Digital Pathways for Lifelong Learning in Rural Communities: A Systematic Mapping Review of Technological Modalities, Inclusion Conditions, and Evidence Gaps, 2000–2025

Nasrulla Ahmed*, Asifa Abdulla

Islamic University of Maldives

***Corresponding Author**

DOI: https://doi.org/10.47772/IJRISS.2026.100700869

Received: 29 July 2026; Accepted: 03 August 2026; Published: 14 August 2026

ABSTRACT

Purpose: This study maps the development, pedagogical functions, inclusion conditions, and methodological characteristics of digitally mediated lifelong learning in rural communities.

Design/methodology/approach: A systematic mapping review examined a digital subset of a Scopus corpus on rural lifelong learning published between 2000 and 2025. Of 739 rural records, 202 articles explicitly addressed online, mobile, tele-enabled, multimedia, blended, distance, or other digitally mediated learning. Multi-label coding covered publication patterns, modalities, pedagogical functions, contexts, outcomes, participation conditions, implementation features, research designs, sampling, and participant groups.

Findings: Publication output increased from 3 records in 2000 to 16 in 2025, alongside a shift from early telehealth and videoconferencing towards online environments, digital-capability development, mobile technologies, virtual mentoring, and multimedia-supported learning. Online or virtual approaches occurred in 107 records, ICT and digital-capability themes in 82, and telehealth or telementoring in 62. Knowledge and competence (n = 120) and access and participation (n = 117) were the leading outcome domains. Health-professional education remained dominant. Reported constraints included geographical distance, inadequate connectivity, affordability, sociocultural and linguistic fit, digital readiness, time pressures, and limited organisational support. Survey and cross-sectional designs predominated, while mixed-method, experimental, and longitudinal evidence was comparatively limited.

Research limitations/implications: The review was restricted to English-language Scopus journal articles and relied primarily on titles, abstracts, and keywords. The corpus constitutes a nested secondary analysis of a broader rural lifelong-learning review and requires transparent disclosure and cross-referencing.

Practical implications: Equitable rural digital learning requires coordinated provision of infrastructure, learner support, pedagogically appropriate interaction, local facilitation, and institutional recognition; investment in platforms alone is unlikely to produce sustained educational participation or application.

Originality/value: The Rural Digital Learning Ecosystem distinguishes material access, learner readiness, pedagogical design, and institutional anchoring and relates them to a progression from access to participation, learning, application, and sustained benefit.

Keywords: rural communities; lifelong learning; digital inclusion; online learning; systematic mapping review

INTRODUCTION

Digital technologies have reconfigured the spatial organisation of lifelong learning by enabling educational resources, professional networks, mentoring, and community-based learning to extend beyond the learner's immediate location. This potential is particularly consequential in rural settings, where access to specialist institutions, training centres, and professional peers is frequently constrained by distance. Digital mediation, however, is not limited to the transmission of content. It shapes entry into learning environments, forms of

interaction, the availability of instructional and social support, and the conditions under which acquired knowledge can be applied in professional and community contexts. In this review, digitally mediated lifelong learning refers to formal, non-formal, informal, professional, or community learning in which digital technology performs an explicit pedagogical or capability-building function.

Research in this field has developed through successive and overlapping technological configurations. Earlier studies commonly examined videoconferencing, web-based continuing medical education, teleconsultation, and remote access to specialist expertise. Such arrangements enabled rural clinicians to participate in activities that would otherwise have required substantial travel, while initiatives such as the RAFT network and Project ECHO integrated continuing education with consultation, case-based discussion, and professional networking (Callas et al., 2000; Geissbuhler et al., 2007; Arora et al., 2011). Subsequent scholarship extended to online courseware, mobile applications, multimedia communication, digital literacy, and virtual communities of practice. Illustrative applications include mobile-supported adult education in Niger, animated agricultural video in Mozambique, digital storytelling in Alaska, intergenerational digital learning among older adults in rural China, and informal smartphone-mediated learning among rural women (Aker et al., 2012; Cueva et al., 2015; Bello-Bravo et al., 2020; Cheng et al., 2022; Gautam & Rai, 2025). Collectively, these studies indicate that the category of digital learning encompasses heterogeneous pedagogical purposes and implementation arrangements.

The extension of technological reach does not, in itself, ensure equitable educational participation. Rural learners may encounter unstable connectivity, inadequate electricity, limited or shared devices, high data costs, inaccessible interfaces, linguistic constraints, limited digital confidence, occupational demands, and insufficient local support. These inequalities became particularly visible during COVID-19-related school closures in remote Nigerian communities, where infrastructural limitations substantially restricted access to online learning (Olanrewaju et al., 2021). Research on online professional development similarly demonstrates that flexibility may coexist with time constraints, workplace pressures, and variable technical support (Feldacker et al., 2017; Xing et al., 2018). The central analytical issue is therefore not merely whether digital provision reaches rural locations, but whether the surrounding conditions enable learners to access, sustain, complete, and apply the learning experience.

Existing syntheses generally concentrate on specific sectors, technologies, or conceptual domains. Bibliometric work on rural digital competence has foregrounded e-learning, online education, and digital inequality, while reviews of remote education have catalogued pedagogical strategies and platforms across educational levels (Andari, 2022; Rozo-García & Ramírez-Montoya, 2025). The substantial telehealth literature provides important evidence on professional learning, yet its findings cannot be assumed to transfer directly to community literacy, agricultural extension, teacher education, later-life learning, or women's informal digital participation. A cross-sector systematic map is consequently required to examine technological modalities, pedagogical functions, participation conditions, implementation arrangements, outcomes, and methodological characteristics across the broader field of rural lifelong learning.

Accordingly, this study analyses 202 digitally mediated records nested within a previously screened corpus of rural lifelong-learning research. The analytical focus differs from that of the broader companion review by treating digital mediation as the primary object of inquiry. The present review examines temporal changes in technological modalities, the pedagogical functions assigned to those modalities, relationships between modalities and reported outcomes, inclusion conditions, implementation characteristics, and the methodological maturity of the evidence base. Its purpose is to determine how the educational contribution of digital technologies is conditioned by the wider rural learning environment.

This manuscript is a focused secondary analysis of the same cleaned parent Scopus corpus used in the broader companion review of rural lifelong learning. The two manuscripts share the parent search and data-integrity audit but address different research questions, analytical categories, figures, tables, conceptual framing, and interpretive claims. This relationship should be disclosed reciprocally in both manuscripts and to journal editors, with cross-citation when bibliographic details are available.

The review was guided by the following research questions:

1. How did publication output and the technological orientation of rural digital lifelong-learning research evolve between 2000 and 2025?
2. Which digital modalities and pedagogical functions have been employed in rural lifelong-learning initiatives?
3. Which learner, professional, organizational, and community outcomes have been reported?
4. Which infrastructural, individual, sociocultural, and institutional conditions influence participation?
5. Which design and implementation characteristics support inclusive and educationally meaningful digital learning?
6. What research designs, sampling approaches, and participant groups characterise the existing evidence base?
7. What substantive and methodological gaps, and corresponding priorities for future research, emerge from the literature?

CONCEPTUAL FRAMEWORK: THE RURAL DIGITAL LEARNING ECOSYSTEM

The Rural Digital Learning Ecosystem was developed as the conceptual framework for the present synthesis on the basis of recurrent patterns identified across the 202-record corpus. Rather than treating access as a single technological condition, the framework conceptualises rural digital learning as the interaction of four analytically distinct but interdependent dimensions. The first dimension is the material foundation, comprising electricity, connectivity, devices, affordability, physical access points, and technical reliability. These conditions establish the feasibility of participation but do not, independently, determine educational engagement or benefit.

The second-dimension concerns learner readiness, including digital competence, language proficiency, confidence, motivation, prior educational experience, available time, accessibility requirements, and household or occupational responsibilities. The third-dimension concerns pedagogical design, including modality, interactivity, feedback, pacing, contextual relevance, assessment, accessibility, and opportunities for practice. Although recorded materials and online modules may support efficient distribution, more complex learning outcomes may require facilitated discussion, mentoring, case-based interaction, formative feedback, and locally relevant application.

The fourth dimension is institutional anchoring, which encompasses facilitation, mentoring arrangements, organisational recognition, technical maintenance, policy support, community participation, and follow-up mechanisms. These elements connect individual learning with professional practice, service improvement, livelihood activity, or collective action. The framework specifies a cumulative outcome sequence comprising reach, participation, learning, application, and sustained value. Constraints operating at an earlier stage may reduce the likelihood of subsequent outcomes, whereas successful implementation may strengthen trust, local capability, and continued demand for learning. Figure 1 presents the proposed framework.

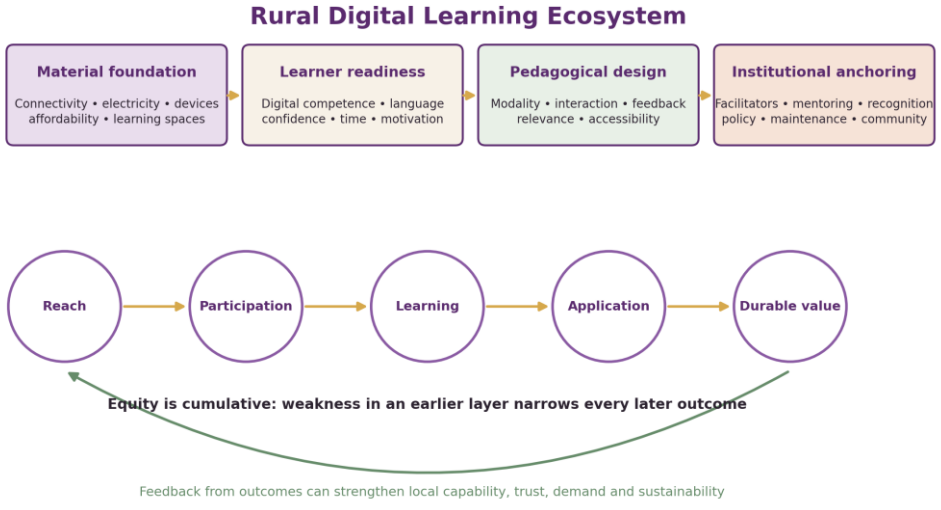

Figure 1. Conceptual framework of the Rural Digital Learning Ecosystem.

METHODOLOGY

3.1 Review Design

A systematic mapping review design was adopted to characterise the breadth, distribution, and methodological profile of a heterogeneous evidence base rather than to estimate a pooled intervention effect. The analysis was nested within a broader Scopus review of continuing education and lifelong learning in rural settings. Although the parent review and the present study share the original database search and data-integrity audit, they address different research questions and employ distinct analytical categories. The parent review maps the full 739-record rural corpus, whereas the present study examines the 202 records in which digital mediation is explicit and analyses technological development, pedagogical functions, outcome patterns, inclusion conditions, implementation characteristics, research methods, sampling procedures, and population coverage. This relationship should be transparently reported to journal editors and cross-referenced when bibliographic details of the companion article become available.

3.2 Database, Search Parameters, and Parent-Corpus Preparation

The source search was conducted in Scopus on 26 July 2026 and was restricted to English-language journal articles published between 2000 and 2025. Terms referring to lifelong learning, lifelong education, adult learning, and continuing education were searched in titles, abstracts, and keywords. Expressions referring to rural areas, villages, remote areas, and remote communities were searched using Scopus ALL field. The search retrieved 17,194 records before the application of limits and 1,446 records after the publication-year, document-type, source-type, and language restrictions reported in the source manuscript.

The supplied CSV contained 1,431 physical rows. Four records had been divided into continuation rows because of malformed long-reference fields; these fragments were recombined to produce 1,427 logical records. This total was 19 records lower than the reported post-filter total, and the missing records could not be reconstructed from the available materials. One duplicate record and one non-English record were subsequently removed. The remaining 1,425 records were screened for explicit rural relevance in the title, abstract, author keywords, or index keywords, resulting in a 739-record parent corpus. These data-integrity procedures are documented in the accompanying audit files and are reported here because they establish the sampling frame for the focused digital analysis.

Table 1. Derivation of the focused digital corpus.

Stage	Records	Analytical significance
Scopus records before database limits	17,194	Identification total reported in the source manuscript
Records reported after database limits	1,446	Expected post-filter corpus
Logical records after repair of four split rows	1,427	Available bibliographic records
Duplicate and non-English records removed	2	Records removed before parent-corpus screening
Records screened for explicit rural relevance	1,425	Parent-corpus screening population
Records retained in the rural parent corpus	739	Sampling frame for the focused digital review
Records retained in the focused digital corpus	202	Final analytical corpus

3.3 Eligibility Criteria

A record from the parent corpus was eligible when a digital technology performed an explicit educational or capability-building role in the title, abstract, author keywords, or index keywords. Eligible modalities included online and virtual education, web-based modules, mobile learning and applications, tele-education, professional learning associated with telehealth, telementoring, videoconferencing, computer-supported learning, digital literacy, multimedia, radio, television, digital storytelling, blended learning, hybrid learning,

and distance education. Technology could function as the learning environment, communication channel, object of competence development, source of specialist support, or medium for the production and exchange of community knowledge. Records were excluded when technology was mentioned solely as clinical equipment, administrative infrastructure, or a contextual feature without an identifiable learning function.

Application of the digital eligibility criterion retained 202 records and excluded 537 records from the parent corpus. The study constitutes an abstract-level systematic map rather than a full-text review of all included articles. Findings are therefore reported as frequencies and patterns of concepts, methodological indicators, and reported outcomes, rather than as pooled estimates of intervention effectiveness.

3.4 Data Extraction and Coding Framework

Extracted bibliographic variables included publication year, journal, author-affiliation country, title, abstract, keywords, citation count, DOI, and Scopus identifier. Existing multi-label codes captured technological modalities, substantive contexts, outcomes, barriers, enabling conditions, research methods, sampling terminology, and participant groups. A distinct pedagogical-function coding layer was developed for the present study. Six functions were specified: courseware and self-directed study; synchronous virtual interaction; mentoring and networked expertise; digital-capability development; mobile or point-of-use support; and media-based community communication. Codes were assigned using titles, abstracts, and keywords, and individual records could receive more than one code.

Table 2. Analytical dimensions and coding categories.

Analytical dimension	Operational categories
Technological modality	Online/web/virtual; ICT and digital capability; telehealth/telementoring; multimedia/community media; blended/distance; mobile/applications
Pedagogical function	Self-directed courseware; synchronous virtual interaction; networked expertise; digital-capability development; mobile point-of-use support; media-based communication
Reported outcome	Access; knowledge/competence; practice quality; livelihoods; retention/isolation; empowerment/social capital; well-being
Participation condition	Distance; infrastructure; affordability; language/culture; motivation/relevance; digital readiness; workload; organisational support
Evidence profile	Research design; sampling terminology; participant groups; author-affiliation countries; publication sources

3.5 Data Analysis

Descriptive frequencies and percentages were calculated using the 202-record focused corpus as the denominator. Because categories were coded on a multi-label basis, totals may exceed 202 and percentages should not be interpreted as mutually exclusive. Temporal development was examined annually and across three periods: 2000–2009, 2010–2019, and 2020–2025. Cross-tabulations were used to compare technological modalities by period, substantive context, and outcome domain. Distributions of research designs and participant groups were examined to assess methodological maturity and population coverage. Author-affiliation country was interpreted as the location of contributing institutions and not necessarily as the geographical setting of data collection.

Barrier and enabling-condition codes were applied using a conservative sentence-level co-occurrence rule. A category was counted only when a relevant concept occurred within the same sentence as an explicit constraining or facilitating expression. The resulting frequencies should therefore be interpreted as minimum documented occurrences rather than prevalence estimates. Sampling procedures were counted only when the abstract-level fields explicitly named a technique, while identifiable numerical sample sizes were recorded separately.

3.6 Transparency, Reliability, and Ethical Considerations

The study employed a single-reviewer, computationally assisted mapping process; independent duplicate screening and intercoder reliability assessment were not available. Reproducibility was strengthened through retention of the record-level focused corpus, preservation of coding variables, use of explicit coding dictionaries, and maintenance of separate audit files for parent-corpus screening and focused inclusion. The study analysed published secondary data and involved no direct interaction with human participants. Applicable institutional and journal requirements for secondary literature analysis should nevertheless be verified prior to submission.

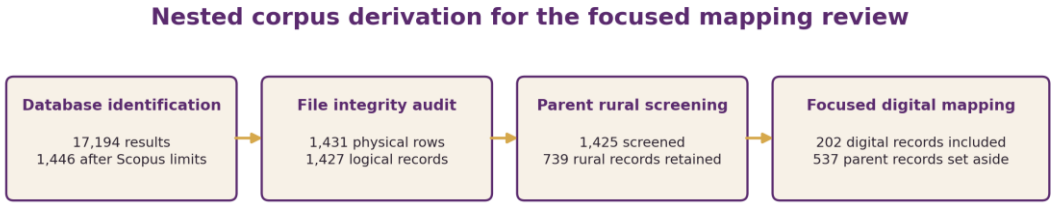

Figure 2. Selection of the focused digital corpus from the parent rural lifelong-learning corpus.

RESULTS

4.1 Study Selection and Corpus Characteristics

The final analytical corpus comprised 202 articles, equivalent to 27.3% of the 739-record rural parent corpus. The included records covered each year from 2000 to 2025. Because eligibility required explicit digital relevance within the bibliographic fields, the corpus captures studies in which digital mediation was visible in the title, abstract, or keywords; programmes whose technological components were reported only in the full text may not have been identified.

4.2 RQ1: Development and Technological Orientation

4.2.1 Publication Trajectory

Annual publication output increased from 3 records in 2000 to 16 in 2025. The periods 2000–2009, 2010–2019, and 2020–2025 contributed 54, 77, and 71 records, respectively. Corresponding mean annual outputs increased from 5.4 to 7.7 and subsequently to 11.8 records. The pattern was not linear: output reached 14 records in 2020, declined to 6 in 2022, and increased to 11 in 2023, 13 in 2024, and 16 in 2025. The three-year moving average presented in Figure 3 indicates sustained long-term growth despite short-term variation.

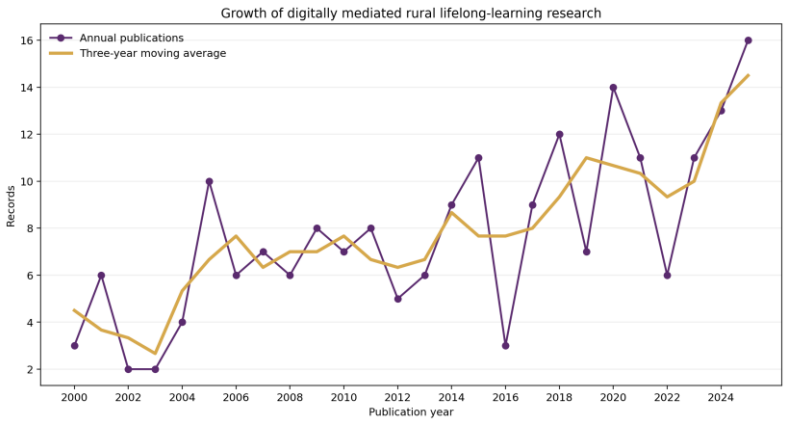

Figure 3. Annual publication output and three-year moving average, 2000–2025.

4.2.2 Temporal Shifts in Technological Modalities

The distribution of technological modalities changed across the three periods. Telehealth and telementoring were the most prominent modalities during 2000–2009, occurring in 31 records, compared with 15 records

concerning online or virtual learning. During 2010–2019, online or virtual learning increased to 45 records and exceeded telehealth or telementoring (n = 23). In 2020–2025, online or virtual modalities remained prominent (n = 47), while telehealth or telementoring was identified in 8 records. Mobile and application-based learning was identified in 1 record during the first period, 9 during the second, and 6 during the third. These results indicate diversification rather than complete technological substitution: specialist-network models remained present but were incorporated into a broader landscape of online platforms, virtual courses, digital-capability initiatives, and multimedia-supported learning.

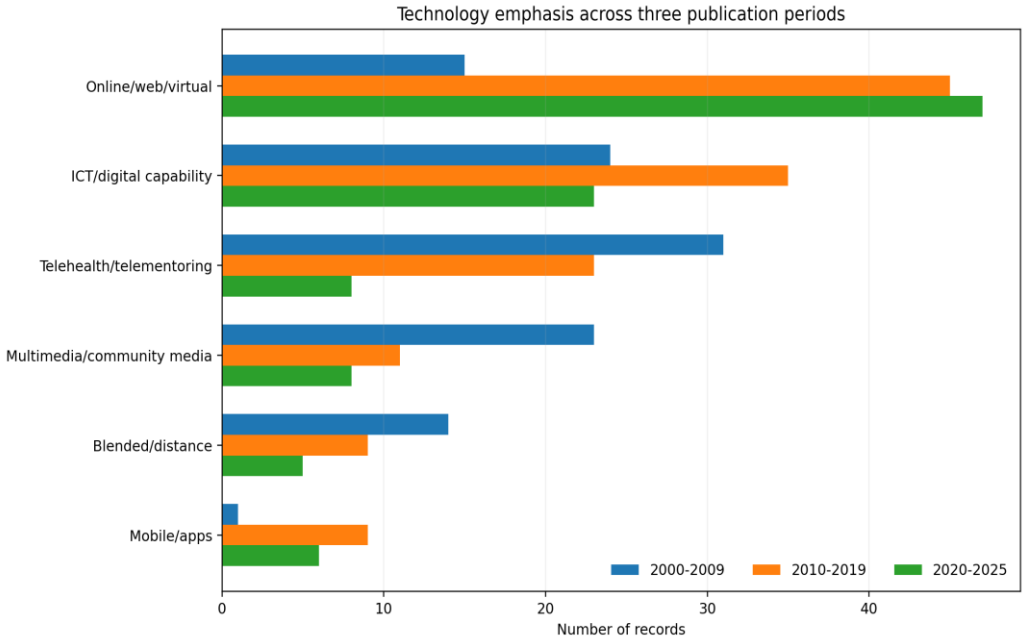

Figure 4. Distribution of technological modalities by publication period.

4.2.3 Sectoral and Geographical Concentration

The sectoral distribution was markedly uneven. Clinical and health-workforce learning was represented in 153 of the 202 records (75.7%). Teacher development and educational institutions constituted the second-largest context (n = 86), followed by literacy, empowerment, and social inclusion (n = 68). Agriculture and livelihood learning (n = 29) and later-life or community well-being (n = 20) were less frequently represented. As coding was multi-label, these values indicate thematic occurrence rather than mutually exclusive sectoral classification.

Author affiliations represented 60 countries, although indexed authorship was concentrated in a limited number of national systems. United States-affiliated authors occurred in 86 records, compared with Canada (n = 29), Australia (n = 23), the United Kingdom (n = 12), and India (n = 9). Source concentration reflected the predominance of health-professional education: Telemedicine and e-Health published 8 records, Rural and Remote Health and the Journal of Continuing Education in Nursing published 5 each, and two additional continuing-education or telemedicine journals published 4 each. This distribution suggests that rural settings were frequently represented as sites of programme implementation, whereas indexed knowledge production remained concentrated in a comparatively small group of countries and journals.

4.3 RQ2: Digital Modalities and Pedagogical Functions

4.3.1 Distribution of Digital Modalities

Online, web-based, or virtual learning was identified in 107 records (53.0%). ICT use and digital-capability development occurred in 82 records (40.6%), telehealth, telemedicine, or telementoring in 62 (30.7%), multimedia or community media in 42 (20.8%), blended or distance delivery in 28 (13.9%), and mobile phones or applications in 16 (7.9%). Categories were non-exclusive; for example, a telementoring intervention could also be classified as online, blended, and multimedia supported.

Table 3. Distribution of technological modalities in the focused corpus.

Technological modality	Records	% of 202
Online/web/virtual	107	53.0%
ICT/digital capability	82	40.6%
Telehealth/telementoring	62	30.7%
Multimedia/community media	42	20.8%
Blended/distance	28	13.9%
Mobile/applications	16	7.9%

4.3.2 Pedagogical Functions of Digital Technologies

The pedagogical-function analysis differentiated the roles performed by digital technologies. Courseware and self-directed study were identified in 72 records, media-based community communication in 48, mentoring and networked expertise in 43, synchronous virtual interaction in 30, mobile or point-of-use support in 17, and explicit digital-capability development in 13. These findings demonstrate that digitally mediated lifelong learning extends beyond online course delivery. Technologies were used to distribute learning resources, connect learners with specialist expertise, facilitate interaction, support decision-making in practice settings, develop digital competence, and communicate knowledge through culturally recognisable media.

Table 4. Pedagogical functions performed by digital technologies.

Pedagogical function	Records	Illustrative applications
Courseware and self-directed study	72	Online modules, web-based resources, distance courses, and computer-supported materials
Mentoring and networked expertise	44	Project ECHO, teleconsultation, communities of practice, and specialist support
Media-based community communication	44	Video, radio, digital storytelling, podcasts, and multimedia resources
Synchronous virtual interaction	29	Videoconferencing, webinars, virtual classrooms, and teleconferences
Mobile and point-of-use support	17	Smartphones, applications, SMS, and handheld decision-support resources
Digital-capability development	13	Digital literacy, computer literacy, information literacy, and technology-related skills

4.3.3 Sectoral Distribution of Digital Modalities

The health sector employed the broadest range of technological modalities. Among 153 health-related records, 87 concerned online or virtual learning, 62 telehealth or telementoring, 46 ICT use or digital capability, 36 multimedia, 20 blended or distance delivery, and 9 mobile technologies. Studies concerning teachers and educational institutions also relied substantially on online or virtual learning (49 of 86 records) and ICT or digital-capability approaches (35 of 86). Adult literacy and social-inclusion research exhibited a different pattern: ICT or digital capability (38 of 68) was slightly more prominent than online or virtual provision (31 of 68), while mobile technologies occurred in 11 records. Agriculture and livelihood studies more frequently addressed ICT or digital capability (15 of 29) than online learning (9 of 29), and later-life studies most often concerned ICT and digital capability (11 of 20). These differences indicate that modality selection was associated with sectoral purpose and pedagogical function as well as technological availability.

4.3.4 Health versus Non-Health Sensitivity Analysis

Because health-related research accounted for 153 of the 202 records (75.7%), a sector-stratified sensitivity analysis was added to assess the extent to which pooled modality frequencies were shaped by the health literature. For this comparison, non-health records were defined as the 49 records not coded as health-related. Counts for the non-health group were derived by subtracting the reported health-sector modality counts from the corresponding full-corpus modality totals. Because the substantive-context coding was multi-label, this comparison is intended as a sensitivity analysis of health-sector influence rather than as a mutually exclusive taxonomy of all substantive sectors.

Table 4A. Distribution of technological modalities in health-related and non-health records.

Technological modality	Health n (N=153)	Health %	Non-health n (N=49)	Non-health %
Online/web/virtual	87	56.9	20	40.8
ICT/digital capability	46	30.1	36	73.5
Telehealth/telementoring	62	40.5	0	0.0
Multimedia/community media	36	23.5	6	12.2
Blended/distance	20	13.1	8	16.3
Mobile/applications	9	5.9	7	14.3

The sensitivity analysis shows a different modality profile outside health. Online or virtual learning remained common in both groups, but ICT and digital-capability approaches were proportionally much more prominent among non-health records (73.5%) than among health-related records (30.1%). Telehealth and telementoring were confined to the health-related group in the reported modality counts, while mobile or application-based approaches represented a larger share of non-health records (14.3%) than health-related records (5.9%). These differences confirm that full-corpus estimates are substantially influenced by the health-professional literature and that findings associated with telehealth, professional networking, and service-oriented learning should not be generalized automatically to agriculture, community learning, literacy, later-life learning, or other non-health settings.

4.4 RQ3: Reported Outcomes

4.4.1 Access, Participation, and Learning Outcomes

Knowledge, skills, capability, or professional competence were identified in 120 records (59.4%), while access, participation, inclusion, engagement, or opportunity occurred in 117 (57.9%). Early videoconferencing studies reported that remote connectivity enabled rural practitioners to participate in continuing education that would otherwise have required travel (Callas et al., 2000; Ricci et al., 2005). Internet-based networks extended this model by combining educational sessions with teleconsultation and access to specialist expertise (Geissbuhler et al., 2007). Online continuing professional development also increased flexibility for clinicians in sub-Saharan Africa, although participation remained contingent on workplace and infrastructural conditions (Feldacker et al., 2017).

Evidence beyond health-professional education indicates that measurable learning outcomes were more likely when the technological intervention was aligned with local conditions and educational purpose. In Niger, the addition of basic mobile-phone support to adult education improved test performance and the retention of mathematics learning (Aker et al., 2012). In Mozambique, animated agricultural video was associated with high knowledge retention and reported adoption of recommended practices at two-year follow-up (Bello-Bravo et al., 2020). Research on rural non-formal education in Thailand produced different outcomes across desktop-

and mobile-supported configurations, further indicating the importance of alignment between course design, technology, and learner context (Intarat & Chanchalor, 2017).

4.4.2 Professional, Organisational, and Community Outcomes

Practice or service quality was identified in 43 records (21.3%), livelihood or economic outcomes in 28 (13.9%), retention or reduced professional isolation in 24 (11.9%), empowerment or social capital in 19 (9.4%), and well-being or quality of life in 10 (5.0%). Telementoring initiatives commonly linked education with workforce capability. Project ECHO connected rural primary-care practitioners with specialist teams, while mental-health adaptations reported improvements in knowledge, self-efficacy, engagement, and perceived professional isolation (Arora et al., 2011; Katzman et al., 2014; Sockalingam et al., 2018). In India, smartphone-supported ECHO clinics were used to mentor counsellors in underserved districts and to assess engagement, learning, competence, and performance (Mehrotra et al., 2018).

Community-oriented studies broadened the range of documented outcomes. Digital storytelling supported culturally situated health communication in rural Alaska (Cueva et al., 2015). An intergenerational model enabled younger family members to support older adults' digital learning in rural China (Cheng et al., 2022). Rural women reported acquiring digital, communicative, and literacy practices through everyday smartphone use (Gautam & Rai, 2025). The Kothmale model integrated community radio and internet access to address awareness, language, affordability, and competence as interconnected dimensions rather than treating connectivity as an isolated intervention (Pringle & David, 2002).

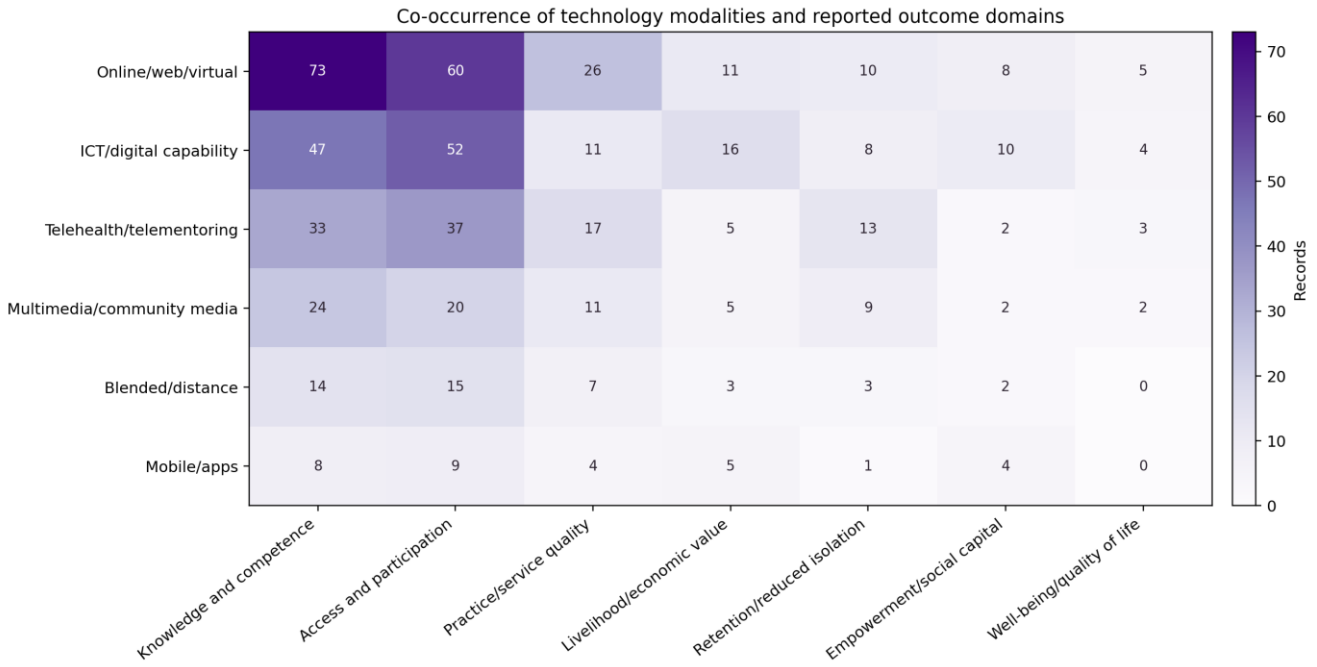

Figure 5. Co-occurrence of technological modalities and reported outcome domains.

4.5 RQ4: Conditions Influencing Participation

4.5.1 Infrastructural and Economic Conditions

The explicit barrier frequencies were conservatively estimated. Geographical distance, travel, or isolation was identified in 25 records, connectivity or infrastructure in 21, and cost or affordability in 12. Although distance frequently motivated digital provision, its effects were compounded by unstable networks, inadequate electricity, limited device availability, and data costs. Evidence from rural Nigerian schools demonstrates that a nominal transition to online education may provide no feasible learning pathway when basic infrastructure is unavailable (Olanrewaju et al., 2021). A needs assessment for mobile medical education in Rwanda likewise emphasised the necessity of adapting interventions to local access conditions rather than transferring systems developed for resource-rich environments without modification (Rusatira et al., 2016).

4.5.2 Individual Capability and Sociocultural Conditions

Language, culture, or contextual mismatch was identified in 11 explicit barrier statements, motivation or perceived relevance in 8, and digital readiness in 5. These frequencies should not be interpreted as evidence of low substantive importance, because abstracts may describe such conditions without explicitly labelling them as barriers. Qualitative evidence illustrates their influence. Rural older adults benefited when instruction was personalised and embedded in intergenerational family relationships (Cheng et al., 2022), whereas informal smartphone-mediated learning among rural women developed through household, neighbourhood, and market practices rather than through formal course structures (Gautam & Rai, 2025). Digital storytelling was valued partly because content was generated within the sociocultural context of the intended audience (Cueva et al., 2015).

4.5.3 Organisational and Institutional Conditions

Time, workload, or staffing constraints were explicitly reported in 4 records, and limited organisational support in 1. These values are likely to underestimate the importance of institutional arrangements because such information is often omitted from abstracts. Studies of online learning among nurses and clinicians indicate that positive attitudes and flexibility do not eliminate the need for protected learning time, technical support, contextually relevant content, and organisational recognition (Karaman, 2011; Feldacker et al., 2017; Xing et al., 2018). E-health programmes intended to support recruitment and retention were similarly dependent on training, sustained use, perceived benefit, and organisational integration (Bagayoko et al., 2014). Participation was therefore influenced by funding arrangements, system maintenance, facilitation, recognition, and opportunities to apply acquired competence in practice.

4.6 RQ5: Design and Implementation Characteristics

4.6.1 Interaction, Mentoring, and Networked Support

Mentoring, peer networks, and collaboration constituted the most frequently identified enabling category (n = 32). This pattern was especially evident in telementoring and professional communities of practice. Project ECHO integrates recurring participation, case-based discussion, specialist feedback, and peer interaction rather than relying on one-directional content transmission. Comparable mechanisms are evident in electronic mentoring, teleconsultation, and networked professional-learning models. In these interventions, technology extends access to expertise across geographical distance, while the educational process is mediated through dialogue, feedback, modelling, and repeated application.

4.6.2 Technical Support and Multimodal Provision

Technology access or technical support was identified in 27 enabling statements, and flexible or multimodal delivery in 24. Hybrid courseware combining web-based documents, multimedia resources, communication, and self-directed study illustrates how multiple media can respond to differentiated learning requirements (Curran et al., 2000). Mobile applications may support point-of-care learning, although needs assessment and user-centred adaptation are required prior to implementation (Rusatira et al., 2016). Evaluation of the Safe Delivery App connected mobile learning with knowledge, clinical skills, quality of care, and perinatal outcomes (Lund et al., 2016). These findings support a function-led rather than technology-led design approach in which the selected medium is appropriate to the intended interaction, practice, and feedback requirements.

4.6.3 Contextualisation and Local Institutional Anchoring

Contextual or local-language provision was identified in 7 enabling statements, community ownership in 2, and employer or policy support in 1. These frequencies reflect limitations of abstract reporting and should not be interpreted as indicating limited substantive significance. Community radio, digital storytelling, animated agricultural video, intergenerational learning, and informal smartphone practices demonstrate that local language, recognisable examples, trusted relationships, and everyday settings may constitute integral

components of instructional design. Inclusiveness is strengthened when local stakeholders participate in problem identification, modality selection, content production, facilitation, and evaluation.

Table 5. Design responses aligned with the Rural Digital Learning Ecosystem.

Ecosystem dimension	Mapped constraints	Corresponding design considerations
Material foundation	Geographical distance, weak connectivity, inadequate devices or electricity, and cost	Low-bandwidth or offline provision; shared access points; technical assistance; realistic cost planning
Learner readiness	Digital competence, language, confidence, motivation, and time availability	Orientation; accessible interfaces; local-language resources; flexible pacing; learner support
Pedagogical design	Passive content, insufficient feedback, weak contextual relevance, or limited practice	Interactive activities; mentoring; case discussion; practical tasks; multimodal resources
Institutional anchoring	Insufficient protected time, facilitation, recognition, maintenance, or follow-up	Local facilitation; organisational recognition; communities of practice; policy and maintenance planning

4.7 RQ6: Research Designs, Sampling, and Population Coverage

4.7.1 Research Designs

The methodological profile was oriented more strongly towards description and exploration than causal evaluation. Survey or cross-sectional indicators were identified in 83 records, compared with 47 records containing qualitative-method indicators. Case studies or programme evaluations occurred in 29 records, while experimental or quasi-experimental designs were identified in 14, mixed-method designs in 8, and review or bibliometric approaches in 3. The recent literature displayed a greater qualitative orientation: qualitative indicators increased from 7 records in 2000–2009 to 27 in 2020–2025, while mixed-method indicators increased from 0 to 6. Experimental or quasi-experimental indicators declined to 2 records in the most recent period.

The growth of publication output was therefore not accompanied by a corresponding expansion of causal or longitudinal evidence. Notable exceptions included the Niger mobile-phone study, which used random assignment and examined persistence of learning, and the cluster-randomised evaluation of the Safe Delivery App, which related workforce learning to care quality and perinatal outcomes (Aker et al., 2012; Lund et al., 2016). Nevertheless, the wider evidence base remained dominated by needs assessments, perceptions, satisfaction, self-reported competence, and cross-sectional associations.

4.7.2 Reporting of Sampling Procedures

Only ten records explicitly reported a sampling technique in the abstract-level fields. Convenience sampling was identified in 4 records, census or total-population approaches in 2, and purposive, random or probability-based, snowball, and stratified sampling in 1 record each. Identifiable numerical sample sizes were reported in 49 abstracts. The limited reporting of sampling procedures restricts the assessment of selection bias, representativeness, and transferability and indicates the need for a subsequent full-text methodological review.

4.7.3 Participant and Population Representation

The participant profile was substantially imbalanced. Health professionals were represented in 106 records (52.5%), whereas no other participant category accounted for one fifth of the corpus. Students or formal learners were the second most frequently represented group (n = 40). All remaining categories appeared in

fewer than 30 records, including women and girls, teachers, administrators, community residents, older adults, young people, and farmers. Consequently, the evidence base provides substantially greater coverage of professional health education than of community-based, agricultural, later-life, and informal digital learning.

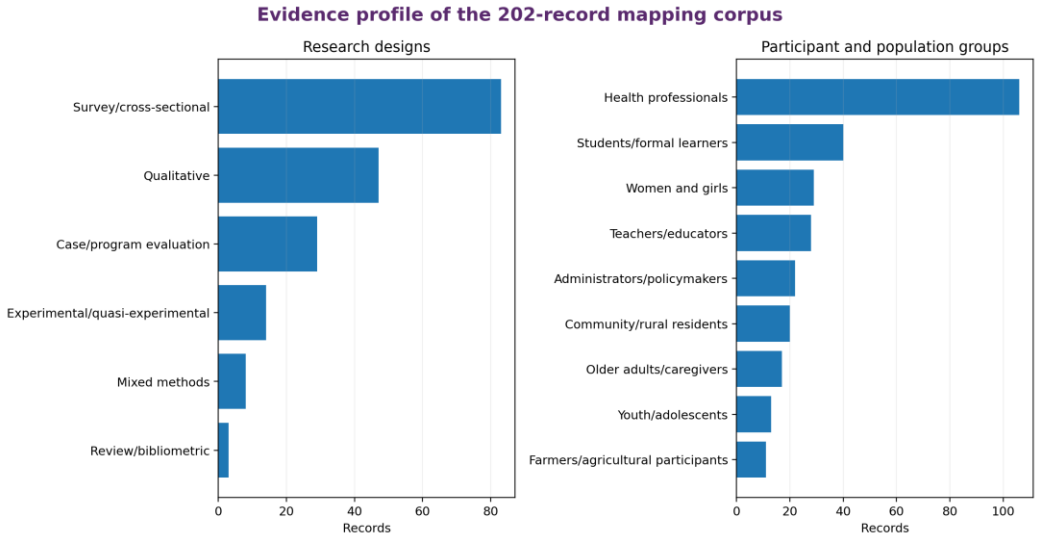

Figure 6. Distribution of research designs and participant groups in the focused corpus.

4.8 RQ7: Evidence Gaps and Future Research Priorities

Seven principal gaps were identified. First, the predominance of healthcare research limits the transferability of findings to agriculture, vocational learning, local governance, climate adaptation, disability inclusion, and community leadership. Second, the concentration of author affiliations in a small group of high-income countries indicates a need for more locally led research and greater indexed visibility of scholarship originating in rural regions. Third, intervention studies rarely distinguish among access, participation, learning, application, organisational change, and sustained community outcomes. Fourth, sampling procedures and implementation characteristics are frequently absent from abstracts and inconsistently reported in the wider literature.

Fifth, the sustainability of digital learning interventions remains insufficiently examined. Many studies assess pilot or short-duration programmes without reporting maintenance, financing, staff turnover, technological dependence, or post-project continuity. Sixth, equity analyses should extend beyond rural–urban comparisons and disaggregate participation and outcomes by gender, age, disability, language, income, device ownership, and connectivity. Seventh, emerging technologies were only minimally represented: one record explicitly referred to artificial intelligence, one to immersive virtual reality, and one to a chatbot. Future research should evaluate such technologies in relation to clearly specified rural learning needs, implementation requirements, ethical considerations, and potential forms of exclusion.

Emerging-technology research should incorporate explicit ethical and governance outcomes alongside educational outcomes. Priority risks include privacy and data protection, algorithmic bias, inaccurate or culturally inappropriate outputs, linguistic exclusion, accessibility barriers, surveillance, unequal access to advanced devices or bandwidth, opaque automated decision-making, and dependence on proprietary platforms. Future studies should document consent and data-governance arrangements, the role of human oversight, community participation in technology selection, procedures for contesting automated outputs, and whether new technologies reduce or reproduce existing rural inequalities.

DISCUSSION

5.1 Evolution of the Field and Diversification of Pedagogical Functions

The temporal pattern does not indicate a linear process of technological substitution. Early telehealth and videoconferencing established a model in which digital connectivity mitigated geographical separation and

facilitated access to specialist knowledge. Subsequent online platforms, mobile technologies, digital-literacy initiatives, multimedia resources, and virtual communities expanded the range of pedagogical functions performed by technology. The field consequently developed from a predominant emphasis on connecting remote sites with specialist centres towards more varied configurations that distribute content, facilitate interaction, develop digital capability, support mentoring, and enable community-based communication.

This diversification is analytically important because broad technological labels may conceal substantial differences in pedagogical design. Recorded modules, synchronous virtual classrooms, mobile decision-support tools, digital storytelling, and telementoring networks differ in their requirements for infrastructure, facilitation, learner readiness, and evaluation. Classification by pedagogical function therefore provides a more informative basis for comparison than the undifferentiated use of terms such as online learning or e-learning.

5.2 Digital Inclusion as a Cumulative and Multidimensional Process

The Rural Digital Learning Ecosystem indicates that connectivity is a necessary but insufficient condition for inclusion. Material access constitutes the initial condition; learners must also possess or develop the capability to use the technology, programmes must provide pedagogically meaningful experiences, and institutions or communities must support recognition and application. Constraints at any of these dimensions may interrupt the progression from reach to sustained value. Device availability, for example, may coexist with unaffordable data, inaccessible language, insufficient feedback, or limited opportunities to apply learning within professional or community contexts.

This cumulative interpretation also accounts for the effectiveness of comparatively low-bandwidth approaches. Community radio, animated video, SMS, and intergenerationally supported learning may correspond more closely to local infrastructure and social organisation than resource-intensive learning-management systems. Technological appropriateness should therefore be evaluated in relation to educational purpose, accessibility, required support, and the practical demands placed on learners.

5.3 Interaction and Institutional Integration as Educational Mechanisms

The prominence of mentoring, peer networks, collaboration, and technical support indicates that social interaction is a central component of digitally mediated learning. Networked models such as Project ECHO provide recurrent opportunities for practitioners to present cases, receive specialist and peer feedback, observe practice, and develop professional confidence. Their educational contribution is therefore not attributable to the technological platform alone. Intergenerational digital learning and community-produced media similarly depend on trust, locally situated relationships, and opportunities for dialogue. Digital technologies extend the spatial reach of interaction, whereas learning is produced through feedback, modelling, practice, reflection, and sustained support.

Institutional integration is equally consequential. Rural professionals require protected learning time, manageable workloads, organisational recognition, technical assistance, and opportunities to apply new knowledge. Community learners require accessible learning spaces, local facilitation, affordable devices, and content connected to relevant social or livelihood priorities. Short-duration interventions that lack maintenance arrangements and local ownership may increase exposure without generating sustained capability. Digital learning should therefore be institutionalised as an educational service rather than implemented as a stand-alone technological intervention.

5.4 Alignment of Technological Modality and Pedagogical Function

The modality–outcome matrix indicates that online and virtual learning was associated with the largest number of records addressing knowledge and access, partly because it was the most prevalent modality. Telehealth and telementoring were comparatively prominent in relation to service quality and workforce retention, reflecting their use within professional networks. ICT and digital-capability initiatives were more strongly associated with social inclusion and livelihood-related contexts, whereas multimedia and mobile approaches were evident

in culturally situated communication and point-of-use learning. These patterns support an approach in which modality selection is guided by the intended pedagogical function and contextual conditions.

Figure 5 should therefore be read as a modality-outcome matrix that provides direct empirical support for the central design claim of this review: no single digital modality is uniformly associated with all desired outcomes. Instead, the mapped co-occurrences indicate different outcome profiles across online/virtual, ICT/digital-capability, telehealth/telementoring, multimedia, blended/distance, and mobile approaches. The matrix supports function-led technology selection while also cautioning that the observed associations describe patterns of co-occurrence in the literature rather than causal effects.

Interventions designed primarily to distribute information may be adequately supported by self-directed, low-bandwidth resources. Interventions intended to develop professional judgement are more likely to require case discussion, feedback, and facilitated interaction. Behavioural or practice change may require rehearsal, reminders, local facilitation, and longitudinal follow-up. Programmes addressing digital inclusion may need to develop foundational digital competence before participants can engage effectively with online content. The selection of a technological platform before clarification of the intended learning function risks conflating technological availability with pedagogical adequacy.

5.5 Expansion of Publication Output and Methodological Maturity

The expansion of the literature was not matched by a comparable increase in experimental, longitudinal, or mixed-method evidence. Survey and qualitative studies provide important insights into needs, feasibility, perceptions, and implementation, but they offer limited evidence concerning the persistence and transfer of learning. Programme evaluations also frequently focused on satisfaction, self-efficacy, or immediate knowledge. The comparatively stronger studies extended outcome assessment beyond participation and examined retained skills, adoption of practices, service quality, or health outcomes.

Future evaluations should employ a staged outcome architecture that differentiates reach, participation, learning, application, organisational or livelihood change, and sustained value. Each stage requires distinct indicators and assessment periods. Evaluations should also document implementation costs, maintenance, learner workload, privacy, unintended exclusion, and dependence on proprietary platforms or externally funded projects. These factors are central to determining whether effective pilots can be institutionalised and sustained within rural settings.

5.6 Theoretical and Methodological Contribution of the Focused Review

The broader rural lifelong-learning review identifies major substantive domains and general patterns of opportunity, constraint, intervention, methodology, and participant representation. The present study offers a distinct contribution by treating digital mediation as the primary analytical construct. It examines temporal variation in technological modalities, differentiates modality from pedagogical function, analyses modality–outcome and modality–sector relationships, evaluates methodological maturity and population coverage, and proposes a conceptual framework specific to rural digital learning. The manuscript should therefore be presented as a transparent, related secondary analysis of a shared parent corpus rather than as an independent database search.

CONCLUSIONS AND IMPLICATIONS

6.1 Summary of Conclusions

Digitally mediated lifelong learning constitutes an increasingly prominent and heterogeneous component of rural educational provision. The literature indicates potential to reduce travel requirements, connect learners with specialist expertise and peer networks, strengthen knowledge and competence, support professional practice, extend community communication, and contribute to livelihood and inclusion outcomes. These benefits, however, are contingent on the interaction of material infrastructure, learner readiness, pedagogical design, and institutional anchoring. The contribution of technology should therefore be assessed through its

capacity to support participation, learning, application, and sustained value rather than through technological availability alone.

6.2 Implications for Policy and Practice

Policy and institutional planning should address the complete set of conditions required for digitally mediated learning. Funding models should include connectivity, electricity, devices, community access points, technical assistance, facilitation, translation, accessibility, protected learning time, mentoring, and maintenance. Low-bandwidth and offline options should remain available where they enhance accessibility, including in contexts where broadband platforms are technically available. Institutions should also connect digital learning with recognised credentials, career development, service improvement, or livelihood opportunities to strengthen the practical value of participation.

Programme design should commence with an analysis of the intended pedagogical function and local implementation conditions rather than with the prior selection of a platform. Relevant considerations include device ownership, connectivity, language, digital competence, accessibility, workload, gendered access to technology, available local support, and opportunities for application. Rural learners and organisations should participate in needs identification, content development, modality selection, facilitation, and evaluation. Data governance, privacy, recurrent costs, and institutional responsibility for maintenance should be addressed before implementation at scale.

6.2.1 Prioritized Policy Actions

Priority 1 - Secure foundational access. Public and institutional investment should first ensure reliable electricity, affordable connectivity and data, appropriate devices, accessible community learning points, and technical support. Platform expansion without these foundations risks widening rather than reducing rural educational inequality.

Priority 2 - Build learner readiness and inclusion. Programmes should provide digital-literacy support, orientation, accessible interfaces, local-language resources, flexible pacing, and assistance for learners affected by disability, limited confidence, time constraints, or shared-device access.

Priority 3 - Match technology to pedagogical purpose. Technology should be selected after the intended learning function is defined. Information distribution may be supported by low-bandwidth resources, whereas professional judgement, complex skills, behaviour change, and collaborative problem-solving generally require interaction, feedback, mentoring, practice, and local facilitation.

Priority 4 - Institutionalise implementation and sustainability. Digital learning should be connected to protected learning time, recognised credentials, career or livelihood pathways, local ownership, maintenance plans, recurrent financing, technical responsibility, and opportunities to apply learning in professional or community settings.

Priority 5 - Govern emerging technologies ethically. Artificial intelligence, chatbots, immersive environments, and learning analytics should be introduced only with explicit safeguards for privacy, informed consent, data ownership, security, human oversight, algorithmic bias, linguistic and cultural appropriateness, accessibility, transparency, and unintended exclusion. Rural communities should participate in technology selection and governance before implementation at scale.

6.2.2 Take-Home Summary for Practitioners

For practitioners, the central message is that successful rural digital learning depends less on technological sophistication than on the fit among technology, learners, pedagogy, and local institutions. Begin by checking whether learners can reliably access and afford the technology and whether they have the digital, linguistic, and practical capabilities needed to participate. Choose the modality according to the intended outcome: low-bandwidth resources may be sufficient for information access, while complex learning and practice change usually require interaction, feedback, mentoring, and opportunities for application. Build local facilitation, culturally and linguistically appropriate content, technical support, accessibility, and institutional recognition

into programme design from the outset. Finally, evaluate not only enrolment or satisfaction but also participation, learning, application, and sustained professional, livelihood, or community benefit.

6.3 Directions for Future Research

Table 6. Priorities for future research and evidence development.

Priority area	Recommended direction
Methodological maturity	Employ longitudinal, mixed-method, experimental, quasi-experimental, realist, and implementation designs where appropriate.
Outcome architecture	Differentiate reach, participation, learning, application, organisational or livelihood outcomes, and sustained value.
Sectoral balance	Extend research beyond health to agriculture, vocational learning, local governance, climate adaptation, disability, youth, and later-life learning.
Equity analysis	Disaggregate participation and outcomes by gender, age, disability, language, income, device ownership, connectivity, and location.
Sustainability	Evaluate costs, maintenance, staffing, platform dependence, institutional ownership, and post-project continuity.
Emerging technologies	Assess artificial intelligence, immersive environments, chatbots, and learning analytics against clearly specified rural needs, risks, and ethical requirements.
Research leadership	Increase locally led research, rural co-design, community data governance, and equitable international collaboration.

6.4 Limitations

The review was restricted to English-language journal articles indexed in Scopus and may therefore underrepresent local journals, reports, theses, books, and non-English scholarship. The supplied export contained 1,427 logical records, compared with the 1,446 records reported after Scopus limits, leaving an unresolved discrepancy of 19 records. The 202-record focused corpus was identified from titles, abstracts, and keywords, and full-text assessment was not undertaken for every article. The reported frequencies consequently indicate the visibility of concepts and methodological characteristics rather than the magnitude or direction of effects. Barrier, enabling-condition, method, and sampling categories were coded conservatively and may underestimate information available only in full texts. The review employed a single-reviewer, computationally assisted process without independent duplicate coding. In addition, the corpus constitutes a nested subset of a broader review; transparent disclosure and appropriate cross-referencing are required if the two manuscripts are submitted or published.

The English-only Scopus restriction may have consequences beyond simple undercounting. It may systematically privilege research from institutions and journals with greater access to English-language publishing and international indexing, while reducing the visibility of locally led scholarship in national languages, institutional repositories, community publications, government reports, theses, books, and other grey literature. The observed geographical concentration of authorship should therefore not be interpreted as a direct measure of where rural digital learning activity or expertise is located. The restriction may also favour formal, institutionally organised, and technologically explicit interventions while missing culturally embedded and informal learning arrangements. Qualitative examples within the included corpus illustrate what may be less visible in database-level mapping: intergenerational support for older adults' digital learning, community-generated digital storytelling, local-language and community-media approaches, animated agricultural video, and everyday smartphone-mediated learning among rural women. These examples suggest that non-English and locally disseminated evidence could alter the apparent balance among technologies, pedagogical functions, participation conditions, and outcomes. Future reviews should therefore consider multilingual databases, regional indexes, targeted grey-literature searches, and locally led qualitative synthesis.

DATA AVAILABILITY AND RELATED-STUDY DISCLOSURE

The supplementary materials comprise the 202-record focused corpus with additional pedagogical-function codes and the screening log for the 739-record parent corpus. The focused corpus was derived from the cleaned Scopus export used in a broader companion review of lifelong learning in rural settings. The present manuscript employs distinct research questions, analytical categories, figures, tables, conceptual framework, and interpretive arguments. The shared data relationship should be disclosed to the editor, and the companion article should be cited when its bibliographic information becomes available.

For publication transparency, the companion review should contain a reciprocal disclosure stating that the present digital-focused mapping review uses a nested subset of the same cleaned parent corpus. Editors should be informed of the shared data source at submission, and each manuscript should cite the other when a citable version is available. The analytical outputs should remain clearly differentiated to avoid any implication that the two articles represent independent database searches.

REFERENCES

1. Aker, J. C., Ksoll, C., & Lybbert, T. J. (2012). Can mobile phones improve learning? Evidence from a field experiment in Niger. American Economic Journal: Applied Economics, 4(4), 94–120. https://doi.org/10.1257/app.4.4.94
2. Andari, R. N. (2022). A bibliometric analysis of digital competency studies in rural areas. In A. Azizah & E. D. Ariyani (Eds.), Proceedings of the International Conference on Applied Science and Technology on Social Science 2022 (iCAST-SS 2022) (pp. 10–16). Atlantis Press. https://doi.org/10.2991/978-2-494069-83-1_3
3. Arora, S., Kalishman, S., Dion, D., Som, D., Thornton, K., Bankhurst, A., Boyle, J., Harkins, M., Moseley, K., Murata, G., Komaromy, M., Katzman, J., Colleran, K., Deming, P., & Yutzy, S. (2011). Partnering urban academic medical centers and rural primary care clinicians to provide complex chronic disease care. Health Affairs, 30(6), 1176–1184. https://doi.org/10.1377/hlthaff.2011.0278
4. Bagayoko, C.-O., Gagnon, M.-P., Traoré, D., Anne, A., Traoré, A. K., & Geissbuhler, A. (2014). E-health, another mechanism to recruit and retain healthcare professionals in remote areas: Lessons learned from EQUI-ResHuS project in Mali. BMC Medical Informatics and Decision Making, 14, 120. https://doi.org/10.1186/s12911-014-0120-8
5. Bello-Bravo, J., Abbott, E., Mocumbe, S., Maria, R., Mazur, R., & Pittendrigh, B. R. (2020). An 89% solution adoption rate at a two-year follow-up: Evaluating the effectiveness of an animated agricultural video approach. Information Technology for Development, 26(3), 577–590. https://doi.org/10.1080/02681102.2019.1697632
6. Callas, P. W., Ricci, M. A., & Caputo, M. P. (2000). Improved rural provider access to continuing medical education through interactive videoconferencing. Telemedicine and e-Health, 6(4), 393–399. https://doi.org/10.1089/15305620050503861
7. Cheng, H., Lyu, K., Li, J., & Shiu, H. (2022). Bridging the digital divide for rural older adults by family intergenerational learning: A classroom case in a rural primary school in China. International Journal of Environmental Research and Public Health, 19(1), 371. https://doi.org/10.3390/ijerph19010371
8. Curran, V. R., Hoekman, T., Gulliver, W., Landells, I., & Hatcher, L. (2000). Web-based continuing medical education. II: Evaluation study of computer-mediated continuing medical education. Journal of Continuing Education in the Health Professions, 20(2), 106–119. https://doi.org/10.1002/chp.1340200207
9. Cueva, M., Kuhnley, R., Revels, L., Schoenberg, N. E., & Dignan, M. (2015). Digital storytelling: A tool for health promotion and cancer awareness in rural Alaskan communities. International Journal of Circumpolar Health, 74, 28781. https://doi.org/10.3402/ijch.v74.28781
10. Feldacker, C., Jacob, S., Chung, M. H., Nartker, A., & Kim, H. N. (2017). Experiences and perceptions of online continuing professional development among clinicians in sub-Saharan Africa. Human Resources for Health, 15, 89. https://doi.org/10.1186/s12960-017-0266-4
11. Gautam, S., & Rai, I. M. (2025). Smartphones in the hands of rural women: Embracing informal learning for digital literacy. Adult Learning, 36(2), 120–130. https://doi.org/10.1177/10451595241263142

12. Geissbuhler, A., Bagayoko, C. O., & Ly, O. (2007). The RAFT network: 5 years of distance continuing medical education and tele-consultations over the Internet in French-speaking Africa. International Journal of Medical Informatics, 76(5–6), 351–356. https://doi.org/10.1016/j.ijmedinf.2007.01.012
13. Gifford, V., Niles, B., Rivkin, I., Koverola, C., & Polaha, J. (2012). Continuing education training focused on the development of behavioral telehealth competencies in behavioral healthcare providers. Rural and Remote Health, 12(4), 2108.
14. Intarat, S., & Chanchalor, S. (2017). ICTs for non-formal education in rural Thailand. Australasian Journal of Educational Technology, 33(4), 107–121. https://doi.org/10.14742/ajet.3165
15. Karaman, S. (2011). Nurses' perceptions of online continuing education. BMC Medical Education, 11, 86. https://doi.org/10.1186/1472-6920-11-86
16. Katzman, J. G., Comerci, G., Boyle, J. F., Duhigg, D., Shelley, B., Olivas, C., Daitz, B., Carroll, C., Som, D., Monette, R., Kalishman, S., & Arora, S. (2014). Innovative telementoring for pain management: Project ECHO pain. Journal of Continuing Education in the Health Professions, 34(1), 68–75. https://doi.org/10.1002/chp.21210
17. Kennedy, A. J., Brumby, S. A., Versace, V. L., & Brumby-Rendell, T. (2020). The ripple effect: A digital intervention to reduce suicide stigma among farming men. BMC Public Health, 20, 813. https://doi.org/10.1186/s12889-020-08954-5
18. Lund, S., Boas, I. M., Bedesa, T., Fekede, W., Nielsen, H. S., & Sørensen, B. L. (2016). Association between the Safe Delivery App and quality of care and perinatal survival in Ethiopia: A randomized clinical trial. JAMA Pediatrics, 170(8), 765–771. https://doi.org/10.1001/jamapediatrics.2016.0687
19. Mehrotra, K., Chand, P., Bandawar, M., Rao Sagi, M., Kaur, S., G, A., Raj, A., Jain, S., Komaromy, M., Murthy, P., & Arora, S. (2018). Effectiveness of NIMHANS ECHO blended tele-mentoring model on integrated mental health and addiction for counsellors in rural and underserved districts of Chhattisgarh, India. Asian Journal of Psychiatry, 36, 123–127. https://doi.org/10.1016/j.ajp.2018.07.010
20. Olanrewaju, G. S., Adebayo, S. B., Omotosho, A. Y., & Olajide, C. F. (2021). Left behind? The effects of digital gaps on e-learning in rural secondary schools and remote communities across Nigeria during the COVID-19 pandemic. International Journal of Educational Research Open, 2, 100092. https://doi.org/10.1016/j.ijedro.2021.100092
21. Page, M. J., McKenzie, J. E., Bossuyt, P. M., Boutron, I., Hoffmann, T. C., Mulrow, C. D., Shamseer, L., Tetzlaff, J. M., & Moher, D. (2021). Updating guidance for reporting systematic reviews: Development of the PRISMA 2020 statement. Journal of Clinical Epidemiology, 134, 103–112. https://doi.org/10.1016/j.jclinepi.2021.02.003
22. Pringle, I., & David, M. J. R. (2002). Rural community ICT applications: The Kothmale model. Electronic Journal of Information Systems in Developing Countries, 8(1), 1–14. https://doi.org/10.1002/j.1681-4835.2002.tb00048.x
23. Ricci, M. A., Caputo, M. P., Callas, P. W., & Gagne, M. (2005). The use of telemedicine for delivering continuing medical education in rural communities. Telemedicine and e-Health, 11(2), 124–129. https://doi.org/10.1089/tmj.2005.11.124
24. Rozo-García, H., & Ramírez-Montoya, M. S. (2025). Teaching and learning strategies in remote education: A systematic review of the literature. Australasian Journal of Educational Technology, 41(2), 71–88. https://doi.org/10.14742/ajet.10070
25. Rusatira, J. C., Tomaszewski, B., Dusabejambo, V., Ndayiragije, V., Gonsalves, S., Sawant, A., Mumararungu, A., Gasana, G., Amendezo, E., Haake, A., & Mutesa, L. (2016). Enabling access to medical and health education in Rwanda using mobile technology: Needs assessment for the development of mobile medical educator apps. JMIR Medical Education, 2(1), e7. https://doi.org/10.2196/mededu.5336
26. Sockalingam, S., Arena, A., Serhal, E., Mohri, L., Alloo, J., & Crawford, A. (2018). Building provincial mental health capacity in primary care: An evaluation of a Project ECHO mental health program. Academic Psychiatry, 42(4), 451–457. https://doi.org/10.1007/s40596-017-0735-z
27. Xing, W., Ao, L., Xiao, H., Cheng, L., Liang, Y., & Wang, J. (2018). Nurses' attitudes toward, and needs for, online learning: Differences between rural and urban hospitals in Shanghai, East China. International Journal of Environmental Research and Public Health, 15(7), 1495. https://doi.org/10.3390/ijerph15071495