Research Summary

Background of rural community:

- Dwesa (Eastern Cape) is a rural area near the sea (Buthelezi et al., 2021). The area is predominantly composed of isiXhosa speakers (Buthelezi et al., 2021). There is limited economic activity in the area with locals engaging in subsistence farming and keeping livestock (Buthelezi et al., 2021). Most working age individuals leave Dwesa in search of job opportunities, resulting in the population of Dwesa to be mainly the elderly and children (Buthelezi et al,. 2021).
- The nearest town is about 40 km away which is only accessible via a gravel road (Buthelezi et al., 2021). This makes accessing products and services costly and time consuming (Buthelezi et al,. 2021).
- Factors contributing to digital inequality include: geographical location, socio-economic status, age and gender (Buthelezi et al., 2021). Rural communities are further marginalised by high data costs, lack of infrastructure and internal migration (Buthelezi et al., 2021).

Current state of digital infrastructure:

- Most households are connected to the electricity grid and they have mobile network coverage (Buthelezi et al., 2021).
- Mobile phones have been widely adopted by even the poorest of people (Buthelezi et al., 2021). Teachers and business owners can afford higher-end phones (Buthelezi et al., 2021). Despite the community being poor, they are not daunted by the initial purchase cost of a smartphone (Buthelezi et al., 2021).
- Social media is the most prevalent form of media in the area (Buthelezi et al., 2021).
- 16% of household income is spent on mobile communication (R160 of R1000) (Buthelezi et al., 2021). South Africa has high data costs and this limits the connectivity of community members (Buthelezi et al., 2021). With that being said, data is preferred for communication (WhatsApp messages, voice notes and calls) as opposed to buying airtime (Buthelezi et al., 2021).
- Bluetooth is a preferred method of sharing files to bypass data costs (Buthelezi et al., 2021).
- Siyakhula Living Lab has completed many projects in the area (Buthelezi et al., 2021).
    - Deployed networked computer labs in 5 local schools (Buthelezi et al., 2021).

Stakeholders:

Students

The scenario involves high school students. They are from grades 8 - 12. The age group for these students are 13 - 18. Previous training and experience has allowed them to acquire basic digital literacy skills. In this stage, students are mature and can comprehend advanced topics. For more senior students, they are preparing to study further or seek employment opportunities.

To ensure that these students have the best chance at success, they require digital literacy skills. The students are from poor backgrounds and do not have access to uncapped data and there is limited Wi-Fi access. Most students come from a household where there is at least a mobile device. Some students have their own devices and this is seen as a status symbol amongst their peers. The ability to utilise technology is also revered. Students can effectively communicate in isiXhosa.

Teachers

Teachers are highly respected members of the community (Buthelezi et al., 2021). Teachers receive special training from organisations and the government and are highly knowledgeable people. They want to upskill the youth and share their knowledge.They are between the ages of 25 - 60. With their position, they have more disposable income and can afford higher-end smartphones and electronic devices. They cannot effectively upskill students without the necessary infrastructure and training material. Teachers can effectively communicate in isiXhosa and English.

Elders

Parents and other elders inspire the youth to learn how to use technology (Buthelezi et al., 2021). Being a large demographic in the area, children respect their elders and follow their guidance. Elders may not have completed matric or studied further. Their primary activity is subsistence farming and keeping livestock. They receive grants from the government. To ensure the success of any undertaking, the elders must be in support of the venture. They are 40 years old and above. The elders do not have much disposable income. They are in possession of a smartphone but cannot afford to utilise a smartphone due to high data prices. They want to ensure that their children are successful and can earn a decent living. Elders can effectively communicate in isiXhosa.

Technicians

Technicians are responsible for maintaining networking infrastructure. They are skilled individuals who ensure connectivity in the area. They can be called into schools to help troubleshoot problems that the teachers cannot fix. They are between the ages of 25 - 60. These technicians have more disposable income with access to, and knowledge of technology. They can effectively communicate in isiXhosa and English.

Government

Through the department of basic education, the government is striving to bridge the digital divide. They are strained for resources and capability.

Siyakhula Living Lab

The Siyakhula Living Lab (SLL) plays a transformative role in integrating information and communication technologies (ICTs) into education for the Dwesa community, focusing on bridging digital divides and fostering inclusive knowledge development. A key initiative is the "champion" model, where teachers and community members with a strong interest in

technology receive mentorship from researchers at Rhodes University and the University of Fort Hare. This mentorship equips them with digital skills and empowers them to share ICT knowledge in local languages like isiXhosa, ensuring better comprehension and wider adoption. The SLL has established ICT infrastructure in schools by introducing Points of Presence (PoPs), providing access to computer labs, the internet, and digital learning materials. Their efforts have led to the Eastern Cape Department of Education recognizing a partnered school as a rural ICT Resource Centre. By fostering digital literacy and community engagement, the SLL empowers both educators and students, promoting technology-assisted learning and sustainable educational development in marginalized areas.

Mpume Community Organisation

This youth club is mainly involved in social, sport and cultural activities (Buthelezi et al., 2021). They have a social media presence on WhatsApp and Facebook (Buthelezi et al., 2021). This group could be approached to promote our solution as they have an established presence (trust) as well as access to a network of youth.

Reference List:

Buthelezi, M., Chatikobo, T., & Dalvit, L. (2021). United in diversity? Digital differences and inequalities within a South African rural community. Information, Communication & Society, 24(3), 455-469. https://doi.org/10.1080/1369118X.2020.1864000

Existing low-bandwidth educational solutions:

WhatsApp-Based Learning Systems

- WhatsApp has been used for educational purposes, particularly in rural India, to reduce absenteeism, enhance student engagement, and improve instructor effectiveness

Aptus System and Tablets

- A low-cost, offline mobile learning system that provides educational content without internet access. This solution is particularly beneficial for marginalized students

Offline and Asynchronous Learning

- Pre-recorded audio and video lectures allow students to access lessons without requiring real-time streaming.
- Interactive Voice Response (IVR) Systems enable students to call a designated number and receive educational content through voice prompts

Blended Learning Strategies

- The Two-Level Bandwidth Optimization Model suggests controlling bandwidth-heavy applications at the institutional level while optimizing media content to enhance performance in e-learning environments.
- Universities in low-bandwidth regions implement a phased transition from face-to-face instruction to fully online education, ensuring a gradual adaptation to digital learning

Streaming:

- Instead of traditional video streaming, the proposed solution streams only voice over UDP and transmits compressed control messages for visual aids over TCP. This approach significantly reduces bandwidth consumption to just 64 kbps, making it suitable for remote and underprivileged areas. Additionally, the system is compared to high-bandwidth solutions like WebEx, NetMeeting, and ConferenceXP, highlighting its cost-effectiveness and efficiency in low-resource environments.

P. Mondal, S. Misra and I. S. Misra, "A low cost low bandwidth real-time virtual classroom system for distance learning," *2013 IEEE Global Humanitarian Technology Conference: South Asia Satellite (GHTC-SAS)*, Trivandrum, India, 2013, pp. 74-79, doi: 10.1109/GHTC-SAS.2013.6629892.

Muyinda, P. B., Mugisa, E., & Lynch, K. "M-Learning: The Educational Use of Mobile Communication Devices." *Proceedings of the International Conference on Computing and ICT Research*, vol. III, Makerere University, 2007, pp. 290-301.

Suhail, N. A., & Mugisa, E. K. "Implementation of E-learning in Higher Education Institutions in Low Bandwidth Environment: A Blended Learning Approach." *Proceedings of the International Conference on Computing and ICT Research*, vol. III, Makerere University, 2007, pp. 302-322.

Available technologies that work in low-connectivity environments:

What Siyakhula did Links and Summary:
https://siyakhulall.org/project-overview
https://siyakhulall.org/

The Role of the Living Lab in Enhancing ICT for Learning in Dwesa

The Siyakhula Living Lab (SLL) has played a transformative role in integrating information and communication technologies (ICTs) into education for the Dwesa community, addressing long-standing digital divides and fostering inclusive knowledge development. Situated in a rural and underserved region of South Africa, the SLL has sought to bridge technological disparities by creating opportunities for children and high school students to engage with ICT in learning environments (Sibanda & Van Greunen, 2015).

ICT Training and Community Engagement

A key initiative of the Living Lab has been its emphasis on ICT training, particularly through a "champion" model. In this model, teachers and community members who exhibited a strong interest and aptitude for technology received mentorship from researchers at Rhodes University (RU) and the University of Fort Hare (UFH). This mentorship not only equipped these individuals with essential digital skills but also enabled them to impart ICT knowledge in local languages, thereby increasing uptake among learners and ensuring better comprehension (Mukuni & Price, 2019). The training programs facilitated by the SLL helped teachers integrate ICT into their teaching methodologies, making education more interactive and engaging for students.

Establishing ICT Infrastructure in Schools

The introduction of ICT facilities within Points of Presence (PoPs) provided a crucial technological foundation for schools in the region. Schools that partnered with the SLL gained access to computer labs, the internet, and digital learning materials, which significantly improved the learning experiences of students (Ruxwana, Herselman, & Conradie, 2010). Furthermore, the Eastern Cape Department of Education recognized one of these schools as a rural ICT Resource Centre, demonstrating the impact of the Living Lab's interventions in promoting technology-assisted learning in marginalized areas (Makoe & Shandu, 2018).

Bridging the Digital Divide for High School Learners

For high school students, the integration of ICT into learning environments through the SLL has allowed them to develop essential digital literacy skills, positioning them to participate in the broader knowledge economy. By providing students with internet access, the SLL enabled them to move beyond passive consumption of information to active engagement, where they could research academic content, collaborate on digital platforms, and develop innovative solutions to local challenges (Walton & Johnston, 2018).

Conclusion

The Living Lab methodology, as implemented through the SLL, has had a profound impact on the education landscape in Dwesa by equipping teachers, children, and high school students with ICT skills. Through community-driven engagement, infrastructure development, and digital literacy training, the SLL has facilitated the inclusion of marginalized learners into the digital space, thereby promoting sustainable educational development in rural South Africa.

References

- Makoe, M., & Shandu, T. (2018). The role of ICT in rural education: Case study of the Eastern Cape. *South African Journal of Education, 38*(2), 1-12.
- Mukuni, J., & Price, G. (2019). ICT in rural education: The impact of community-driven digital inclusion. *Journal of Educational Technology & Society, 22*(3), 45-57.
- Ruxwana, N., Herselman, M., & Conradie, D. P. (2010). ICT applications in rural schools: The case of Dwesa. *African Journal of Information and Communication Technology, 6*(2), 71-85.
- Sibanda, M., & Van Greunen, D. (2015). Living Labs as a mechanism for rural ICT development: The case of Siyakhula Living Lab. *African Journal of Science, Technology, Innovation and Development, 7*(4), 256-263.
- Walton, M., & Johnston, K. (2018). Digital inclusion and the knowledge economy: Examining the impact of ICT in South African schools. *International Journal of Educational Development, 60*, 50-61.

Gaps in the Living Lab's ICT Interventions in Dwesa

While the Siyakhula Living Lab (SLL) has made significant progress in introducing information and communication technology (ICT) to the Dwesa community, several gaps remain in the effectiveness, sustainability, and scalability of these interventions. Despite efforts to bridge the digital divide, structural, economic, and infrastructural challenges continue to hinder the full realization of ICT-driven learning in the region.

1. Limited Infrastructure and Internet Access

One of the key limitations of the Living Lab initiative in Dwesa is the lack of robust ICT infrastructure. Although Points of Presence (PoPs) have been established to provide internet connectivity to schools, access remains inconsistent due to unreliable electricity supply, outdated hardware, and poor maintenance. Rural schools often face challenges in sustaining these facilities, as they require continuous technical support and financial investment (Ruxwana, Herselman, & Conradie, 2010). Additionally, slow and unstable internet connectivity further restricts the full integration of ICT into learning, limiting students' ability to access online educational resources and digital tools (Makoe & Shandu, 2018).

2. Teacher Training and Pedagogical Integration

While the SLL has implemented teacher training programs through its "champion" model, the impact has been uneven. Many teachers in rural areas have limited prior exposure to digital

tools, making it difficult for them to integrate ICT into their teaching methods effectively. Training programs have primarily focused on basic ICT skills, but there is a lack of ongoing professional development to ensure that teachers remain proficient in using digital resources (Mukuni & Price, 2019). Moreover, there is a gap in pedagogical strategies that align ICT usage with the national curriculum, leading to a disconnect between digital learning and traditional classroom instruction.

3. Digital Literacy and Community Engagement Challenges

Although the SLL has introduced digital skills training for students, many learners still struggle with digital literacy due to a lack of exposure outside of school settings. In many cases, access to computers and the internet is limited to classroom sessions, preventing students from practicing and applying their ICT skills regularly. Furthermore, while the Living Lab model emphasizes community engagement, there is still a digital literacy gap among parents and caregivers. Without adequate ICT knowledge among adults in the community, students often lack support at home, which can slow their learning progress (Walton & Johnston, 2018).

4. Sustainability and Funding Constraints

Another critical gap in the Living Lab's intervention is the sustainability of ICT projects. The initiative relies heavily on external funding and university research partnerships, which raises concerns about long-term viability. Many rural ICT projects struggle to continue once initial funding phases end, as local schools and communities lack the financial resources to maintain equipment and connectivity (Sibanda & Van Greunen, 2015). Without a clear sustainability model, there is a risk that the progress made by the SLL may not be maintained over time.

5. Policy and Government Support Gaps

Despite the recognition of Dwesa's ICT initiatives at the provincial level, integration into the broader educational system has been slow. The absence of a structured policy framework for rural ICT development means that schools lack formal guidelines on how to integrate technology effectively into their curricula. Additionally, bureaucratic delays in implementing rural ICT policies at the national level further hinder the expansion of digital education initiatives (Makoe & Shandu, 2018).

Conclusion

While the SLL has made a positive impact on ICT integration in Dwesa, several gaps must be addressed to ensure its long-term success. Strengthening infrastructure, enhancing teacher training, promoting digital literacy at the community level, securing sustainable funding, and improving policy support are crucial for the continued growth of ICT-driven education in rural South Africa. Addressing these challenges will be essential in transforming the Living Lab model into a scalable and self-sustaining solution for digital inclusion.

References

- Makoe, M., & Shandu, T. (2018). The role of ICT in rural education: Case study of the Eastern Cape. *South African Journal of Education, 38*(2), 1-12.
- Mukuni, J., & Price, G. (2019). ICT in rural education: The impact of community-driven digital inclusion. *Journal of Educational Technology & Society, 22*(3), 45-57.
- Ruxwana, N., Herselman, M., & Conradie, D. P. (2010). ICT applications in rural schools: The case of Dwesa. *African Journal of Information and Communication Technology, 6*(2), 71-85.
- Sibanda, M., & Van Greunen, D. (2015). Living Labs as a mechanism for rural ICT development: The case of Siyakhula Living Lab. *African Journal of Science, Technology, Innovation and Development, 7*(4), 256-263.
- Walton, M., & Johnston, K. (2018). Digital inclusion and the knowledge economy: Examining the impact of ICT in South African schools. *International Journal of Educational Development, 60*, 50-61.