IST-Africa 2024 Conference Proceedings
Miriam Cunningham and Paul Cunningham (Eds)
IST-Africa Institute and IIMC, 2024
ISBN: 978-1-905824-73-1

Socio-Technical Insights Deploying Rural Solar Computer Housings for Informal Learning and Information Access

Kim GUSH, Grant CAMBRIDGE
CSIR, Meiring Naude Rd, Pretoria, 0184, South Africa
Tel: +27 012 8412864, Email: kgush@csir.co.za, gcambrid@csir.co.za

Abstract: The deployment, maintenance, monitoring and long-term support of information and computing solutions in rural and under-resourced environments requires innovative thinking and an integrated approach to addressing the multi-faceted challenges of such an undertaking. This paper presents recent developments and ongoing challenges faced after an extensive period of real-world interactions with multiple solar-powered computer housing deployments in rural South African communities. The solar housings are complex cross-disciplinary socio-technical systems providing a versatile digital library and physical access to computer terminals. Technical, social, and external challenges need to be understood and overcome for the installations to have a meaningful impact on the communities. Examples from field deployments are described in order to highlight lessons learned and corrective actions that could be implemented to reduce socio-technical difficulties in both existing and subsequent deployments.

Keywords: Technology application**,** Rural Computer Access, ICT4D, Technology Enhanced Learning, Solar Power, Digital Library, Informal Education

1. Introduction

Acquiring basic computer skills training with access to educational content and digital literacy tools is important to people in almost every sector of society. This is especially challenging in rural and under-serviced communities. The e-Government impact area of the Council for Scientific and Industrial Research (CSIR), in partnership with a South African Government Department, has been deploying information and communication technologies (ICTs) in remote South African communities since the early 2000s. One aspect of this initiative is the installation of Solar-powered "Digital Doorway" housings or "DDs". The long-term goal is to progress beyond basic computer literacy and contribute to the effective utilisation of digital technology in the community. "What is most important about ICTs is not so much the availability of the computing device... but rather people's ability to make use of that device and line to engage in meaningful social practices" [1]. Studies have concluded that a major benefit of the digital library aspect of the DD installations is in short-term educational support in the form of school-related research [2].

Access to computers, digital libraries, and the Internet in rural communities, is often extremely limited and needs to be shared between many individuals. According to Statistics South Africa, a mere 8.5% of low-income households with youths aged 5-24 were likely to have internet access at home, with around 11.6% of rural residents owning computers or laptops [3]. Recent reports indicate that 52.9% of rural users have access to the internet via mobile devices [4]. Technology requires electrical power, and reports suggest that approximately 25% of South Africa's rural population do not have access to electricity [5].

The insights presented below are important in the context of the above statistics. The paper is organized in the following manner: objective, methodology, socio-technical systems in the DD context, technical design and site monitoring considerations, impact goals, general challenges, real-world experiences, discussion and conclusions.

2. Objective

The objective of this paper is to highlight technical developments, improvements and monitoring aspects of currently installed solar-powered DD housings, and their associated social support structures in rural communities. Real-world examples are used to highlight observed challenges and success factors in site selection, installation and long-term use of the technology. Technical aspects of the hardware are described. Contrasting sites are chosen to emphasise key issues. Insights were and are being gathered using technical monitoring, site visits, and ongoing engagement with the communities involved. Both failed or underperforming sites, and successful sites are described.

3. Pragmatic Mixed-Methods Research Methodology

A pragmatic, participatory, concurrent mixed-methods strategy of inquiry is being employed in the research aspect of the initiative, as both qualitative and quantitative data are collected simultaneously [6]. The research is ongoing and includes:

- Quantitative data obtained and analysed through technical monitoring systems installed at each site coupled to a back-end visualisation dashboard as discussed in [7]
- Qualitative data gathered through repeated site visits, observation, written correspondence and informal interviews with site administrators, users and installation teams. The feedback from participants remains anonymous.

While earlier studies on the DDs have been more rigorous in their approach to data collection and analysis (see [2], [8], [9]), the authors trust that the insights here will contribute to an even greater understanding of this complex field.

4. Socio-technical Systems and the First Few Feet

The DD solar housings are complex cross-disciplinary socio-technical systems attempting to embrace the premise that the design process (which is iterative and ongoing) should consider both social and technical factors that influence functionality and usage. Particularly, “System performance relies on the joint optimization of the technical and social sub-systems” [10]. A diagram of the intersection of social and technical sub-systems and external factors is shown in Figure 1.

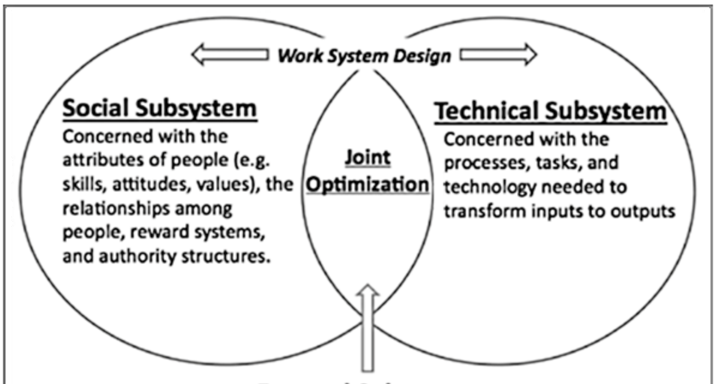

Figure 1 Socio-technical theory as illustrated in [11]

In terms of the DD deployments, the intersection of this diagram represents the necessary focus for a successful and optimised solution where: 1) the social relationship with the technical intervention is a healthy one, 2) local support for the project and a sense of community ownership is present, 3) the technology is functioning correctly and meeting one or more needs of the community, 4) the external sub-systems such as long-term project financing, maintenance, internet data, monitoring, and support contracts are in place.

Key technical, social, and additional elements are illustrated in Figure 2.

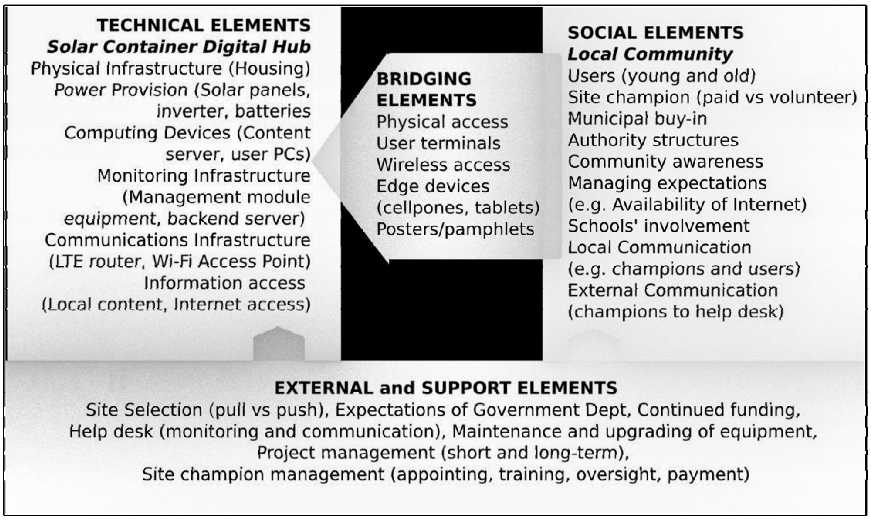

Figure 2 Key technical, social, bridging, external, and supporting elements

The success of each individual installation and the initiative as a whole is reliant on adequately functioning technical elements, engaged, informed, and active social (community) aspects, suitable bridging elements being in place (e.g., having physical access to the user terminals or functioning edge devices connecting to the Wi-Fi content), and well-coordinated external and support elements through active communication between all entities. "… technology and the community cannot be viewed as separate from each other, and the implementation of the technological solutions to community needs must consider the societal and technological inter-relationships" [12].

5. Technical Design

At the core of each site deployment lies the free-standing solar-powered Digital Doorway housing consisting of a custom-designed structure containing rugged user computer terminals, a content server, Wi-Fi connectivity, cellular wireless broadband internet access, remote-monitoring unit, solar panels, inverter, batteries and various peripheral devices and supporting infrastructure (See Figure 3, Figure 4, and Figure 5). While the first solar container appeared in 2009, the most recent designs have been deployed since 2019, with several iterative upgrades since then. The DDs highlighted in this paper were installed between 2020 and late 2023.

Sites are typically located at community centres in primarily rural, low-income communities, and aim to provide the following benefits:

- A rapidly deployable housing structure that foregoes the need for additional on-site building construction and that may be relocated if required
- A source of renewable power, independent of the country's electricity grid, with backup batteries able to keep the equipment powered up at night, through inclement weather conditions and during the frequent power disruptions that occur in South Africa
- A communal hub for social interaction, technological engagement, and entertainment

- A "first-use" hands-on computer learning experience for users without other access to computer equipment or internet connectivity at home or at school
- A skills development and growth opportunity for locally appointed site administrators
- A local digital library providing both physical and Wi-Fi access to educational, informative, and interactive content. This includes a comprehensive offline repository packaged under the Kiwix collective (an "offline reader for online content" [13]), which includes the full Wikipedia database, audio lectures, digital books and various other digital media. Interactive science simulations and educational games are included.

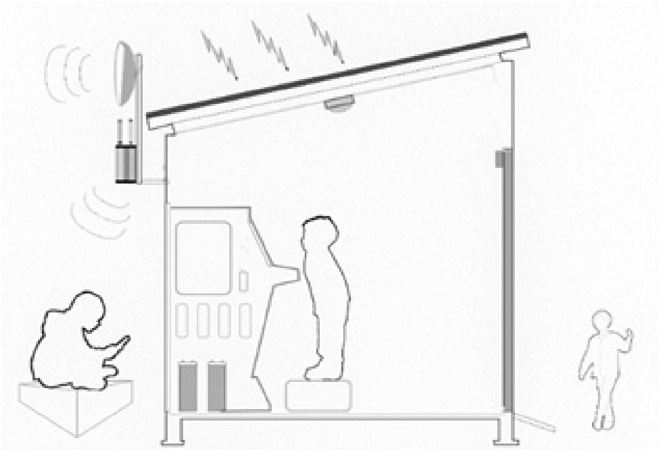

Figure 3: DD housing. Profile drawing depicting solar elements, communication equipment, housing elements and user interactions with the terminals and Wi-Fi access point

The DD initiative shares similarities with various other solar-powered ICT hubs that have been trialled or deployed for formal and informal educational use. Examples include the Computer Aid laboratories [14], solar-powered schools [15], SolarSPELL (a portable, rugged, solar-powered digital library [16]), and the Offline-pedia project which aims at providing Ecuadorian rural communities with access to offline information [17].

The physical terminals (see Figure 4), content server, and Wi-Fi access points could be regarded as the "First few feet" in terms of user connectivity. While the terminology "Last mile" implies a provider-centric view, "First mile" emphasises a user-centric view of connectivity [18]. By having large amounts of content cached locally on the server, the user benefits from the installations even when the internet is inaccessible.

Figure 4 Interior user terminals and management module display embedded in a custom steel housing

Figure 5 Exterior view of the latest solar housing

Technical design iterations are inspired by a combination of factors and role players, including direct feedback from users of the system, observed technology and security flaws by the installation team and engineers, cost saving necessities, and general observations. Recent changes and improvements to the technical design include the following:

- A redesigned housing (Figure 5) with improved physical security modifications
- The installation of front and back door sensors communicating with the monitoring unit
- Internet cost reduction from satellite connectivity to cellular LTE connectivity

- Improvements to the monitoring unit and how it communicates back to the dashboards.

6. Site Monitoring

Site monitoring happens via both data-driven technical means and telephonic communication with on-site administrators and is vital for the ongoing success of an installation. In addition, monitoring is key to a functional help desk that can log issues and incidents at a site, visualise site status and connectivity health, and initiate the required maintenance and support where necessary [7].

System monitoring and time-series logging with near-real-time communication to back-end visualisation dashboards or an off-site help desk is one aspect of attaining a comprehensive picture of the status of sites throughout the country and where attention is required. The technical monitoring system comprises: (a) local software agents for monitoring equipment parameters such as battery and solar voltages, network usage, available data balance etc. (b) a custom-designed monitoring board and software for analysing, storing and transmitting relevant data to the help-desk, and (c) a back-end server and software for collation and visualisation.

There is overlap between technical monitoring of the sites and the social aspects of administrator involvement and general site usage by the community. The logs of the connected Wi-Fi edge devices, indicate the number of users connecting to the content server. The door-sensor logs indicate the frequency of the administrators opening and closing the front doors. See [7] for a detailed description of the monitoring sub-systems.

7. Desired Impact

The goal is that the DD solution will facilitate basic education regarding computer usage and information access, and assist users to participate in the sprawling and complex digital world in a meaningful way, making "Effective Use" of the internet as a digital tool for improving lives. "What is significant is having access and then with that access having the knowledge, skills, and supportive organizational and social structures to make effective use of that access and that e-technology to enable social and community objectives" [19].

Social aspects affecting the success of the initiative include inter alia: community engagement with the hardware, authority structures, involvement of administrators and users in the use and care of the equipment and community awareness of the benefits of the local content and internet access. Support structures in the community and at a project administration level are key to sustaining the impact of the technology in the long term. Ideally, the intervention should result in participatory "distributed leadership" [20] and mutual ownership of the technology with a clear understanding of its potential benefits.

Local Digital Doorway administrators are a crucial element in successfully implementing these sites. These human interfaces between technology and community are recognised as vital in other projects of this nature, e.g., the solarSPELL initiative where digital libraries "are matched with locally based trainers who can support the necessary development of internet-ready skills" [16].

8. General Challenges Experienced

Many of the challenges encountered in integrating the DDs in communities are shared by organisations and institutions implementing similar rural initiatives. For example, in the Gwakwani project and a University's engagement with the rural community in that area, the authors highlight challenges of: insufficient financing; ineffective communication among stakeholders; lack of community buy-in and participation; geographical distance and inaccessibility; lack of support; insufficient training; and lack of maintenance [12]. There are clear overlaps with the five main types of sustainability challenges mentioned in [21], namely “financial, social, policy, organisational and technological.”

8.1 Technical challenges

Remote site locations mean extended travel times for installation and repairs. Poor road access can make transporting the DD as a single housing challenging. Due to the short life cycles of most IT equipment, identical replacements are often unavailable a few years later. Using a wireless router for Internet connectivity presents challenges in terms of signal strength, constantly changing IP addresses, and difficulties in data balance monitoring.

The need to lower the overall cost of equipment must be weighed against the potential for cheaper equipment to fail earlier, thus necessitating replacement or repair and ultimately having the opposite effect in terms of costs. Seemingly insignificant details are easily overlooked, e.g., low Total Bytes Written (TBW) ratings could result in earlier failure of SD cards and Solid-State Drives (SSDs), incurring additional travel and replacement costs.

Due to the risk of theft or vandalism, equipment must be secure and rugged with solar panels securely fixed to the roof and equipment secured within a steel rear compartment.

While the advantages of solar installations in off-grid locations are obvious, there are complications that arise in their long-term upkeep including the need for cleaning of solar panels and eventual replacement of batteries. "...a short-term focus is not conducive to the longevity of electricity distribution systems, which necessitate funding that takes into account long-term, systemic infrastructure support" [22].

8.2 Social and administrative challenges

Given that successful deployments require the optimisation of social as well as technical aspects [10], the following challenges present themselves:

- Identifying sites via a “pull” rather than a “push” approach – the community itself identifies a clear need for the technological solution. Related to this is the challenge of appointing enthusiastic site administrators with a genuine desire to maximise the potential of the facility. In the absence of this person, the unit will at best be under-utilised, and worst, not utilised at all, as discussed in section 9 below
- With multiple site deployments, ensuring adequate communication between community leaders, implementation agents, and funders, regarding suitable site selection and administrator appointments, is often difficult
- Balancing the installation’s security with accessibility and high foot traffic near the installation can be difficult, for example DDs in schools are accessible only when the school is open and generally only available to students and teachers at that school
- Access to the wealth of educational resources available on the local content server could supplement classroom material and benefit pupils in the area. This would require a commitment of time and resources to ensure that it happens. With a funder often being measured on more visible and measurable metrics such as “number of sites deployed” this investment in community interactions is often not a priority.

What follows are real-life accounts and descriptions from field installations, illustrating challenges and successes in site deployments.

9. Real-world Examples – Failed or Underperforming Sites

9.1 Site 1

This site is in one of South Africa’s tribal communities, in the local King’s compound in a peri-urban area approximately 120km north of Pretoria. There are several schools within a 10km radius of the site. The initial Container DD location was later deemed unsuitable, and at the request of the King, the unit was moved closer to the main entrance. This necessitated extensive trimming of trees to get sufficient sunlight onto the solar panels. The move also interfered with the quality and stability of the wireless signal. This resulted in the router obtaining a new IP address every few minutes, making it impossible to remotely connect to the server or the management module to upload new scripts and fix software issues. This was resolved by extending the height of the router.

From the outset, due to a lack of proper coordination between the site owner and the team responsible for community engagement, no formal administrator was appointed, nor were any volunteers willing to be trained. This resulted in the installed and fully functional Container DD not being used. When the technical team arrived for site visits and minor maintenance, "somebody would rush out with a broom and start cleaning the interior". The lack of a site administrator to clean the solar panels resulted in dust and dirt build-up, reducing the power from each panel, thus reducing the entire system's efficiency.

9.2 Site 2

This site is in a deep rural, mountainous area approximately 600km south of Pretoria and 180km from the nearest city. The Container DD was installed at a community centre. There are several schools within a 10km radius of the DD.

From the outset, due to extensive delays in a formal administrator being appointed, and in the absence of any volunteers willing to be trained, the Container DD was not being used, not powered up, and always remained locked. The Container DD was vandalised and set alight during the unrest of July 2021. The technical team discovered the damage during an upgrade cycle and managed to recover some equipment. The housing and most of the critical components like solar panels and batteries were damaged beyond economical repair.

9.3 Site 3

This site was installed at a community centre in a peri-urban area approximately 80km north-east of Pretoria. The site has a community centre, and a library with desktop computers and free Internet access, raising questions about the prioritisation of certain site selections over more needy locations. A local entrepreneur runs an Internet cafe and printing business.

Due to electrical connection problems at the community centre, the owner of the internet cafe would "borrow" the inverter from the Container DD and use it in their business, but was caught out when the inverter was damaged due to overloading.

The highest foot traffic at the site occurs during pension and social grant pay-days. The grant recipients have little desire to interact with the DD content or the Internet. The owner of the Internet cafe volunteered to be an administrator, but they were not deemed suitable because they were putting their own interests above those of the community.

10. Real-world Examples – Successful Sites

10.1 Site 4

This site is located on a farm in a rural area, approximately 10km west of Riebeek-Kasteel in the Western Cape. The farm is run by a Non-Governmental Organisation (NGO) with a vision to "Develop rural development strategies to help unlock the potential of children, youth and women on farms" [23]. The children attend school in a nearby town, approximately 1 hour away by bus. Adults are trained in computer literacy in the morning and the site is very heavily used in the afternoons when the children return from school. The NGO Staff and the users clearly see the benefits of having a Container DD. This site could be classified as a "Pull Site", where the NGO specifically requested a Container DD.

The director of the NGO lives on the premises and is involved in daily farm activities. Many young people who live on the farm have been trained to be assistant site administrators, a good example of the "Network Weaving" concept described in [20]. The site's success is primarily due to the enthusiastic volunteers and a well-managed environment where the computer housing is located. The Container DD is well used (see Figure 6) and the testimonials below are evidence of its impact:

"Thank you so much to the Department for this amazing donation of a digital doorway that assists rural children to access the Internet and digital educational games and activities aimed at improving their literacy and Maths. Apart from the educational improvement, it also increases their concentration, and helps them to deal with failure because they can only move to the next level if they master the previous level... It also teaches them to read and follow instructions. These are important life skills that the farm children are now learning through the medium of digital education."; "... the rural farm children in our INSPIRE-homework support programme are working hard. They love education and learning... The competition is tangible when they play educational games against each other or complete activities in different teams!... Thank you so much to everyone who supports our work with rural farm children and teenagers ... Please know that we are so grateful." [24]

10.2 Site 5

The Solar Container DD is situated in Kwanokothula, approximately 5km south of Riversdale in the Western Cape. The DD is next to a community centre that has high foot traffic. The site can also be classified as a "Pull Site" with enthusiastic site administrators. An additional request was made to refurbish a damaged container to be used as a small community library.

Requests were received for range extension of the Wi-Fi to enable access from users' own edge devices. The challenge for Internet provision to a wider user base however, is managing and funding data, and ensuring adequate data throughput.

The community is very vibrant and excited about the project. The head of Library Services (in charge of the site) is extremely passionate about and involved in the community. Users see the benefits of accessing the Internet and the local repositories on the content server. The site's success is primarily due to the enthusiastic volunteers and a well-managed environment. Users interacting with the user terminals are shown in Figure 7.

Figure 6 Students interacting with user terminals at site 4

Figure 7 Young and old interacting with the computers at site 5

10.3 Site 6

Monyakeng (near Wesselsbron), a small, primarily farming town, is located in the Free State province. The main road to Wesselsbron is in a bad state, making vehicle access a challenge. The DD is situated in a community centre that has high foot traffic.

The site is currently being managed by a former local councillor and volunteer who understands the social undercurrents in and around the community. He has a good understanding of what the DD can do for the local community and is actively involving the local children. There is a programme where the volunteer takes them through a numeracy-based application and "graduates" them through the levels. The Monyakeng community has shown great appreciation for the project. The site is well looked after, and the children clean it regularly. They benefit from access to the Internet and local content. Like other model DD sites, this site's success is due primarily to the enthusiastic volunteers and the well-managed environment where the computer housing is located.

11. Conclusions

Solar-powered computer labs and information hubs have the potential to impact rural communities in positive ways, reducing inequalities and contributing to digital inclusion [25] without imposing digital authoritarianism. The particular technical intervention described in this paper combines the versatility of solar-powered housings, rugged ICT hardware, informative digital content and remote monitoring capabilities. Numerous complexities are involved in deploying, monitoring, updating, and maintaining such interventions in varied rural social contexts, from the absence of stable Internet access to the unavailability of suitable site administrators. These findings are not unique to the DD initiative and are elaborated upon by numerous authors, e.g. [12] [16] [21].

Referring back to Figure 2, we suggest that the following points for the successful implementation of complex technical projects in rural communities should be considered:

- Approaching technology implementation in a holistic manner from the outset, balancing technical interventions with social dynamics
- Thoughtful site selection and pre-installation site visits should accompany community engagement
- Selecting locations where the community leaders express a genuine desire to utilise the technology for the improved well-being of the users, and can provide enthusiastic site administrators
- **Technical** - the necessity for functional, adequately maintained hardware, with suitable monitoring facilities, and awareness of expected equipment life cycles
- **Social** – a motivated community where the technology is requested, rather than pushed, site administration responsibilities are shared, and relations with external stakeholders is healthy. This "community pull" approach typically results in greater responsibility towards, and more active engagement with the technology
- **Bridging Factors** - Appropriate technology integration into the community. Attention should be paid to the various bridging interfaces between the social and the technical aspects (e.g. the means of physical and remote access, awareness of the resource) such that the two can integrate productively
- **External Factors** - In the case of government initiatives, prioritising active municipal and community engagement and ongoing support funding to ensure a functional solution beyond the initial deployment and contract phase
- At the project planning stage, both technical and social aspects should be looked at in terms of long-term resilience.

The technological intervention should be seen as only one aspect of the complex challenge to improve the lives of community members. Establishing a stable and supportive social environment around the DD remains a significant challenge at many locations. In spite of these challenges, sites with passionate administrators, enthusiastic users and a functioning and integrated technical intervention have a noticeable positive impact on their communities.

Declaration of Use of Content generated by Artificial Intelligence (AI) (including but not limited to Generative-AI) in the paper

The authors confirm that there has been no use of content generated by Artificial Intelligence (AI) (including but not limited to text, figures, images, and code) in the paper entitled "***Socio-Technical Insights Deploying Rural Solar Computer Housings for Informal Learning and Information Access***".

References

[1] M. Warschauer. Reconceptualizing the Digital Divide. First Monday, vol. 7, no. 7, POI: 10.5210/fm.v7i7.967, 2002.

[2] A.G. van der Vyver and M. Marais, Evaluating Users' Perceptions of the Digital Doorway: A Narrative Analysis. In: Information Technology for Development, vol. 21, no. 1, POI: 10.1080/02681102.2013.841629, 2015, pp. 99-112.

[3] StatsSA. Education Series Volume VIII: COVID-19 and Barriers to Participation in Education in South Africa. Statistics South Africa, 2022, pp. x, 27.

[4] ICASA. The State of the ICT Sector Report of South Africa, Mar 2022. ICASA, Centurion, 2022, pp. 13.

[5] World Bank. Access to Electricity, Rural (% of Rural Population). Accessed: 27 Jun, 2023, from https://data.worldbank.org/indicator/EG.ELC.ACCS.RU.ZS?locations=ZA

[6] J.W. Creswell and J.D. Creswell, Research Design, ed. Fifth edition, 1506386709, Los Angeles, 2018

[7] K. Gush. An Open-Source Tool-Set for Meaningful Monitoring and Visualisation of Rural ICT Projects. In: The Institute of Electrical and Electronics Engineers, Inc. (IEEE) Conference Proceedings, Piscataway, Jan 1, 2018, pp. Page 1 of 8.

[8] M.E. Herselman, R. Smith, K. Gush, G. Cambridge, A. Botha and M.A. Marais. Applying the Digital Doorway Design Research Model in Facilitating Skills Transfer in Rural Communities, 2010.

[9] K. Gush. Digital Doorways and the Analysis of Software Application Usage in 'Unassisted Learning' Environments in Impoverished South African Communities, MTech dissertation, UNISA, Pretoria, 2011. https://uir.unisa.ac.za/handle/10500/4746

[10] G. Baxter and I. Sommerville. Socio-Technical Systems: From Design Methods to Systems Engineering, In: Interacting with Computers, vol. 23, no. 1, POI: 10.1016/j.intcom.2010.07.003, 2011, pp. 4-17.

[11] L.G. Militello, N.B. Arbuckle, J.J. Saleem, E. Patterson, M. Flanagan, D. Haggstrom and B.N. Doebbeling. Sources of Variation in Primary Care Clinical Workflow: Implications for the Design of Cognitive Support. In: Health Informatics Journal, vol. 20, no. 1, POI: 10.1177/1460458213476968, London, England, 2014, pp. 35-49.

[12] S. von Solms and H. Nel. A Socio-Technical System for Rural Community Engagement: The Gwakwani Project. In: First Australian International Conference on Industrial Engineering and Operations Management IEOM Society International, Sydney, Australia, Jan 2023, pp. 2121-2130.

[13] Kiwix. Internet Content without Internet Access. Accessed: 10 June, 2023, from https://www.kiwix.org

[14] Computer Aid. Solar Community Hubs. Accessed: June 10, 2023, from https://www.computeraid.org/work-projects/projects/our-solar-community-hubs

[15] Samsung. Samsung Africa Launches Solar Powered Internet Schools. Accessed: June 10, 2023, from https://news.samsung.com/global/samsungafrica-launches-solar-powered-internetschools

[16] L. Hosman, C. Walsh, M. Comisso and J. Sidman, Building Online Skills in Off-Line Realities: The SolarSPELL Initiative (Solar Powered Educational Learning Library). In: First Monday, vol. 25, no. 7, POI: 10.5210/fm.v25i7.10839, Chicago, 2020.

[17] S. Minniti, J. Salazar and J. Vega, Implementing Low Cost Digital Libraries for Rural Communities by Re-Functioning Obsolescent Television Sets, View (Utrecht), vol. 8, no. 15, POI: 10.18146/2213-0969.2019.jethc169, 2019, pp. 123.

[18] S. Strover. The First Mile. In: The Information Society, vol. 16, no. 2, POI: 10.1080/01972240050032915, New York, 2000, pp. 151-154.

[19] M. Gurstein. Effective use: A Community Informatics Strategy Beyond the Digital Divide. In: First Monday, vol. 8, no. 12, 10.5210/fm.v8i12.1107, 2003.

[20] M. Marais and S. Vannini. Network Weaving to Foster Resilience and Sustainability in ICT4D, arXiv.Org, DOI 10.48550/arxiv.2108.09808, Ithaca, 2021.

[21] M.G. Faroqi, N.A. Siddiquee and S. Ullah. Sustainability of Telecentres in Developing Countries: Lessons from Union Digital Centre in Bangladesh, Telematics and Informatics, vol. 37, 10.1016/j.tele.2018.05.006, Oxford, 2019, pp. 113-127.

[22] N.CHITIYO, R. MANHIBI, J.H. VAN DIJK and G. VAN STAM. Electricity and Solar Power in Health Institutes: Complexities in Rural Zimbabwe, ISTAFRICA, May 2020, pp. 1-11.
[23] Inspire Children and Youth, Accessed: June 10, 2023, from http://inspirechildrenandyouth.org
[24] Inspire Youth. Inspire Children and Youth Facebook Page, Accessed: Jun 10, 2023, from https://www.facebook.com/inspirechildrenandyouth
[25] K. Salemink, D. Strijker and G. Bosworth. Rural Development in the Digital Age: A Systematic Literature Review on Unequal ICT Availability, Adoption, and use in Rural Areas, Journal of Rural Studies, vol. 54, 10.1016/j.jrurstud.2015.09.001, Elmsford, 2017, pp. 360-371.