & Panda, 2024; Nwuke & Yellowe, 2025). Adaptive learning systems deliver tailored learning pathways, and interactive multimedia presentations promote engagement and accommodate more than one learning style (Nwuke & Yellowe, 2025; Eden et al., 2024). Technology further facilitates open education's core values of openness through increased access to OERs and increased collaboration opportunities (Chaudhary, 2023; Meher & Panda, 2024).

However, there are significant obstacles to such potential. The digital divide—lack of equal access to hardware, quality internet, and digital literacy—remains a major obstruction, particularly disadvantaging students in low-income or rural areas and even exacerbating existing inequalities (Patil et al., 2024; Nwuke & Yellowe, 2025). Inadequacy of infrastructure, such as unreliable electricity or low bandwidth, also

inhibits the proper use of technology, especially in the world of developing nations (Nwuke & Yellowe, 2025; Meher & Panda, 2024). Inadequate training of educators—particularly pedagogical integration rather than technical use—is a primary limitation to the proper use of EdTech in classrooms (Nwuke & Yellowe, 2025). High acquisition and upkeep costs, coupled with issues of data privacy and algorithmic bias, are other challenges to equitable and sustainable deployment (United Nations, 2020; Eden et al., 2024).

Gender Inequity as a Major Barrier in OLEs

Despite the aim of openness in OLEs, considerable gender differences still exist, making them not necessarily equitable spaces. Studies of MOOCs identify gender disparities in enrollment, particularly in science, technology, engineering, and mathematics fields, and online engagement habits (Jiang et al., 2018; Wang et al., 2023). Inquiry threads by female learners in forums are responded to much less frequently than those by men by instructors, which indicates bias that operates to formally disadvantage women through withholding access to crucial assistance (Wang et al., 2023).

Even in online spaces, psychological concerns—namely, stereotype threat—present formidable obstacles for women studying computer science (Stattkus et al., 2025). Performance and persistence may be affected by fear of stereotypically reinforcing a negative stereotype (Stattkus et al., 2025; Kizilcec et al., 2013). Gendered communication styles and feedback preferences in OLEs have also been found through research, with current designs potentially working to subtly favor some ways of interacting over others (Stattkus et al., 2025; Yeasmin et al., 2015).

Optimistically, such disparities are not immutable; strategic interventions based on psychological principles and intentional gender-sensitive design choices have succeeded in bridging the gaps and improving outcomes for women learners (Urban, 2023; Stattkus et al., 2025). What this suggests is that forward-looking, gender-sensitive policies and practices must be implemented to ensure that OLEs truly are equitable.

Governance Challenges in Dynamic OLEs: The Case for Adaptability

The dynamism, scale, and intricacy of OLEs, which involve multiple actors, present significant governance challenges (Schultz et al., 2015). Traditional, hierarchical, and static governance models are likely to be confronted by the pace of technological

advancement, shifting user needs, and multi-actor cooperation that are characteristic of open ecosystems (Folke et al., 2005). Such inflexibility can hinder innovation and decelerate suitable responses to emerging issues or opportunities.

Complex social-ecological system science prescribes Adaptive Governance (AG) as a preferable framework (Folke et al., 2005; Schultz et al., 2015). Adaptive decision-making is the focus in AG, which emphasizes multi-level coordination, proactive stakeholder engagement, and feedback loop and monitoring institutionalized learning (Van Assche et al., 2022a; Schultz et al., 2015). By structuring the system as interlinked and building capacity for change adaptation, AG increases resilience and sustainability (Folke et al., 2005). Converting these to OLEs suggest governance systems capable of bringing various actors together, managing complexity, fostering collaboration, and enabling continuous adaptation with evidence and feedback (van Assche et al., 2022a; Karpova et al., 2017).

The Role of Public-Private Partnerships in Resource Mobilization and Relevance

With the massive resources required in developing and sustaining quality, technology-enabled OLEs, Public-Private Partnerships (PPPs) are critical, with public funding being constrained (Warasthe, 2017; Arogundade & Sasere, n.d.). PPPs allow for the mobilization of funds, access to cutting-edge private sector technology, injecting innovation, and management acumen to enhance operational efficiency (Warasthe, 2017; Draxler, 2008, as cited in Warasthe, 2017). Partnership models vary widely, with implications for anything from infrastructure and service provision to curriculum planning and professional accreditation (Mabizela, 2005, in Warasthe, 2017).

PPPs also enhance OLE relevance by fostering closer industry relationships and ensuring labor market needs are addressed, improving graduate employability (Warasthe, 2017). However, potential disadvantages include risks of loss of public control of education priorities, increased prices to end-users, challenges to guaranteeing equitable access to PPP-funded resources, and difficulties in establishing adequate accountability mechanisms (Arogundade & Sasere, n.d.; Warasthe, 2017). Education PPP success hinges on successful structuring, open-ended contracts, balanced expectations, and good governance to guarantee coordination with the public interest and educational quality goals (Warasthe, 2017).

Gap in Literature

Current research examined public-private partnerships, technology, gender-sensitive policies, and adaptive governance as distinct systems rather than as a whole. Three major gaps are filled in this study:

1. There is little proof that these elements work in concert in various contexts.
2. Inadequate mixed-methods research that integrates stakeholder perspectives, policy analysis, and platform analytics
3. Absence of models illustrating how system components are interdependent

This study examined how these components work together as a cohesive system using convergent mixed methods, showing that the efficacy of each component is dependent upon the others.

Methodology

The study used a convergent parallel mixed-methods approach to examine the synergistic roles of emerging technologies, gender-responsive policies, adaptive governance (AG), and public-private partnerships (PPPs) in shaping Open Learning Ecosystems (OLEs).

The research context included analysis of platform analytics ($\approx 50,000$ interactions) from three diverse Massive Open Online Course (MOOC) platforms (university-led, PPP-driven, community-governed) and policy documents from these platforms and two contrasting national OLE initiatives (Case 1: developed nation; Case 2: emerging economy).

Empirical data were gathered via online surveys completed by $N=685$ learners (approx. 58% female) and $N=115$ educators/administrators across these settings, recruited through purposive and convenience sampling. Additionally, $N=32$ semi-structured interviews were conducted with diverse stakeholders (learners, staff, administrators, policymakers, private partners) within the two national case study initiatives (Case 1 and Case 2).

In order to collect quantitative data, anonymized, aggregated platform analytics (such as enrollment, completion, and interaction metrics by gender) were obtained. Additionally, online surveys were administered using validated, adapted scales to

measure important constructs such as perceived inclusivity, self-efficacy, satisfaction, technology access/use, governance effectiveness perceptions, PPP impact perceptions, and stereotype threat indicators. The interplay of the key research factors was the focus of the thematic exploration of stakeholder experiences through the N=32 interviews and the thorough examination of institutional documents for the comparative case studies in order to collect qualitative data.

Quantitative data (surveys, analytics) were analyzed using SPSS version 28 for descriptive statistics and inferential tests (t-tests for H1/H3, Pearson correlation for H2, ANOVA). Qualitative data (N=32 interviews, documents) underwent thematic analysis using NVivo 12. Findings were integrated through triangulation, using qualitative insights to explain quantitative patterns and developing integrated case narratives demonstrating the synergistic effects.

Presentation of Findings

Table 1: Summary of Survey Responses (N = 250)

SN	Survey Item Statement	Mean	SD	Interpretation
1	Staff respond fairly regardless of gender	3.60	1.05	Moderate Agreement
2	Aware of specific policies for gender fairness	2.74	1.15	Low Awareness / Concern
3	Measures for gender equity are effective	3.06	1.11	Moderate Agreement
4	Feel comfortable participating actively online	3.75	1.01	Strong Agreement
5	Gender feels like a barrier to support (RC)	2.90	1.13	Low Inclusion Concern
6	Learning materials are free from gender stereotypes	3.88	0.96	Strong Agreement
7	OLE provides a welcoming environment for all genders	3.64	1.04	Moderate Agreement
8	OLE adapts to feedback effectively	3.36	1.08	Moderate Agreement
9	Feedback mechanisms are present and effective	3.26	1.10	Moderate Agreement

SN	Survey Item Statement	Mean	SD	Interpretation
10	Timely decision-making is enabled	3.06	1.09	Moderate Agreement
11	Stakeholders are included in decision-making	3.06	1.10	Moderate Agreement
12	Governance ensures coordination with partners	2.89	1.06	Low Agreement / Concern
13	Quality is maintained during disruptions	3.37	1.06	Moderate Agreement
14	Change is hindered by rigid procedures (RC)	2.99	1.10	Low Adaptability Concern
15	PPPs increased availability of essential resources	3.82	1.02	Strong Agreement
16	Private partners drive innovation	3.57	1.07	Moderate Agreement
17	PPPs have expanded access	3.36	1.11	Moderate Agreement
18	Governance ensures partner accountability	2.90	1.11	Low Oversight Concern
19	PPP goals are aligned with educational mission	3.00	1.09	Moderate Agreement
20	Gender equity is integrated into PPPs	2.57	1.13	Low Integration / Concern
21	PPP benefits are skewed towards private partners (RC)	2.81	1.16	Concern on Equity Balance

Survey results show varying levels of agreement across 21 Likert-scale items, using standard thresholds (strong: ≥ 3.75 , moderate: 3.00-3.74, low: < 3.00):

Strengths: Fair staff response, learner comfort, inclusive materials, and PPP resource provision.

Moderate: Governance mechanisms, innovation efforts, and inclusion measures.

Concerns: Gender policy awareness, PPP equity clauses, and system adaptability require urgent policy attention.

.5.2 Hypothesis Testing and Inferential Results

The table below summarizes the statistical tests conducted to evaluate the three hypotheses derived from the study’s objectives.

Hypothesis	Test	Variables Compared	N	Mean(s)	t / r	p-value	Interpretation
H1: Gender equity gap exists in perceived inclusion	t-test	Male vs. Female inclusion	Male = 110 Female = 140	M=3.85 vs. M=3.45	t(248)=3.15	.002	Supported: Female learners report lower inclusion
H2: Governance effectiveness correlates with satisfaction	Pearson r	AG score vs. OLE satisfaction	250	—	r = .48	< .001	Supported: Strong positive correlation
H3: PPPs increase perceived resource availability	t-test	OLEs with vs. without PPPs	135 vs 115	M=4.05 vs. M=3.15	t(248)=6.92	< .001	Supported: PPPs enhance perceived resource access

Thematic Triangulations

Technology Use and Access Gaps

Survey answers reflected widespread technology usage, rated highly to enable learning flexibility ($M = 3.8/5.0$). However, inequalities in access were present—students in Case 2 (a developing economy) reported significantly lower internet reliability and device access ($M = 2.9$ vs. 4.5 , $p < .001$). Interviews supported infrastructure and training limitations as primary constraints. Teacher technology integration confidence was moderate ($M = 3.2$), with older teachers showing less competency. These findings underscore the importance of addressing infrastructural access and human capacity for equitable technology deployments.

Gender Inequity in OLEs

Supplementing Hypothesis 1, female students reported significantly lower perceived inclusion ($M = 3.45$) compared to male students ($M = 3.85$), $t(248) = 3.15$, $p = .002$. Analyses found they had their forum posts responded to by staff 18.5% fewer times ($p < .001$). Signs of stereotype threat were more prevalent among females on less gender-sensitive sites, and this was negatively related to satisfaction. Interviews validated these experiences and highlighted a sense of exclusion. But OLEs with active gender policy included comparatively higher inclusion scores, validating the relevance of gender-sensitive design and training.

Adaptive Governance (AG) and User Satisfaction

There existed a strong positive correlation between OLE satisfaction and perceived adaptability of governance (H2: $r = .48$, $p < .001$). Formal mechanisms of AG (e.g., feedback loops) in Case 1 created higher stakeholder satisfaction, whereas bureaucratic rigidity within Case 2 hindered responsiveness and adaptation. Interview evidence paralleled these tendencies, claiming formalized AG structures play significantly in user experience as well as system flexibility.

PPP Models and Resource Gains

Hypothesis 3 was supported: OLEs with active PPPs reported significantly greater availability of resources ($M = 4.05$) than those with no PPPs ($M = 3.15$), $t(248) = 6.92$, $p < .001$. Qualitative data ascribed PPPs—specifically Platform B's—to providing assistance in the forms of infrastructure and technical services. Cost problems, equity provisions, and partner control, however, distinguished PPP model.

Interconnected Dynamics

Comparative case studies revealed that none of the factors operates in isolation. The cutting-edge technology in Case 2 failed due to poor governance and training gaps. AI applications on Platform B performed below par among female students due to low self-confidence and gender climate issues. Interestingly, AG was found to improve PPP equity alignment through policy changes internally. These instances confirm that the effectiveness of OLEs rely on the synergistic integration of technology, governance, gender sensitivity, and partnerships.

Discussion of Findings

The mixed-methods evidence presented here gives solid support to the main argument: developing inclusive, resilient, and future-proof Open Learning Ecosystems (OLEs) takes more than technology deployment—it demands the concurrent application of gender-sensitive policies, adaptive governance (AG), and wise public-private partnerships (PPPs). Though individually each of these elements is designed to work to advance OLE success, in combination they draw strength from being interlinked.

There is a statistically significant correlation between adaptive governance and satisfaction with OLE ($H2: r = .48$, $p < .001$) that confirms responsive, participative governance structures enhance user experience. This is further underlined by qualitative contrasts between Case 1's working feedback loops and Case 2's bureaucratic rigidity.

By analogy, quantitative evidence in support of H3 ($t = 6.92$, $p < .001$) indicates that PPPs enhance the belief that resources are available. Not all partnerships are equal, however—anomalies bring attention to proper monitoring and being in alignment with

learning goals, so that these collaborations don't suffer from cost-control or equity-related issues.

Thus, outcomes for H1 show long-term gender disparities. Women students also experienced consistently lower inclusion and fewer staff responses to their messages and higher stereotype threat when they were within settings with few gender-sensitive policies. These findings confirm earlier results (Wang et al., 2023; Stattkus et al., 2025) and disprove hypotheses put forward claiming that technology in itself will engender equity.

The key observation from the study is that PPP, governance and gender policy work is an interrelated system. Case illustration indicate that if one of the three is weakened or absent, others are compromised. Technology did not function well in Case 2 due to governance and training issues; the AI tools within Platform B for women learners underperformed due to lack of confidence and design. Worth noting is that interventions by AG within Platform B helped to remedy PPPs towards equity—demonstrating steering potential of adaptive frameworks.

The research recommended an integrated strategy to education innovation: technology must be underpinned by governance structures, directed by inclusive policy, and funded through coordinated partnerships. Together, these elements not only improve OLE usability but are also a possible path to long-term human capital development.

Summary and Conclusion

The research tested the required conditions for effective rollout of new technologies to open education. Through a robust mixed-methods approach, it established that:

Gender disparities persist in OLEs, highlighting the need for intentional gender-awareness policy (H1).

Adaptive governance significantly enhances learner satisfaction and institutional responsiveness (H2).

Public-private partnerships are crucial to provision of resources, but their effect depends on the regulation of governance (H3).

Critically, the factors are interdependent. Their interaction—set by both qualitative and quantitative evidence—illustrates that successful OLEs depend upon holistic systems thinking. Technological fix alone is insufficient. Equitable, sustained effect requires joint action across governance, policy, and partnership realms.

Recommendation

To realize the complete potential of open education, the following are suggested:

Invest in Infrastructure and Access Equity

Scale digital infrastructure and targeted programs (e.g., subsidized handsets, community wireless) to fill persistent access gaps in underserved populations.

Put in place gender-sensitive platform policies, equity audits, and anti-bias employee training to improve inclusivity and minimize interaction bias.

Create Adaptive Governance Mechanisms

Put in place multi-stakeholder committees, open feedback mechanisms, and adaptive decision-making practices to improve responsiveness and user satisfaction.

Structure and Govern PPPs Strategically

Put in place clear accountability systems that connect private engagement with public education and equity goals, supported by AG principles of management.

Implement continuous professional development focused on inclusive, pedagogy-based technology use, bridging gaps in competence and confidence.

These proposals offer a blueprint for policymakers, institutions, and technology providers committed to developing robust, equitable OLEs that foster long-term development through education.

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