E-INFRASTRUCTURE FOR SUSTAINABLE DEVELOPMENT IN MALAWI: TRANSFORMING THE INFORMATION LANDSCAPE THROUGH DIGITAL LIBRARIES AND TVWS

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Abstract

As most of the developed world progresses towards ubiquitous connectivity, Least Developed Countries (LDCs), which Malawi is part of, are left on the wrong side of the digital divide. This is so because in the majority of the LDCs the cost of bandwidth is very prohibitive and even where it exists, internet connectivity is not reliable. This puts to question whether a practical, cost-effective and appropriate solution to using Information and Communication Technology (ICT) to drive economic growth and enable the development of other critical industry sectors in disadvantaged communities is possible. The paper, therefore, makes an analysis of a pilot project that is linking St. Mary's Secondary School to University of Malawi and National Library Service digital repositories using DSpace and Television White Spaces (TVWS) architecture to deliver information to test this possibility. The use of TVWS to provide affordable and reliable broadband internet connectivity is meant to close the digital divide and the paper will examine its efficiency, cost-effectiveness, quality of service delivery and challenges. Lastly, the paper explores opportunities for the library and information science (LIS) profession to develop an e-infrastructure that will transform the information landscape into a key player in enhancing the quality of lives of the people and meaningfully contribute to sustainable development of the country.

Keywords: Appropriate Technologies; Sustainable Development; Digital Libraries; TVWS, ICT; E-Infrastructure

1. Statement of the Problem

Malawi is struggling to achieve meaningful sustainable development owing to several factors among them lack of access to information and knowledge. While many developed countries have capitalised on the Internet to harness its capability in enhancing access to latest and vast information, Malawi is failing due to high costs of bandwidth, unreliable connectivity and low internet penetration. Furthermore, digital libraries which have become the bloodstream of information and knowledge in the first world are yet to make a mark in the country. Currently, they are a prestige to a few institutions of higher learning and where they are available, the content is either inadequate or restricted to the host institution. The paper aims at exploring the use of TVWS technology to develop a hybrid e-infrastructure to deliver internet using affordable broadband connectivity and e-granary content to re-enforce availability of materials that will meaningfully enhance learning and in the long run contribute to sustainable development.

2 Scope of the Study

The study was conducted on St. Mary's Secondary School Form IV students and Form III and IV teachers who participated in the survey conducted by the TVWS Project in September 2013.

3 Objectives of the Study

- To examine the efficiency, affordability and reliability of broadband internet connectivity using TVWS infrastructure to deliver digital libraries to disadvantaged communities;
- To examine the effectiveness, relevance and accessibility of the digital library to secondary school students; and
- To lay a foundation for the development of a theoretical framework for the deployment of a hybrid e-infrastructure to strengthen and re-enforce content availability to facilitate sustainable development.

4 Research Questions

- How efficient, affordable and reliable is the use of broadband internet connectivity using TVWS infrastructure?
- How effective, relevant and accessible is the content on the digital library to secondary school students?
- How feasible is the development of a hybrid e-infrastructure to strengthen and re-enforce information and knowledge sharing for sustainable development?

5 Significance of the Study

The study is very significant as it will explore the ability of TVWS to deliver efficient, affordable and reliable Internet connectivity. Specifically, it will lay a foundation for a theoretical framework for the development of a hybrid e-infrastructure that will strengthen provision of content that is readily available and relevant to all sectors of the Malawian society thereby contribute to sustainable development.

6 Limitations of the Study

Funding was the biggest limiting factor to the study as the researchers were supposed to connect St. Mary's Secondary School to CHANCOSpace or NDR to access the digital libraries for a study period of two months at a budget of USD1700/month for reconfiguration of the network to meet research needs. Instead, the researchers opted to study and collect data regarding students' access to the aforementioned digital libraries. This option posed another limitation, that of having fewer participants as the students who were in Form IV at the time of the project had completed their studies a year earlier. Using students who had participated in a study a year earlier also posed another limitation in that they depended on their memory and therefore minimal recollection of the user experience.

7. Literature Review

7.1 Sustainable Development

Digressing from the most quoted definition from Our Common Future, also known as the Brundtland Report, the study will settle for EITO's (2002) that defines sustainable development as a dynamic process which enables all people to realise their potential and improve their quality of life in ways that simultaneously protect and enhance the Earth's life-support systems.

7.2 Digital Libraries

A digital library is a library in which collections are stored in digital formats (as opposed to print, microform, or other media) and accessible by computers. The content may be stored locally, or accessed remotely (Trivedi, 2010). Digital libraries can vary immensely in size and scope, and can be maintained by individuals, organizations, or affiliated with established physical library buildings or institutions, or with academic institutions. In Malawi, digital libraries are just taking root, with many maintained by institutions of higher learning with the National Library Services coming recently on the scene with the National Digital Repository.

7.3 Television White Spaces

White Spaces refer to the identified gaps in a given radio spectrum or band. The gaps are sometimes referred to as idle channels or "blank spaces," existing at the level of the Additive White Gaussian Noise (AWGN) in a given radio or wireless system (Mikeka, 2013). TVWS holds a key to affordable broadband Internet delivery since there are "possibilities presented by TV Whitespace technology to provide affordable broadband connectivity to unserved and underserved public libraries …" (BCoE, 2013). BCoE, 2013 also contends that "In unconnected urban and rural areas, entrepreneurs could use inexpensive, but reliable, WI-FI and other types of radio equipment capable of operating on TV band white spaces spectrum to deliver cost-effective broadband services."

7.4 Appropriate Technologies

Macmillan Dictionary defines appropriate technology as technology that is suitable for the place in which it will be used, usually involving skills or materials that are easily available in the local area. According to Margolus, Nakashima and Orr [n.d.], the concept of Appropriate Technology (AT) stemmed from the work of British economist Dr. Fritz Schumacher in the 1970s.

7.5 E-Infrastructure

A report commissioned by the Department for Business Innovation and Skills of the Research Councils UK defines e-infrastructure as digitally-based technology (hardware and software), resources (data, services, digital libraries), communications (protocols, access rights and networks), and the people and organisational structures needed to support modern, internationally leading collaborative research be it in the arts and humanities or the sciences.

7.6 Hybrid e-Infrastructure

Hybrid is simply about having the choice between different types of infrastructure from a single provider, for example a user choosing a dedicated server or a virtual server. As well, hybrid infrastructure offers significant levels of integration where a dedicated or virtual server are integrated over a private network. Bridging these two pieces together over the network creates a single infrastructure resource. And it is hybrid because it combines two different types of infrastructure and in our study, it is hybrid because we propose the combination of DSpace over TVWS and e-granary.

7.7 E-Granary

E-granary is a platform that provides instant access to a broad variety of educational resources including websites, books, audio, video and journals. The e-granary server referred to as "the Internet in a Box" offers instant access to over 32 million digital resources for users with insufficient internet access. The information contained within the e-granary can be shared between readers and a single e-granary joined to a wireless or wired LAN (local area network) can serve very many users. The e-granary server comes with an inbuilt proxy and search engine that imitates the internet experience. It also comprises of inbuilt tools that permit subscribers to make and edit limitless offline websites as well as upload local materials. Approximately six percent of the information within the e-granary digital library is not accessible on the public internet as majority of the materials need payment or subscription. (Balancing Act, 2014).

8. Research Methodology

Study Group	Population Size	Sample Size	%	No. of Respondents	Response Rate
Teachers	15	11	73.3	8	72.7%
Students	80	40	50	35	87.5%
Total	95	51	53.7	43	84.3%

Table 1: Population size, sample size and response rate

The study used questionnaires to collect data from the students and teachers. There was a total population of eighty (80) and fifteen (15) students and teachers respectively. Out of this population, a research sample of forty (40) and eleven (11) teachers respectively was identified and questionnaires were distributed to these. The response rate was thirty-five (35) and eight (8) representing 87.5% and 72.7% students and teachers respectively.

9. Analysis and Discussion of Findings

The collected data was manually tallied and analysed using Microsoft Excel and below are the findings.

9.1 General

No	General	Yes		No		No idea		No response		n	Total %
		Freq	%	Freq	%	Freq	%	Freq	%		
1	Are you aware of the TVWS project conducted at your school?	35	100	0	0	0	0	0	0	35	100
2	Do you know what TVWS are?	29	82.5	6	17.1	0	0	0	0	35	100
3	Do you think TVWS has improved academic performance amongst pupils?	27	77.1	8	22.9	0	0	0	0	35	100
4	Were there any problems experienced during the project implementation?	25	71.4	10	28.6	0	0	0	0	35	100
5	Were there any successes and positive outcomes (even unexpected ones)?	30	85.7	5	14.3	0	0	0	0	35	100

Table 2: General - Students

No	General	Yes		No		No idea		No response		n	Total %
		Freq.	%	Freq	%	Freq	%	Freq	%		
1	Are you aware of the TVWS project conducted at your school?	6	75	2	25	0	0	0	0	8	100
2	Do you know what TVWS are?	6	75	2	25	0	0	0	0	8	100
3	Do you think TVWS has improved academic performance amongst pupils?	5	62.5	3	37.5	0	0	0	0	8	100
4	Were there any problems experienced during the project implementation?	7	87.5	1	12.5	0	0	0	0	8	100
5	Were there any successes and positive outcomes (even unexpected ones)?	4	50	2	25	1	12.5	1	12.5	8	100

Table 3: General - Teachers

All the students and 75% of the teachers were aware of the TVWS project that was conducted in 2013. 82.9% of the students knew what TVWS is while 37.1 never. 75% of the teachers knew what TVWS was while 25% never. 77.1% of students thought the technology had helped improve their academic performance while 22.9% did not. 62.5% of the teachers thought the technology had helped students improve their academic performance while 37.5% thought they had not. 71.4% of the students experienced problems during project implementation while 28.6 did not. 87.5% of the teachers experience problems during project implementation while 12.5% did not. 85.7% of the students said there were successes and positive outcomes from the project while 14.3% said there was none. 50% of the teachers said there were successes and positive outcomes from the project, 25% said there was none while another 25% did not respond.

9.2 Accessibility, Effectiveness and Relevance of Digital Library

No	Accessibility, Effectiveness and Relevance of Digital Library	Yes		No		No idea		No response		n	Total %
		Freq	%	Freq	%	Freq	%	Freq	%		
1	Were you aware of the availability of a digital library at your school?	35	100	0	0	0	0	0	0	35	100
2	Were you satisfied with the device you were using to access the digital library?	13	37.1	22	62.9	0	0	0	0	35	100
3	Were you satisfied with the way you were using the digital library?	10	40	21	60	0	0	0	0	35	100
4	Was it easy for you to use the digital library?	11	31.4	24	68.6	0	0	0	0	35	100
5	Did you have search skills to use the digital library competently?	12	34.3	23	65.7	0	0	0	0	35	100

6	Was the digital library easy to search?	15	42.9	20	57.1	0	0	0	0	35	100
7	Was the content available on the digital library meeting your learning needs?	9	25.7	20	57.1	6	17.1	0	0	35	100
8	Were you satisfied with the services provided by the digital library?	10	28.6	23	65.7	2	5.7	0	0	35	100
9	Was the level of quality of service provided by the digital library meeting your expectations and demands?	7	20	24	68.6	2	5.7	2	5.7	35	100
10	Have you ever used CHANCOSpace?	35	100	0	0	0	0	0	0	35	100
11	Have you ever used National NDR?	30	85.7	0	0	2	5.7	3	8.6	35	100
12	Do you think the technology has made it easier for you to learn?	34	97.1	1	2.9	0	0	0	0	35	100
13	Do you think the technology changed the way you have been learning during the project?	32	91.4	1	2.9	1	2.9	1	2.9	35	100

Table 4: Accessibility, effectiveness and relevance of the digital library - Students

No	Accessibility, Effectiveness and Relevance of Digital Library	Yes		No		No idea		No response		n	Total %
		Freq	%	Freq	%	Freq	%	Freq	%		
1	Were you aware of the availability of a digital library at your school?	6	75	2	25	0	0	0	0	8	100
2	Were you satisfied with the device you were using to access the digital library?	5	62.5	1	12.5	1	12.5	1	12.5	8	100
3	Were you satisfied with the way you were using the digital library?	4	50	3	37.5	1	12.5	0	0	8	100
4	Was it easy for you to use the digital library?	4	50	3	37.5	1	12.5	0	0	8	100
5	Did you have search skills to use the digital library competently?	3	37.5	5	62.5	0	0	0	0	8	100
6	Was the digital library easy to search?	3	37.5	5	62.5	0	0	0	0	8	100
7	Was the content available on the digital library meeting your teaching needs?	2	25	6	75	0	0	0	0	8	100
8	Were you satisfied with the services provided by the digital library?	3	37.5	5	62.5	0	0	0	0	8	100

9	Was the level of quality of service provided by the digital library meeting your expectations and demands?	3	37.5	4	50	1	12.5	0	0	8	100
10	Have you ever used CHANCOSpace?	6	75	2	25	0	0	0	0	8	100
11	Have you ever used National NDR?	6	75	2	25	0	0	0	0	8	100
12	Do you think the technology has made it easier for you to teach?	6	75	2	25	0	0	0	0	8	100
13	Do you think the technology changed the way you have been teaching during the project?	5	62	3	37.5	0	0	0	0	8	100

Table 5: Accessibility, effectiveness and relevance of the digital library - Teachers

All the students and 75% of the teachers respectively were aware of the availability of a digital library at the school while the rest were not. 37.1% of the students were satisfied with the device they were using to access the digital library, while 62.9% were not. 62.5% of the teachers were satisfied with the device they were using, while 12.5% were not, the same percentage had no idea and another did not respond. 40% of the students were satisfied with the way they were using the digital library while 60% were not. 50% of the teachers were satisfied with the way they were using the digital library, 37.5% were not while 12.5% had not idea. 31.4% of the students found it easy to use the digital library while 68.6% did not. 50% of the teachers found it easy to use the digital library, 37.5% did not while 12.5% had no idea. 34.3% of the students and 37.5% of the teachers had search skills to use the digital library competently while 65.7% students and 62.5% teachers did not. 42.9% of the students and 37.5% of the teachers found the digital library easy to search while 57.1% students and 62.5% teachers did not. 25.7% of the students and 25% of the teachers affirmed that the content available on the digital library was meeting their learning and teaching needs respectively while 57.1% students and 75% teachers did not. 28.6% of the students were satisfied with the services provided by the digital library, 65.7% were not while 5.7% had no idea. 37.5% of the teachers were satisfied with the services while 62.3% were not. 20% of the students were satisfied that the level of quality of services provided by the digital library was meeting their expectations and demands, 68.6% were not, 5.7% had no idea and 5.7% did not respond. 37.5% of the teachers were satisfied while the rest were not. All the students had used CHANCOSpace. 75% of the teachers had used CHANCOSpace while the rest had not. 85.7% of the students had used NDR, 5.7% had no idea what NDR was and 8.6% did not respond. 75% of the teachers had used NDR while 25% never used. 97.1% of the students felt the technology had made it easier for them to learn while 2.9% did not. 75% of the teachers felt the technology had made it easier for them to teach while the rest of them did not feel the same way. 91.4% of the students felt the technology had changed the way they were learning during the project, 2.9% did not, 2.9% had no idea while another 2.9% did not respond. 62.5% of the teachers felt the technology had changed the way they were teaching during the project while 37.5% of them felt otherwise.

9.3 Efficiency, Affordability, Reliability of Internet Connectivity Using TVWS

No	Efficiency, Reliability and Affordability	Yes		No		No idea		No response		n	Total %
		Freq	%	Freq	%	Freq	%	Freq	%		
1	Is Internet connectivity efficient when using TVWS?	33	94.3	0	0	0	0	2	5.7	35	100
2	Is Internet connectivity affordable when using TVWS?	33	94.3	0	0	1	2.9	1	2.9	35	100
3	Is Internet connectivity reliable when using TVWS?	30	85.7	1	2.9	2	5.7	2	5.7	35	100

Table 6: Efficiency, reliability and affordability of Internet connectivity - Students

No	Efficiency, Reliability and Affordability	Yes		No		No idea		No response		n	Total %
		Freq.	%	Freq.	%	Freq.	%	Freq.	%		
1	Is Internet connectivity efficient when using TVWS?	6	75	2	25	0	0	0	0	8	100
2	Is Internet connectivity affordable when using TVWS?	5	62.5	3	37.5	0	0	0	0	8	100
3	Is Internet connectivity reliable when using TVWS?	4	50	3	37.5	1	12.5	0	0	8	100

Table 7: Efficiency, reliability and affordability of Internet connectivity – Teachers

75% of the students indicated that Internet connectivity was efficient when using TVWS while 25% disagreed. 84.3% of the teachers agree that Internet connectivity was efficient when using TVWS while 5.7% did not respond. 62.5% of the student attested that Internet connectivity was affordable when using TVWS while 37.5% did not. 94.3% of the teachers agreed that Internet connectivity was affordable when using TVWS, 2.9% of them disagreed while 2.9% did not respond. 50% of the students confirm that Internet connectivity was reliable when using TVWS, 37.5% did not while 12.5% of them had no idea. 85.7% of teachers agree that Internet connectivity was reliable when using TVWS, 2.9% disagree, 5.7% had no idea while 5.7% did not respond.

9.4 Theoretical Framework to Develop a Hybrid e-infrastructure for Socio-Economic Development

No	Development of an e-Ifrastructure	Yes		No		No idea		No response		n	Total %
		Freq	%	Freq	%	Freq	%	Freq	%		
1	Would you benefit more if the technology was connected to other sources other than CHANCOSpace and NDR?	31	86.6	1	2.9	1	2.9	2	5.7	35	100

2	Would you support the idea of combining e-granary with the current digital library to develop an e-Infrastructure?	35	100	0	0	0	0	0	0	35	100

Table 8: Theoretical framework to develop a hybrid e-infrastructure - Students

No	Development of an e-Ifrastructure	Yes		No		No idea		No response		n	Total %
		Freq	%	Freq	%	Freq	%	Freq	%		
1	Would you benefit more if the technology was connected to other sources other than CHANCOSpace and NDR?	7	87.5	1	12.5	0	0	0	0	8	100
2	Would you support the idea of combining e-granary with the current digital library to develop an e-Infrastructure?	6	75	1	12.5	1	12.5	0	0	8	100

Table 9: Theoretical framework to develop a hybrid e-infrastructure – Teachers

88.6% of the students believe they would benefit more if the technology was connected to other sources other than CHANCOSpace and NDR, 2.9% do not, 2.9% had no idea while 5.7% did not respond. 87.5% of the teachers believe they would benefit more if the technology was connected to other sources other than CHANCOSpace and NDR while 12.5% did not. All the student were in support of the idea of combining e-granary with the current digital library to develop a hybrid e-infrastructure. While 75% of the teachers agreed with the students, 12.5% of them did not and another 12.5% had no idea.

9.5 Training

No	Training	Yes		No		No idea		No response		n	Total %
		Freq	%	Freq	%	Freq	%	Freq	%		
1	Did you receive any training pertaining to TVWS?	0	0	33	94.3	1	2.9	1	2.9	35	100
2	Was the training you received enough for you to understand TVWS and its functionalities?	0	0	34	97.1	0	0	1	2.9	35	100
3	Did you receive training pertaining to digital libraries?	0	0	32	91.4	3	8.6	0	0	35	100
4	Was the training enough to enable you to perform better?	0	0	33	94.3	2	5.7	0	0	35	100

Table 10: Training - Students

No	Training	Yes		No		No idea		No response		n	Total %
		Freq	%	Freq	%	Freq	%	Freq	%		
1	Did you receive any training pertaining to TVWS?	1	12.5	7	87.5	0	0	0	0.0	8	100
2	Was the training you received enough for you to understand TVWS and its functionalities?	1	12.5	0	0	0	0	7	87.5	8	100
3	Did you receive training pertaining to digital libraries?	1	12.5	0	0	0	0	7	87.5	8	100
4	Was the training enough to enable you to perform better?	1	12.5	0	0	0	0	7	87.5	8	100

Table 11: Training - Teachers

94.3% of the students never received any training pertaining to TVWS while 5.7% did not respond. 12.5% of the teachers received such training while 87.5% did not. All the students did not respond as to whether the training was enough for them to understand TVWS and its functionalities. 12.5% of the teachers said the training they received was enough while 87.5% did not respond. 91.4% of the students never received any training pertaining to digital libraries while 5.7% did not respond. 12.5% of the teachers received such training and 87.5% never received any. All the students did not respond to whether the training on digital libraries was enough to enable them perform better. 12.5% of the teachers affirmed that the training received was enough to enable them perform better while 87.5% did not respond.

10. Conclusion

In conclusion, the survey has uncovered that TVWS has been proven to be an invaluable tool in enhancing students' academic performance as evidenced by its capability to provide efficient, affordable and reliable broadband internet connectivity. Though the technology has enabled delivery of digital libraries, most of the content is irrelevant to secondary school students who themselves expressed the need for developing a theoretical framework to deploy a hybrid e-infrastructure to strengthen and re-enforce content availability to facilitate sustainable development.

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