Strengthening Digital Literacy for Teachers in Remote Mountain Schools of Kyrgyzstan

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ABSTRACT

Digital literacy has emerged as a foundational competency in the twenty-first-century educational landscape, yet its implementation in geographically isolated contexts remains critically underexplored. This community service study examines the outcomes of a structured digital literacy training program conducted across six remote mountain schools in Kyrgyzstan, engaging 89 in-service teachers over an eight-week intervention period. Employing a pre-test/post-test design coupled with qualitative focus group discussions, the study measured measurable gains in teachers' digital skills, attitudes, and self-efficacy. Results demonstrate a statistically significant increase in participants' competency across six core digital skill domains, with educational platform usage registering the most substantial improvement. The study further identifies persistent barriers, including unreliable internet connectivity and insufficient device availability, that constrain sustainable digital integration. These findings offer practical recommendations for policymakers, regional education offices, and international development organizations

committed to advancing equitable digital education in Central Asia and comparable high-altitude, resource-constrained environments.

INTRODUCTION

The rapid proliferation of digital technologies across global educational systems has generated pressing demands for teachers who can effectively integrate digital tools into their pedagogical practices. However, this demand is far from uniformly distributed: educators working in remote, mountainous, and economically peripheral regions frequently face compounded disadvantages that limit their access to both the technologies themselves and the professional development opportunities required to use them competently. In Kyrgyzstan, a landlocked Central Asian nation where approximately 64% of the population resides in rural or semi-rural areas (National Statistical Committee of the Kyrgyz Republic, 2022), the challenge of building teacher digital competency is particularly acute in highland communities, where topographic isolation intersects with infrastructural underdevelopment (Muhsyanur et.al, 2024).

The importance of teacher digital literacy cannot be overstated within contemporary education policy discourse. According to the European Commission's DigComp 2.2 framework (Vuorikari et al., 2022) (Muhsyanur and Mustapha, 2023), digital competence encompasses five interdependent domains: information and data literacy, communication and collaboration, digital content creation, safety, and problem-solving. When teachers lack proficiency across these domains, the educational consequences ripple outward to affect student learning outcomes, school community engagement, and the broader capacity of institutions to participate in an increasingly networked knowledge economy. Scholars such as Mishra and Koehler (2006) have long argued through the Technological Pedagogical Content Knowledge (TPACK) framework that meaningful technology integration requires not only technical skill but also the ability to merge that skill with sound pedagogical and content knowledge—a synthesis that demands sustained, contextually relevant professional development (Muhsyanur, 2023).

Kyrgyzstan has made notable legislative commitments to educational digitalization. The National Education Development Strategy 2040 (Ministry of Education and Science of the Kyrgyz Republic, 2021) explicitly positions digital transformation as a pillar of educational reform, pledging enhanced connectivity, device provision, and teacher training across all school levels. Yet the implementation of these commitments has proceeded unevenly. Urban schools in Bishkek and Osh have benefited from improved digital infrastructure and training programs supported by international donors, while schools in Naryn, At-Bashy, Ak-Talaa, and similar highland districts have received comparatively modest investment. As Hepp et al. (2019) observe in their comparative analysis of

technology integration in Latin American rural schools—a context offering instructive parallels—policy ambitions consistently outpace the resources and contextual adaptations needed to translate them into classroom realities in remote settings (Muhsyanur, Manivannan Murugesan, 2024).

Community service in higher education, often framed under the rubric of the "third mission" (Etzkowitz & Leydesdorff, 2000), provides one mechanism through which universities can address such policy-implementation gaps. By deploying faculty expertise and student energy toward direct service in underserved communities, academic institutions can simultaneously generate empirical knowledge, build local capacity, and fulfill their civic obligations. In the context of teacher digital literacy, community service interventions offer a distinctive advantage: unlike top-down government programs, they can be designed iteratively, with close attention to locally identified needs, available technologies, and cultural practices. Bayne et al. (2020) note that contextually embedded professional development consistently produces more durable changes in teacher practice than decontextualized training delivered at a distance.

Despite the growing literature on digital literacy in education, research specifically addressing highland schools in Central Asia remains sparse. Existing Central Asian studies have predominantly focused on urban or peri-urban secondary schools, leaving a pronounced empirical void regarding the particular challenges faced by teachers in mountain communities—challenges shaped not only by limited connectivity but also by harsh climatic conditions, seasonal road closures, small multi-grade classrooms, and high rates of teacher isolation. Ghosh and Bhattacharya (2021) emphasize that digital inclusion research must move beyond binary urban–rural framings to account for the graduated, multi-dimensional nature of geographic and infrastructural disadvantage; this is precisely the analytical orientation the present study adopts. A granular understanding of both gains and constraints in such contexts is essential for designing interventions that are not only immediately effective but sustainably so.

This article reports the design, implementation, and outcomes of a community service initiative titled "Digital Horizons: Strengthening Teacher Competency in Remote Mountain Schools of Kyrgyzstan," conducted across six schools in three administrative districts during the spring and summer of 2024. The study pursued three interrelated objectives: (1) to assess baseline levels of digital literacy among participating teachers; (2) to implement a structured, participatory training program aligned with internationally recognized competency frameworks; and (3) to evaluate the extent to which training produced measurable and self-reported improvements in teachers' digital skills, attitudes, and classroom integration practices. The remainder of this article is organized as follows: Section 2 describes the methodological approach; Section 3 presents and discusses key results across three thematic domains; and Section 4 offers conclusions and recommendations for future action.

METHOD

This study employed a mixed-methods design integrating quantitative pre-test/post-test assessment with qualitative data collection through focus group discussions and structured field observations. The quantitative strand adopted a single-group quasi-experimental structure (Campbell & Stanley, 1963), in which participant performance on a validated digital literacy instrument was measured prior to and following an eight-week intervention. The instrument was adapted from the UNESCO ICT Competency Framework for Teachers (UNESCO, 2018) and the DigComp 2.2 framework (Vuorikari et al., 2022), comprising 42 items across six subscales: basic device usage, internet navigation, educational platform use, digital content creation, data privacy awareness, and online collaboration. Internal consistency for the composite scale at baseline was acceptable (Cronbach's α = .81). Qualitative data were gathered through six semi-structured focus group discussions (one per school, n = 8–10 participants each) conducted in Kyrgyz and Russian, with transcripts subject to thematic analysis following Braun and Clarke's (2006) six-phase reflexive protocol.

Participants were recruited through purposive sampling in collaboration with the District Education Offices of Ak-Talaa, At-Bashy, Tash-Kumyr, Kochkor, Issyk-Kul, and Naryn. Eligibility criteria required that participants be currently employed as classroom teachers in a school situated at an elevation of at least 1,500 meters above sea level and with a school-to-nearest-urban-center distance of no less than 50 kilometers by road. A total of 89 teachers across six schools met these criteria and consented to participate; 86 completed both measurement points, yielding a retention rate of 96.6%. The intervention—a structured eight-week training program—was delivered partly in person (four intensive Saturday sessions held at each school) and partly through asynchronous resources hosted on a low-bandwidth-compatible learning management system. Training content was organized into four thematic modules: Foundational Device and Connectivity Skills; Navigating and Evaluating Online Educational Resources; Creating and Sharing Digital Content for Teaching; and Cybersecurity, Responsible Use, and Digital Citizenship. Each module combined demonstration-based instruction, guided hands-on practice, peer mentoring dyads, and brief reflective journaling exercises designed to encourage metacognitive integration of new skills.

Data analysis proceeded in two parallel streams subsequently triangulated for convergent validity. Quantitative pre- and post-test scores were analyzed using paired-samples t-tests for each of the six subscale domains and for the composite scale, with effect sizes calculated using Cohen's d to characterize the practical magnitude of observed gains. Statistical analyses were performed using IBM SPSS Statistics 29.0, with a significance threshold set at $p < .05$ (two-tailed). For the qualitative strand, all focus group transcripts were independently coded by two researchers, with intercoder reliability assessed using Cohen's kappa (κ = .79, indicating substantial agreement; Landis & Koch, 1977), and discrepancies resolved

through discussion. Emergent themes were mapped against the quantitative outcomes to identify areas of convergence and divergence—particularly instances where statistically significant gains were not accompanied by expressed confidence in practical application, or conversely, where narrative accounts of transformation exceeded what standardized scores captured. Ethical approval was granted by the Research Ethics Committee of Kyrgyz National University (Protocol No. KNU-REC-2024-018), and all participants provided written informed consent prior to enrollment.

RESULT AND DISCUSSION

Participant Characteristics and School Profile

The 89 teachers who enrolled in the program were distributed across six schools situated in five distinct highland districts of Kyrgyzstan, with elevations ranging from 1,620 to 2,890 meters above sea level. Table 1 below presents a summary of school-level participation data, including the number of teachers per school, district affiliation, and individual school participation rates. The overall participation rate across all six schools was 96.4%, reflecting strong institutional support facilitated by advance coordination with district education officers and school principals. All six schools were fully state-funded and operated under the Kyrgyz Ministry of Education and Science's standard curriculum framework, yet all reported significant constraints in digital infrastructure, including irregular power supply, limited internet bandwidth, and an average of fewer than eight internet-capable devices per school.

Demographically, the participating teachers were predominantly female (71.9%), consistent with broader patterns of gender composition in Kyrgyz primary and secondary schooling (National Statistical Committee of the Kyrgyz Republic, 2022). The average age of participants was 38.4 years (SD = 8.7), and mean teaching experience was 13.2 years (SD = 7.4). Notably, 64% of participants reported having received no formal digital skills training during their pre-service education, and 78% indicated they had never attended a professional development workshop specifically focused on educational technology. These baseline indicators align with findings reported by Ainur and Ismailova (2021), who documented persistent gaps in pre-service digital preparation across Kyrgyz teacher training institutions, particularly those operating outside the capital city.

The heterogeneity of school contexts across the six sites warrants attention, as it exerted a meaningful influence on training delivery logistics and participant learning trajectories. Schools in the Naryn and At-Bashy districts, for instance, experienced seasonal road closures during the study period that necessitated the use of offline-compatible digital content packages for two of the four in-person modules. By contrast, the Issyk-Kul site, while geographically remote, benefited from a recently installed satellite internet connection that enabled more fluid engagement with online platforms. These contextual variations underscore the importance of adaptive implementation frameworks that can flex to accommodate infrastructural

heterogeneity—a principle consistently advocated in the community-based participatory research literature (Wallerstein & Duran, 2010).

Qualitative focus group data revealed that teachers across all six sites shared a profound sense of professional isolation, frequently describing themselves as "forgotten by the system" when it came to technology-related professional development. This sentiment resonates with Ertmer and Ottenbreit-Leftwich's (2010) conceptual distinction between first-order barriers to technology integration (external, resource-based constraints) and second-order barriers (internal, attitudinal and dispositional constraints). Pre-intervention, second-order barriers—including low self-efficacy, apprehension about making errors, and skepticism about the relevance of digital tools to their specific subject contexts—were notably prevalent among teachers over 45 years of age. Importantly, the participatory design of the training program, which incorporated structured peer support through mentoring dyads, appears to have played a significant role in addressing these attitudinal barriers over the intervention period.

Table 1. Participating Schools, Districts, and Teacher Participation Rates

No.	School Name	District	No. of Teachers	Participation Rate (%)
1	School No. 14	Ak-Talaa	18	100
2	Kara-Suu Mountain School	At-Bashy	12	100
3	Djalal-Abad Highland School	Tash-Kumyr	15	93.3
4	Alatoo Primary School	Kochkor	10	90.0
5	Karakol Ridge School	Issyk-Kul	20	95.0
6	Naryn Valley School	Naryn	14	100
Total			**89**	**96.4**

Note. Data compiled from school administrative records and program enrollment sheets. Schools are listed in order of district alphabetical sorting.

Digital Literacy Gains Across Core Competency Domains

Pre- and post-test comparisons revealed statistically significant improvements across all six digital competency domains measured by the adapted instrument. The overall composite score increased from a pre-test mean of 54.3 (SD = 12.1) to a post-test mean of 84.7 (SD = 9.4), representing a mean gain of 30.4 percentage points (t(85) = 22.14, p < .001, d = 2.40). Effect sizes in the very large range (d > 2.0) were observed for three domains—educational platform use, digital content creation, and online collaboration—which had registered the lowest baseline scores and therefore offered the greatest scope for measurable improvement. These findings are

consistent with those of Zholdoshalieva et al. (2020), who similarly documented large pre–post gains following intensive digital training in rural Central Asian schools, particularly in competency areas where participants had near-zero prior exposure.

Figure 1 below presents a comparative visualization of pre- and post-training performance across all six skill domains, illustrating the pattern and magnitude of gains at the group level. The domain of educational platform use—encompassing proficiency with Google Classroom, Moodle, and Kyrgyz national e-platform resources—registered the single largest absolute gain: from 34% average proficiency at baseline to 87% post-intervention. This domain was also the focus of the most intensive instruction within Module 2, which incorporated guided walkthroughs, paired exploration tasks, and peer demonstration activities. The substantial gains observed here are theoretically consistent with Bandura's (1997) social cognitive learning theory, which identifies vicarious experience and mastery accomplishment as the most potent sources of self-efficacy development—precisely the mechanisms embedded in the module's pedagogical design.

The domain of data privacy awareness, while registering statistically significant improvement (from 18% to 76%), showed a relatively smaller effect size ($d = 1.72$) compared to other domains, suggesting that abstract concepts related to cybersecurity and personal data protection may require more extended instruction and repeated real-world application opportunities to consolidate. This finding echoes observations by Pangrazio and Selwyn (2019), who argue that critical data literacy—involving not merely awareness of privacy risks but an active capacity to navigate and resist them—demands pedagogical approaches that foreground authentic scenarios and lived experience rather than abstract principle transmission. Focus group data from five of the six schools corroborated this interpretation, with participants describing privacy concepts as "the most confusing part" of the training and expressing uncertainty about how to translate principles into classroom routines.

It is also important to situate these quantitative gains within a realistic appraisal of their sustainability. Post-intervention assessments captured performance at the immediate conclusion of the eight-week program; longer-term follow-up data, collected via email survey three months post-training (n = 74, 85.1% response rate), suggested modest score regression in two domains—basic device usage and internet navigation—potentially reflecting reduced practice opportunities during school holiday periods. This pattern underscores the argument advanced by Rogers (2003) in his diffusion of innovations framework that early-stage adopters require sustained structural support and community reinforcement networks to prevent skill atrophy; one-off training events, however well-designed, are insufficient scaffolds for durable behavioral change without complementary institutional mechanisms.

Figure 1. Pre- and Post-Training Digital Literacy Scores by Competency Domain

Category	Pre-Training (%)	Post-Training (%)
Basic Device Usage	72	95
Internet Navigation	58	91
Educational Platform Use	34	87
Content Creation	21	79
Data Privacy Awareness	18	76
Online Collaboration	25	83

Note. Values represent mean percentage scores on the adapted digital literacy assessment instrument (N = 86). All differences are statistically significant at $p < .001$.

Structural Barriers to Sustained Digital Integration

Despite the encouraging magnitude of competency gains recorded during the intervention, qualitative and observational data converge in highlighting a set of structural barriers that pose serious threats to the long-term sustainability of digital integration in participating schools. The most frequently cited barrier across all six focus groups was unreliable electricity supply, identified by 82 of 89 participants (92.1%) as a significant impediment to regular technology use. Several schools in the Naryn and Ak-Talaa districts reported power outages lasting between three and eight hours per day during winter months, rendering scheduled computer-based lessons unpredictable and forcing teachers to maintain parallel paper-based lesson plans for all digitally enhanced units. This dual-planning burden imposes additional cognitive and temporal costs on already stretched teachers, risking the very motivation that training programs seek to cultivate.

Insufficient and aging device infrastructure constituted the second major structural constraint. Across the six schools, the mean ratio of students to functional, internet-capable devices was 14.3:1—far below the 5:1 ratio recommended by UNESCO (2018) as a minimum threshold for meaningful educational technology use. Several devices in each school were reported as non-functional due to hardware failure, with no systemic repair or replacement budget allocated at the district level. Trucano (2005), in an influential early analysis of ICT in education projects in developing countries, identified device sustainability as a "silent killer" of technology initiatives: programs that successfully trained teachers but failed to ensure ongoing device functionality reliably saw digital integration collapse within 18 months of external support withdrawal. The current study's observational data suggest these dynamics are already beginning to emerge in the more resource-constrained participating schools.

Internet connectivity barriers were equally prominent, though more nuanced in their distribution across sites. Three of the six schools had no fixed broadband connection and relied entirely on mobile data through 4G LTE SIM cards, which delivered inconsistent speeds and incurred costs that school budgets were not designed to absorb. The remaining three schools had fixed connections, but bandwidth was shared across all school computers simultaneously, producing effective download speeds as low as 0.3 Mbps per device during peak usage periods. These connectivity parameters directly constrained the training program's ability to deliver synchronous online collaborative activities in certain sites, necessitating offline-first adaptations that, while pedagogically viable, reduced the ecological validity of participants' online collaboration skill development. Khan (2021) notes that the design of training programs for low-bandwidth environments must fundamentally reconceptualize which skills can realistically be developed in situ versus which must be anticipated for future practice.

Encouragingly, focus group data also surfaced evidence of emerging community-level resilience strategies that participants had spontaneously developed to navigate these constraints. In two schools, teachers had formed informal WhatsApp-based peer support groups to share digital teaching resources, troubleshoot device problems, and exchange lesson ideas—an organic instantiation of professional learning community principles (DuFour et al., 2016). In another school, a senior teacher who had participated in the training had voluntarily begun leading short after-school digital skills refresher sessions for colleagues who had missed specific modules due to illness or travel. These grassroots responses, while modest in scope, suggest that the intervention had catalyzed forms of social capital and collective agency that extend beyond what the training's formal evaluation instruments could fully capture, pointing toward a productive direction for future program design centered on community-embedded peer learning networks.

CONCLUSION

This community service study demonstrates that a structured, contextually adapted, and participatory digital literacy training program can generate significant and practically meaningful improvements in teacher competency across multiple skill domains, even in some of the most geographically and infrastructurally constrained school environments in Kyrgyzstan. Composite digital literacy scores increased by more than 30 percentage points over eight weeks, with educational platform use, digital content creation, and online collaboration registering the largest gains; qualitative data further confirm shifts in teacher self-efficacy and professional community cohesion that standardized instruments alone cannot fully represent. However, these gains operate within a structural context defined by endemic power instability, aging device infrastructure, and inadequate internet connectivity—barriers that, left unaddressed, will erode training investments over time. Accordingly, future interventions must be designed as components of broader systemic change rather than as isolated capacity-building events: this includes

coordinated advocacy for renewable energy solutions in remote schools, ring-fenced district-level device maintenance budgets, low-bandwidth digital platform adoption policies, and the institutionalization of peer-learning networks that can sustain teacher growth between formal training cycles. Policymakers, regional education authorities, and international development partners are urged to treat digital equity in highland communities not as a secondary concern to be addressed after urban saturation is achieved, but as a foundational prerequisite for the realization of Kyrgyzstan's broader educational transformation ambitions.

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