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Designing Mobile-Assisted Academic Literacies for Low-Bandwidth Contexts: A Design-based Research (DBR) Approach in Rural Pakistani Universities

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Abstract

This design-based research (DBR) investigates the development and iterative refinement of mobile-assisted academic literacies (MAAL) pedagogies within low-bandwidth environments characteristic of rural Pakistani universities. Conducted across three intervention cycles over eighteen months, the study engaged 127 undergraduate students and seven faculty members from three public sector universities in Sindh and Punjab provinces. Through participatory design workshops, classroom implementations, and qualitative data analysis, findings reveal that asynchronous mobile strategies utilising offline-first architectures substantially enhance students' critical reading, disciplinary writing, and information literacy practices while reducing data costs by up to 73 per cent. The research identifies five design principles: modular content architecture, adaptive assessment protocols, peer-to-peer mesh networking, culturally responsive scaffolds, and integrated faculty development. This study contributes empirically grounded frameworks for digitalisation in resource-constrained contexts, addressing the research-practice gap in Pakistan's higher education landscape.

Keywords: Mobile-assisted academic literacies, design-based research, low-bandwidth contexts, rural universities, digital divide, Pakistan higher education

Introduction

The Higher Education industry in Pakistan is at the edge of digital transformation and one of the agencies that have been promoting the wholesome adoption of e-learning is the Higher Education Commission (HEC) through its Digital Pakistan Vision 2025. Nonetheless, there is systemic inequality between cities and rural institutions making it difficult to execute it fairly. Rural universities, which are provided to students with about 42 per cent of the total population in Pakistan, face systematic challenges: spotty connectivity of 2G/3G speeds, lack of institutional facilities, and poor digital literacy of the faculty and student body (HEC, 2022). Such limitations require the development of pedagogical solutions that do not rely on bandwidth and help develop vital academic skills.

The core of academic literacies, including critical reading, disciplinary writing, and

information synthesis, are the key success factors in undergraduate level. Face to face teaching in rural setting can be inefficient, and also traditional teaching learning management system (LMS) requires more connectivity than local systems. Mobile technologies have affordances that have potential to be promising in the form of ubiquity, affordability and offline capability but are still underexplored in the Pakistani academic literacies scholarship. This gap is discussed in this study through the development, deployment, and optimization of mobile-assisted pedagogies that are specifically adjusted to low-bandwidth conditions.

The research is being placed at the context of the public sector of universities in rural Sindh and Punjab where the infrastructural deficiencies are the most intense. These schools and colleges admit large groups of first-generation university-students, who have often had an agricultural background, and whose academic conventions of discourse may seem culturally and linguistically foreign to them. The study follows the design-based research (DBR) approach, which allows the systematic investigation in the form of successive cycles of design, implementation, analysis, and redesign in realistic learning contexts. The method produces contextually sound principles as it promotes theoretical knowledge about mobile learning in resource limited settings.

Significance of the Study

The study has three contributions to the Pakistani and global research. One, it creates empirically proven design principles of mobile-based academic literacies under low bandwidth conditions, which directly responds to the HEC strategic focus of inclusive digital learning. The principles provide practical advice to rural higher education institutions that want to adopt scalable and cost-efficient pedagogical innovations without necessarily having to undergo massive technological transformations at the infrastructure level.

Second, the research adds to the South Asian voice in the literature of mobile learning that is largely dominated by Euro-American researches and carried out in high-connection settings. This study addresses the problem of universalism in digital pedagogies by preempting rural Pakistani lives, and shows how the idea of contextual constraint can generate instead of suppress innovation. The results are related to other low-resource settings throughout the Global South, especially in sub-Saharan Africa

and Southeast Asia, where connectivity issues are the same.

Third, the DBR research process used enhances the Pakistan education research capacity by providing models of university-community partnerships. The faculty members were co-designers where they created research based practices as they helped generate knowledge. This capacity-building aspect compliments the interest of HEC to develop the indigenous research experience and decrease dependence on imported education solutions.

The study also concerns real-time practical requirements. The level of the academic writing of Pakistani students is also alarming since HEC (2021) confessed that only 34 per cent of undergraduates have a satisfactory level of critical analysis. At the same time, mobile penetration is above 85 per cent in the whole country and even in villages, which opens an untapped pedagogical opportunity. Using this infrastructure that already exists, the study provides strategies on academic development that are financially viable.

Research Objectives

The study pursued four interrelated objectives:

1. To design and develop mobile-assisted academic literacies pedagogies compatible with 2G/3G connectivity and offline functionality in rural Pakistani university contexts.
2. To examine students' engagement patterns and learning outcomes across three iterative DBR cycles, focusing on critical reading, disciplinary writing, and information literacy development.
3. To identify context-specific design principles that support sustainable implementation of mobile learning in low-bandwidth environments.
4. To evaluate faculty capacity development needs and co-design professional learning frameworks responsive to rural institutional constraints.

These objectives reflect DBR's dual commitment to practical problem-solving and theoretical contribution, positioning the research at the intersection of applied educational design and scholarly inquiry.

Research Questions

The study addressed the following research questions:

1. How can mobile-assisted academic literacies pedagogies be designed and refined to support undergraduate learning in low-bandwidth rural Pakistani university contexts?
2. What design features most effectively support offline-first academic literacies development whilst minimising data costs for rural students?
3. How do students' academic reading, writing, and information literacy practices evolve across iterative DBR cycles?
4. What faculty development frameworks enable sustainable enactment of mobile-assisted pedagogies in resource-constrained environments?
5. What institutional policy recommendations emerge to support scalable implementation across Pakistan's rural higher education sector?

Such questions were used to facilitate data collection and data analysis, which were used to ensure a systematic investigation, and to have emergent insights which influenced further design cycles. The flexibility of the DBR methodology allowed reactive narrowing of the research areas as research contexts were revealed to be more complex.

Literature Review

Academic literacies are complex social activities whereby students are engaged in negotiating meaning in disciplinary communities. Lea and Street (1998) conceptualize this into a three-level framework that encompasses the study skills, academic socialisation and academic literacies the latter focusing on power relations and institutional discourses. This view contradicts deficit approaches to student writing, academic growth is shaped and formed as a form of enculturation instead of technical mastery. The studies conducted in Pakistani situations indicate that there are significant problems in writing proficiency at undergraduate level. According to HEC (2021) national assessment, only thirty-four per cent. of students have sufficient critical analysis skills, with Rehman and Saba (2019) citing disciplinary standards, citation style, and rhetorical structure as the main barriers to ESL students. These challenges are magnified especially in rural universities where English medium

instruction is in conflict with minimal exposure to academic registers.

Wingate (2012) proposes integrated strategies that would incorporate academic skills within the discipline-specific content as opposed to the remedial models that are prevalent in Pakistani universities. According to Lillis and Scott (2007), successful academic literacies teaching should be based on ideological aspects and this should acknowledge how institutional practices discriminate against various linguistic repertoires. This is especially relevant in Pakistan where the legacies of colonialism give precedence to the Anglo-centric academic norms over the knowledge systems of native groups. Shamim (2011) criticizes the reproduction of social stratification in English language policies, whereas Rizvi et al. (2006) opine that postcolonial approach could shed light on such relationships of power. The study therefore necessitates paradigms that consider the international scholarly standards as well as the local ones.

Digital Equity and Mobile-Assisted Learning

The literature on mobile learning glorifies the ubiquitous access and flexibility of context. According to Kukulska-Hulme and Traxler (2013), the following are the important affordances: individuality, portability, and connectivity. These assumptions usually however assume good infrastructure that is not available in rural Pakistan. According to Traxler (2018), the research in the Global South is underrepresented, and most of the scholarship is based on Northern settings. Pal et al. (2009) enhance this criticism by showing how low-bandwidth settings require radically new design logics in which asynchronous interaction and offline-first designs are paramount.

Complex patterns of mobile adoption are found in Pakistani researches. According to

Ahmed and Mahmood (2015), ninety-two per cent of the students of public universities possess their smartphones, but the high price of data usage and the ability to connect to the Internet limit the educational process. Rahim and Ali (2014) record the emphasis of the mobile cultures in Pakistan on the social connectivity rather than academic uses and the need of pedagogical scaffolding. Farooq and Bell (2020) also show that they can use low-cost technologies to facilitate rural education by designing them based on the existing practice instead of standard imported models. The above findings imply that effective mobile-based academic literacies need to be able to

balance the potential of technology with the financial and infrastructural realities.

The discourse of the digital divide goes beyond access to include quality, affordability and digital capital. Malik and Fatima (2017) emphasize the poor bandwidth, poor institutional support, and lack of digital literacy in the faculty of rural Pakistani universities. Khan and Ilyas (2014) measure this gap, with rural locations getting thirty-seven per cent slower connectivity rates compared to urban centres although they have the same device ownership. These differences imply that with such disparities, design solutions must address bandwidth scarcity as a generative constraint, but not as a deficiency.

Low-Bandwidth Pedagogy and Offline-First Design

New research on low-bandwidth learning provides pertinent knowledge. Porter (2016) promotes the principles of offline-first design, according to which the synchronisation of content is performed in opportunities, which are also followed in telecentres in Africa. Wong and Looi (2011) name seamless learning as the ideal, but note that connectivity gaps will still necessitate a conscious effort to design seams (to create deliberate disconnection points) with which to design learning activities. This idea is useful in rural Pakistani settings where connection is intermittent as opposed to non-existent.

Design thinking is informed by research in the related Global South settings. Pal et al. (2009) refer to the occasionally cheap commodity concept in which the affordability of connectivity varies sporadically, suggesting the use of modular content architectures that the learners can download at the low-cost periods. Unwin (2017) sharply criticizes the ICT4D efforts as being biased towards connectivity instead of focusing on pedagogy, stating that significant learning must take account of local social practices and epistemologies. These insights are consistent with postcolonial arguments against educational technology, which argue that low-bandwidth situations require culturally situated design.

Pakistani institutional facts also make implementation problematic. According to Saeed and Zameer (2020), the proportion of faculty of rural universities who are ready to engage in e-learning is only twenty-three per cent, and the main obstacle, according to Waraich and Mahmood (2009), is the lack of appropriate technical

infrastructure. The results of this study support the importance of faculty development as part of technological design, and not as an add-on.

Design-Based Research based on Educational Technology

Design based research (DBR) provides a methodological rigour in the development of context sensitive interventions. Design-Based Research Collective (2003) places DBR in the level of employing the iteration of design within real-life contexts to solve complex issues through working on real-life problems as well as generating practical resolutions and theoretical knowledge. Anderson and Shattuck (2012) prove increasing popularity of DBR in educational technology which is capable of closing the research-practices gaps. McKenney and Reeves (2019) offer a thorough guide, which includes the involvement of multiple sources of data, joint design, and refinement based on principles.

DBR is appropriate to this study in three folds. To begin with, it supports low-bandwidth requirements as design characteristics, but not restrictions. Second, its participatory ethos is in line with faculty capacity development needs. Third, it has an iterative structure that allows academic semester by semester optimisation. Pakistani educational research is increasingly beginning to use DBR, although there are few published examples. This research adds variety in the methodology of local scholarship but produces context-demanding design knowledge.

Rural Pakistan Higher Education Problems

Pakistani universities in the rural areas have unique problems that need specific solutions. The Digital Vision implementation framework provided by HEC (2022) recognizes the lack of infrastructure but does not provide much guidance in the low-bandwidth setting. It is known that administrative centralisation usually alienates policy to the realities on the ground. Batool and Qureshi (2015) record the fact that the teaching of academic writing is generic and decontextualised in that it lacks knowledge of the differences in disciplines. According to Mahmood (2018), postgraduate students face problems with electronic resources because digital literacy was not provided through sufficient instruction in undergraduate.

Academic literacies development is also influenced by the socio-cultural factors. In the rural areas, there are a large number of first-generation learners who assume

family farming duties alongside their schoolwork. English is used as a gate keeping system but learning is usually based on levels of proficiency not supported by previous schooling. According to Shamim (2011) the policy of language should be sensitive to these linguistic ecologies, and pedagogies should support a scaffolding between local languages and academic English. This study reacts by developing a multilingual assistance on mobile interfaces.

The degree of institutional autonomy is wide ranging with the older universities being better resource endowed as compared to newer rural institutions. The cross-institutional design of the study allows comparing the aspects of implementation, producing malleable instead of prescriptive principles. Participation sustainability also suffers due to faculty workload and insufficient research incentives that are being mitigated with the help of integrated professional development.

Theoretical Framework

The present paper uses sociocultural theory, New Literacy Studies, and postcolonial approaches to come up with a contextually sensitive discussion of mobile-assisted academic literacies. According to the sociocultural theory of learning introduced by Vygotsky (1978), the social interaction is the starting point of learning and is mediated by cultural means and Wertsch (1998) goes on to propose that cognitive processes may also be reconstituted using technology artifacts. Mobile devices can be used in low-bandwidth situations as forms of psychological technologies that assist in building academic literacies and peer-to-peer relations form zones of proximal growth, which provide the rationale to the team-based and peer learning models. New Literacy Studies, which has been proposed by Street (2003) and Gee (2015), question the idea of literacy as a universal ability, which can be seen as socially situated in terms of power relations. The given view can be applied to the context of the Pakistani postcolonial educational setting, where there are tensions between Anglo-centric academic standards and the indigenous knowledge frameworks, which forward the elements of design that would reflect the local knowledge base and multilingual texts. The educational technologies are criticized by postcolonial theory (Spivak, 1999; Rizvi et al., 2006), which suggests that the existing knowledge flows should be destabilized with the use of educational technology so that knowledge flows become

centered and peripheral, making rural Pakistani universities spaces of epistemic possibilities. This model promotes a culture responsive design, local content creation and sharing of knowledge between the Global South. Last but not least, the theory is supplemented by the theory of Connectivism (Siemens, 2005), which concerns the navigation of the information in the networked world of distributed knowledge. The theory however, needs to be adjusted to low bandwidth situations that are local and intermittent networks. This combination of these theories produces a hybrid framework of mediating literacy practices using a sociocultural, postcolonial, and connectivist perspective that is customized in low connectivity settings.

Methodology

This study utilized three-cycle Design-Based Research (DBR) design over a period of eighteen months, including three rural state universities, where design, implementation, and analysis were conducted in actual educational conditions (McKenney and Reeves, 2019). Every cycle twelve weeks involved contextual analysis, co-design workshops, classroom implementation, data collection and retrospective analysis to make redesigns. The former cycle was dedicated to the analysis of needs and prototypical development where 43 students and 2 faculty members attended University A (Punjab). The second cycle increased to 41 students and 3 faculty of Universities A and B (Sindh) and experimented with modified designs. Sustainable implementation strategies were tested on the third cycle that had 43 students and 2 faculty of all three universities. The sample population of the study included 127 undergraduate students (mean age 20.3 years, 68% female) and 7 members of the faculty (Agriculture, English, and Computer Science departments) and was purposely sampled with rural universities that have 2G/3G connectivity, over 500 enrolled students, and interested in professional development. The data were gathered in various ways, including in academic writing samples (n=254), semi-structured interviews with students (n=36) and faculty (n=7), focus groups on peer learning (n=54), classroom observations (27 sessions), and mobile platform technical analytics (engagement, offline usage, sharing). Qualitative data was organized using the thematic analysis approach, which implements the reflexive approach by Braun and Clarke (2019), and the coding was done in stages, followed by the cross-cycle

analysis to create design principles. Paired t -tests were used to compare pre/ post rubric scores on critical analysis, rhetorical structure, vocabulary, and citation practices and descriptive statistics on relationships between offline engagement and gains in literacy. Integration of mixed methods offered an overall picture on the effects of features of designs on learning processes.

Analysis and Results

Pilot Cycle Findings

The first design cycle indicated essential system failures when traditional mobile learning designs were subjected to rural connectivity conditions. The average time taken by students to download a single 15-megabyte PDF reading was 27 minutes and seventy-three per cent had to give up because of error of time out. Observations by faculty members revealed that synchronous discussion forums were unsustainable, and students were frustrated by the rate of data use of three days of agricultural wages. The offline-first design was shown to increase the engagement level significantly in technical analytics. Average time of interaction was a result with 4.2 minutes per session rising to 18.7 minutes per session when the pre-loading was done over campus Wi-Fi (intermittent in faculty offices). The content architecture based on modules with 500 kilobyte learning packets allowed ninety one per cent. of the students to complete at least three modules per week. P2P sharing through Bluetooth mesh networks came naturally, of which sixty-four per cent of the respondents redistributed the content to their colleagues.

The data obtained in interviews also pointed at such cultural aspects of mobile use. Students identified with data anxiety - unwilling to study because of the uncertainty about the costs. Privacy was noted especially by female participants who favored asynchronous activities at which they could bargain on the household chores. Faculty observed that peer review via mobile platforms increased equality by diminishing hierarchical distance, thus enabling less vocal students to have an equal opportunity at participating in a discussion. The results led to the redesign of the second cycle, with the focus put on hyper-modular content, offline annotation tools, and gender-responsive schedule.

Second Cycle Refinements

The cross-cycle (second cycle) analysis of writing samples (n=41) showed statistically significant changes in such aspects as critical analysis (t(40)=4.23, p= 0.001) and rhetorical organisation (t(40)=3.91, p= 0.001). Disciplinary vocabulary gains were however modest (t(40) =1.87, p=0.069), which means that twelve-week interventions need to be complemented with discipline-specific glossaries. The information literacy practices of the students were significantly developed in terms of evaluating the sources and eighty-seven per cent of the students identified the predatory journals in the post-tests whereas twenty-three per cent identified the predatory journals in the pre-intervention analysis.

Five major themes were produced as a result of qualitative analysis. To start with, the asynchronous scaffolding allowed students to listen to the lecture explanation three times and work in the fields and then write a response when they got back to it as one of the Agriculture students remarked: I could listen to the lecture explanation three times when working in the fields, and then write my response when I returned (Interview, 14 March 2024). Second, there was horizontal learning community via peer-to-peer mentorship based on annotated exemplar sharing. Third, culturally responsive material with case studies related to Sindh and Punjab settings were more relevant, with thirty-four per cent higher completion rates being seen to the locally outstanding material.

The data of faculty development showed that the co-design workshops enhanced the technological pedagogical content knowledge (TPACK). Pre/ post surveys indicated a change in mean confidence scores of 2.8 to 4.1 on a five point scale. Nonetheless, there were still institutional limitations: two faculty members said that they could not fully implement it because of examination pressures and administration opposed to alternative assessment. This highlighted the importance of making mobile pedagogies to conform to current curricular designs.

Third Cycle Validation

The last cycle was the evaluation of sustainable implementation in three institutions. Sample analysis (n=43) of writing samples supported previous gains with total literacy scores increasing by 1.2 standard deviations. Women students (n=29) made

slightly higher gains as compared to men counterparts (d=0.18), which can be explained by the fact that they experienced more offline peer discussion features. Table 1 shows comparative pre/post rubric scores over all the cycles.

Table 1: ***Pre/Post Academic Literacies Rubric Scores by Cycle (Mean, SD)***

Dimension	Cycle 1 (n=43)	Cycle 2 (n=41)	Cycle 3 (n=43)
Critical analysis	2.3 (0.71) → 3.4 (0.62)	2.4 (0.68) → 3.6 (0.59)	2.5 (0.65) → 3.7 (0.58)
Rhetorical organization	2.1 (0.78) → 3.2 (0.71)	2.2 (0.74) → 3.4 (0.68)	2.3 (0.72) → 3.5 (0.66)
Disciplinary vocabulary	2.7 (0.69) → 3.0 (0.64)	2.8 (0.66) → 3.1 (0.61)	2.8 (0.63) → 3.2 (0.59)
Citation practices	1.9 (0.82) → 3.5 (0.73)	2.0 (0.79) → 3.7 (0.70)	2.1 (0.76) → 3.8 (0.67)

Technical analytics of the last iteration revealed that 78 per cent of actions were on-line and the average number of synchronisation events was 4.3 weekly per student amongst low-cost data windows (typically, 2am 6am). P2P sharing rose to 82 per cent of participants and formed strong mesh networks that were not dependent on cellular networks. The consumption of data decreased by 73 per cent in comparison to the traditional use of LMS, so it is a great cost reduction.

The qualitative results were summarized in the form of five empirically based design principles. Firstly, modular content architecture provided access on a granular basis with students only downloading what they needed. Second, adaptive assessment procedures allowed them to submit through SMS-coded responses in unavailable data, and later synchronise when connectivity was restored. Third, peer-to-peer mesh networking capitalized on the pre-existing social content sharing practices, and turned the potential issues of academic integrity into pedagogical resources. Fourth, the culturally responsive scaffolds incorporated the local bodies of knowledge (i.e. the use of metaphors of indigenous crop management to describe academic argumentation). Fifth, integrated faculty development included technical training entrenched in collaborative design, which continues to be implemented after researcher intervention.

Scalability was impeded in the institution due to faculty interviews. Promotion criteria favoring research publications instead of teaching innovation was among the disincentives that were mentioned by three participants. Two Heads of Department raised some issues with mobile devices that it led to disciplinary issues and that there needed to be policy alignment that indicates academic rigour. On the other hand, students encouraged the expansion of institutional Wi-Fi, but admitted the cost factor. These tensions have provided recommendations at micro, meso and macro levels of implementation.

Discussion

Design Principle of Low-bandwidth Contexts

The five design concepts realized in this study expand mobile learning literatures in that they view bandwidth scarcity as a generative limitation instead of a theoretical shortcoming. Although Porter (2016) suggests the use of the offline-first structure, the current study will prove the ways in which the concept of modular design and peer mesh networks can turn intermittency into pedagogical benefit. The reduction of the data cost by 73 per cent specifically targets the economic barrier that Rahim and Ali (2014) indicate and makes mobile learning possible to the low-income students.

The scaffolds that were culturally responsive were found to be especially important. The intervention incorporated academic ideas into the well-known rural knowledge systems, thus contributing to colonial heritage that he criticized Shamim (2011). To illustrate, the explanation of thesis statements by the metaphor of irrigation channel building in the channeling of the intellectual flow as the management of water was used as a point of cognitive hooks and the verification of the indigenous expertise. This is in line with the postcolonial theses of provincialising the educational technology, the rejection of mere importation of Northern pedagogical patterns.

The peer-to-peer mesh networking concept echoes the connectivist theory but is adjusted to the limited settings. Siemens (2005) assumes that learning takes place by navigation in the network; yet traditional assumptions of connectivity are invalid in the present case. The sharing architecture that was based on Bluetooth developed localised knowledge networks, which showed that connectivist principles could be implemented at micro-scale without constant internet. This observation converts

universalist discourses of digital divide, unveiling the top-down innovations by bypassing the constraints of infrastructure.

Development of Academic Literacies

Developments in critical analysis and citation practices were also better than expected, which implies that higher-order thinking can be successfully facilitated by mobile scaffolding. The asynchronous quality allowed them to have long engagement with the complicated writings, thus addressing time poverty of students who are combining academic and agricultural work. This observation supports the arguments of Wingate (2012) who supports the idea of integrated development of academic skills but also translates it to mobiles.

Nevertheless, showing small improvements regarding disciplinary vocabulary means that generic academic literacies methods are limited. The incorporation of discipline-related glossaries in cycle three led to the improvement of outcomes, but twelve-week interventions might not be enough to entrench lexical knowledge. This implies that longitudinal research must be done to investigate vocabulary learning at varied semesters. The result also sheds light on the barriers to mobile interfaces in deep reading; although it is appropriate in skill-building exercises, expansive reading of disciplinary language might need combination strategies.

There were surprising trends of gender dynamics. The fact that female students use offline peer conversations more than expected in terms of assumptions surrounding cultures of masculinised technologies in Pakistan. This is consistent with the findings of Ahmed and Mahmood (2015) who argue that mobile devices can provide safe zones where females can participate in the activity as long as the devices have privacy settings. The asynchronous structure also allowed the negotiation of domestic obligations, which led to more equal involvement. This highlights the need to include gender responsiveness in educational technology to go beyond gender-neutral premises.

Institutional Change and Faculty Development

Development of faculty as a factor of sustainability became critical. The co-design model was integrated, resulting in a huge enhancement of TPACK confidence but was hindered by institutional structures. The fact that the promotion guidelines favor

research to teaching innovation is indicative of something even more rooted in Pakistani higher education. The observation supports the fact that Saeed and Zameer (2020) have documented the lack of faculty preparedness, and the policy levers to change the situation.

The participatory design of the study followed the model of collaborative research-practice partnerships, which reinforced the capacity of indigenous research. Faculty participants reported greater confidence in making classroom inquiry with two remaining presenting their findings at national conferences. This capacity-building aspect responds to the strategic focus of the HEC on developing research in rural universities, which reveals how DBR may fulfill two roles of generating knowledge and developing professionals. Educational change issues in hierarchical structure are marked by institutional resistance by department leaders. The issue of mobile devices leading to discipline issues signifies the lack of exposure to formatted integration of pedagogical strategies instead of the perceived technological dangers. It means that scalability involves policy advocacy that shows its alignment with the current quality assurance frameworks, especially to the Digital Vision metrics proposed by HEC (2022).

Limitations and Methodological Reflections

Although DBR was designed through iteration, the eighteen months period did not allow longitudinal evaluation of the effects of retention. The development of literacies should also be followed up in various semesters to determine the long term. Single discipline (Agriculture, English, Computer Science) restricts the generalisation to the sciences or professional programmes which may need alternative literacies practices.

The sample was geographically dispersed in Punjab and Sindh; it did not include rural universities in Khyber Pakhtunkhwa and Balochistan, where the infrastructural and cultural background is very different. Further studies must be extended to these areas especially by taking into consideration security-related connectivity interruptions peculiar to these provinces.

Data collection was also impaired by technical constraints. Analytics were unable to know the difference between actual offline usage and mere app idling, which might benefit the usage statistics. Nonetheless, interview data and writing

results triangulation offered validity tests. The peer to peer sharing statistics was based on self reporting but the Bluetooth proxies logs supported seventy eight per cent of the self reported cases.

Positionality This could be because of positionality as urban-based researchers. Member checking and joint analysis sessions were consciously undertaken to pre-empt the voice of participants. Emic views were made by using rural faculty co-authors of the design principles, thus making sure that findings were made using emic perspectives. The power discrepancies that exist between the researcher and the practitioner in the research setting, however, necessitate persistent reflexivity.

Contributions to Knowledge

This research has three contributions. First, it produces empirically justified design principles of mobile-supported academic literacies under low-bandwidth environments, fills a research gap as identified by Pal et al. (2009). These principles also provide practical guidelines to rural Pakistani universities and other similar situations in the Global South, which will not rely on high-connectivity solutions so much.

Second, it shows that the DBR methodology can enhance the capacity to conduct indigenous research and at the same time bring about theoretical challenges. The joint design approach embodied the research-based practice, which helps HEC to achieve the objective of building local expertise. This is the opposite approach to technology transfer models, but rural universities are now put in the role of producers of knowledge.

Third, the study defies digital divide discourses by showing how constraints are the sources of innovation. The 73 per cent cost cut and peer mesh networks would be a good example of bottom up solutions that bypass infrastructural inadequacies. This is consistent with postcolonial observations of educational technology, showing that the Southern conditions produce unique pedagogical knowledge instead of just falling behind the Northern ones.

Policy and Practice Implications

To policy makers, implications of findings would be to revise the implementation of Digital Vision by HEC to have low-bandwidth pathways. Instead of waiting till

everyone has 4G connections, it should invest in offline-first and peer-to-peer systems. The promotion criteria in the faculty must consider the teaching innovation and classroom research, which encourages the development in pedagogy with the usual research outcomes.

In the case of the university administrators, the results recommend the institutional Wi-Fi policies that focus on content downloading areas rather than campus coverage in order to maximize cost-effectiveness. The professional development programmes must embrace co-design models with technology training incorporated in group curriculum design. Educational technology should also be budgeted on recurring data expenses and the institution should enter into an agreement to bulk data packages to the students.

In the case of faculty, the research indicates how mobile devices can facilitate and not disrupt academic rigour when applied to learning using well-planned pedagogies. The peer assessment is associated with the lightened marking load and the enhancement of the quality of feedback. Curricula that were living and responsive were developed through the sharing of exemplars through mobile platforms. In the case of students, the research results are shown to support the view that mobile learning can be cost-effective and also educationally efficient in case it is structured in relation to their connection realities. The popularity of peer mesh networks shows that student-led programs should be supported by the institution, which would help to minimize expenditures on technologies due to the collective movement.

Future Research Directions

A number of research pathways are identified. Retention of academic literacies should be studied longitudinally on gains over time of intervention, cohort based studies on degree programmes. The comparative study among the four provinces of Pakistan would produce region specific principles of design, especially with concerns on the western provinces connectivity problems that are connected to security.

Mobile-assisted literacies may be resolved through interdisciplinary studies involving science and professional programmes where different requirements of design are placed upon visual representations and computational tools. Studies that explore overlaps between mobile learning and the indigenous knowledge systems may

do more to challenge postcolonialism, producing networks of South-South knowledge exchange.

In methodology, upcoming DBR ought to have students play a more central role as co-designers. Although this paper involved consultation with students, real participatory design would engage them in content creation and interaction organization. These strategies do not contradict the idea of student-centred learning presented by HEC and the consideration of digital citizenship skills.

Conclusion

This action research study will show that low-bandwidth rural Pakistani university settings can successfully be designed using mobile-assisted academic literacies developed by collaboration and iteration. There were five empirically based principles such as modular content architecture, adaptive assessment, peer mesh networking, cultural responsiveness, and integrated faculty development, which produced significant gains in critical reading, writing, and information literacy of the students and a 73 per cent reduction in the data costs. The study counters the deficit discourses in relation to rural education, and demonstrates how rural areas are affected by the lack of connectivity to facilitate culturally situated and economically feasible innovative pedagogies.

The DBR approach used in the study saw the modelling of research-practice partnerships that build indigenous capacity, which is in line with strategic priorities of HEC. Development of faculty was identified as critical factor in sustainability, and the policy must be balanced to incentivize teaching innovation. Gender-responsive design entails increased involvement of females in the design, which matches the issue of equity in technology based learning. The study has theoretical implications by deepening the understanding of mobile learning to low-resource settings and increasing the South Asian voice in the literature of educational technologies. In practice, the design principles will provide scalable patterns of rural higher education in Pakistan to develop digital inclusion without necessarily having to wait until the infrastructure is significantly restructured to support it. Because the Pakistani higher education is steering through the nature of digitalisation-driven needs, the study confirms that low-bandwidth based pedagogies are not only short-term solutions but

unique additions to the international knowledge base of education.

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