# Provisioning of Educational Content to Rural Schools in PNG using RACHEL

**Picky Airi**

## Abstract

This paper discusses the use of offline open educational resources as an alternative for provisioning of educational content in particular to rural schools in PNG. The Remote Area Community Hotspot for Education and Learning service is presented as a case study for such provisioning. The paper describes the opportunities and challenges of adopting RACHEL using a recent project as an example. The paper then proposes a follow-up survey on this project to establish empirical data to support the adoption of this technology for PNG schools.

**Key words:** RACHEL, OER, rural schools, NDoE, ICT, Internet, educational content

## Introduction

A key statement under access to education in the Papua New Guinea Vision 2050 is that more improvement is required in terms of quality, efficiency and equity (Government of Papua New Guinea, 2009). The government made a commitment towards achieving the Global 2030 goals of education whereby it should provide relevant and quality education to every child (National Department of Education, 2016). This was in accordance with the Medium-Term Development Plan III 2018-2022, which identifies education as a priority for development and further to that, ICT was identified as an enabler to underpin many improvements in education.

One of National Department of Education's (NDoE) focus areas is learning with the expected output of schools having access to, and using, current approved curricula and assessment system (NDoE, 2016). The National Education Plan identifies two main strategies under this focus area: implement e-learning suitable for Papua New Guinea (PNG), and use ICT to enhance teaching and learning (NDoE, 2016). Two of the objectives under the first strategy are to coordinate and advise schools on ICT infrastructure for e-learning, and conduct trials of strategies and resources for e-learning. These objectives are important as they will provide guidance to decision-making and action. It is in this context that this paper presents the idea of provisioning educational content to rural schools using Remote Area Community Hotspot for Education and Learning (RACHEL).

Thus, the paper will discuss the use of offline open educational resources (OER), different OERs available and present RACHEL as a suitable option for schools in PNG. It will describe the opportunities and challenges of adopting RACHEL using a recent project as an example. Finally, the paper will propose a follow-up survey to establish empirical data to support the adoption of this technology.

## Challenges rural schools face in access to quality education content

Schools in the rural districts struggle to deliver the same educational experiences provided by their larger suburban and urban peers and often operate with higher per-pupil costs and stretched budgets (Rural Education and Consensus Panel, 2015). A study done in the Mpumalanga province of South Africa concerning schools in rural areas highlighted that rural areas are remote and relatively underdeveloped (Du Plessis, 2014). The following observation was made:

> "As a result, many rural communities and their schools are poor and disadvantaged, lacking basic infrastructure for sanitation, water, roads and other transport, electricity and information and communication technology. The socio-economic realities of rural areas put learners in rural schools at a disadvantage. In addition, many rural communities lack the professional help, and support, governance structures, books and learning materials that they need to provide the necessary support and care for learners" (Du Plessis, 2014, p. 1109).

It may seem strange why we are comparing our rural communities to that of South Africa, however the realities are similar as the situation is not so much different here in PNG. Rural areas are characterized by various factors that negatively influence the delivery of quality education (Du Plessis, 2014).

> "Technology's ability to bridge distance, increase administrative efficiency, and customize experiences at relatively low cost holds a great promise for rural communities" (Rural Education and Consensus Panel, 2015, p. 25).

While it is widely recognized that the role of ICT is pivotal in education (Du Plessis, 2014; Rural Education and Consensus Panel, 2015; Dennis, Martin, Wood & Madison, 2010) there appears to be little research undertaken and reported on the use of ICT in PNG schools from the perspective of the day-to-day teaching and learning experiences of teachers in rural contexts. In order to deliver on the promise of technology in rural education, policy makers like the NDoE together with other authorities need an evidence-based report about how technology could be brought to bear on the challenges facing rural educators. Reports will also help identify what policies and systems need to be implemented to ensure technology can be utilized.

## Providing access to online resources via internet

Access to the Internet[1] is fundamental to achieving United Nations' fourth Sustainable Development Goal (United Nations General Assembly, 2015) of ensuring inclusive and equitable quality education and promote lifelong learning opportunities for all in the future (Internet Society, 2017). The Internet Society (2017, p. 1) further asserts that the Internet can improve the quality of education in many ways:

> "It opens doorways to a wealth of information, knowledge and educational resources, increasing opportunities for learning in and

[1] The Internet (big "I") is the worldwide network comprising of all other networks interconnected and communicating on the open Web. This is what we refer to when we mean the open, public network that connects the globe.

> beyond the classroom. Teachers use online materials to prepare lessons, and students to extend their range of learning. Interactive teaching methods, supported by the Internet, enable teachers to give more attention to individual students' needs and support shared learning."

Furthermore, the Internet Society (2017) affirms that access to the Internet helps educational administrators to reduce the costs and improve the quality of schools and colleges. Whilst the Internet Society upholds its view of the Internet as a key tool in improving the quality of teaching and learning, it also acknowledges that there are a number of factors inhibiting achievement of these gains, lack of Internet access being the first and foremost among others.

**The challenge of access to internet in PNG**

Particularly in PNG, this lack of meaningful access is a result of the high cost of broadband internet with many users and agencies not having access to affordable and reliable Internet connectivity (Martin, 2017). In fact, PNG was ranked 163 out of 169 countries by the International Telecommunications Union (ITU) in 2013 in terms of internet affordability (National Research Institute, 2016, p. 148). Despite significant improvements in telecommunications in the country, internal prices are too high, limiting access and imposing undue costs on all levels of society (Lawrence, 2017; National Research Institute, 2016). With respect to access, even within broadband, it should be noted that speed also matters. Service providers recommend a minimum speed of two Mbps (megabits per second) for data intensive services such as video on demand (ITU, 2011). The level of broadband speed is also a key determinant of the range of online educational activities possible (ITU, 2013).

According to a report by the Lowy Institute on infrastructure (Rena, 2011) challenges for PNG, entry-level internet packages appear to be above the ITU's benchmark required to accelerate internet penetration. With high internet accessibility costs, many primary, secondary and tertiary level schools and colleges in PNG will not be able to consider even an entry-level internet package amidst the inadequate funding issues they are facing.

**Offline open educational resources (OER) as an alternative**

The Internet is not the answer to every challenge posed by education according to the Internet Society (2017). However, it has led to important innovations in educational content. One of the Internet Society's key considerations suggested to policy makers is to use national policies that draw together experience in both education and technology, within different countries' national contexts as guidelines. In their efforts to provide suggestions, five priority areas were identified (Internet Society, 2017): (1) infrastructure and access, (2) vision and policy, (3) inclusion, (4) capacity, and (5) content and devices.

The fifth priority is the focus of discussions here. Given the high cost of internet access, limited infrastructure, and financial constraints of rural schools, an alternative method of content delivery has to be explored. A technology that will maximize the Internet's contribution to educational content whilst potentially minimizing costs to schools in terms of access and infrastructure. Open educational resources seem to fit the bill.

Although learning resources are often considered as key intellectual property in a competitive higher education world, more and more institutions and individuals are sharing digital learning resources over the Internet openly and without cost, as OERs (OECD, 2007). These can supplement local educational resources, extending the range and quality of materials available to students (Internet Society, 2017).

> "The definition of OER currently most often used is "digitized materials offered freely and openly for educators, students and self-learners to use and reuse for teaching, learning and research". OER includes learning content, software tools to develop, use and distribute content, and implementation resources such as open licenses. This report suggests that "open educational resources" refers to accumulated digital assets that can be adjusted and which provide benefits without restricting the possibilities for others to enjoy them" (OECD, 2007, p.10).

In January 2007 the OECD identified over 3000 open courseware courses available from over 300 universities worldwide. In repositories such as MERLOT, Connexions (now OpenStax CNX), OpenLearn, and others with hundreds of thousands of pieces of content or materials representing thousands of freely available learning hours. More resources that are recent include UNESCO collections, eGRANARY and RACHEL. Although the dominant language so far is English, translation of resources combined with a growing number of non-English OER projects cater for greater language diversity and increased global use (OECD, 2007). The majority of producers of resources and OER projects are well-reputed institutions located in English-speaking countries in the developed world. The potential number of users is enormous.

OERs make a wealth of learning opportunities freely available to anyone with an internet connection. However, schools without an internet connection cannot use these resources and the knowledge gap keeps widening. World Possible is one such organization that makes exciting high-quality content available for offline use so that anyone can access.

**World Possible's Brief History**[2]

In 2008, Noberto Mujica, a Cisco Systems engineer who traveled to Ethiopia to teach classes at a university with a large number of computers found there was no usable internet access. He came up with the idea of putting together a collection of materials stored on a server so that all students could access them. Later that year with three more colleagues from Cisco working alongside the local Ethiopians, the organization World Possible was born.

Despite a few technical challenges, in 2009 Noberto and a handful of volunteers built the first large versions of the offline educational server, which they named RACHEL or Remote Area Community Hotspot for Education & Learning. In the same year, a group of volunteer Cisco Systems Engineers and Jeremy Schwartz, a volunteer director who worked in venture capital, traveled to Sierra Leone to pilot RACHEL. Unfortunately, the trip failed dramatically due to local

[2] This section draws on the history provided in https://worldpossible.org/. About us page.

issues on the ground, and most group members cancelled their trip. World Possible went dormant as an organization, but a handful of RACHEL servers continued to be active in Africa and India.

Nine years on, its impact continues to grow as it reaches an estimated 500,000 plus learners around the world. The organization has grown to include a chapter program with over 90 partners using RACHEL for their offline education programs and projects. RACHEL has been brought to a total of 47 countries (including PNG) and 14 state correctional facilities in one year through its chapter program. According to its 2016 brief, they shipped 648 RACHEL servers in one year. Its free content library of downloadable websites grew to over 100 modules, and users downloaded over 90 terabytes of content. World Possible in fact have created two tools to improve learning in offline areas, OER2Go and RACHEL. RACHEL has indeed established a reputation as a viable option worthy of consideration for offline education projects.

**How does RACHEL work?**

RACHEL is a portable plug-and-play server that stores open educational resources and makes that content available over any local (offline) wireless connection. It is an offline server with leading educational and learning sites suitable for use in schools, community centres, health centres or places of learning worldwide where there is no or limited Internet access. The content includes websites, simulations, text files, images, sound and video in digital format. There is even some basic open source software included for downloading and installation. RACHEL makes deploying a library of digital content as easy as pushing a button. There are four different variations of RACHEL: RACHEL-Pi, RACHEL-Plus 3.0 and RACHEL-Corrections 3.0 and RACHEL USB.

**RACHEL – Pi**

An inexpensive variation of the RACHEL, known as RACHEL-Pi (Figure1) runs on a small low power computer called the Raspberry Pi. The information on the server is preinstalled and there is enough space available (if more than 64GB microSD is used) to add additional content that may also contain videos. The components in the device (mainly the microSD card) are susceptible to failure over time as it was not designed to run servers, and max out at USB 2.0 speeds. This does not make for a stable long-term deployment. Additionally, the processing power of this device does not allow enabling content updating and usage monitoring tools. RACHEL-Plus should be considered for any actual field deployments. For use at home, demonstration, or trial run, consider using RACHEL that can even be custom-built at a low cost. In this paper, we trialed a custom-built RACHEL-Pi to a rural secondary school.

| Type | Image | Cost* (excluding shipping) | Package includes | Features | Can it be customized | Hardware/OS |
|---|---|---|---|---|---|---|
| RACHEL – Pi |  | $169.00 (USD) **550.77 PGK** | x1 Raspberry Pi 3B,<br>x1 64GB microSD,<br>x1 power supply 5v. | • 10 users with mixed-media usage up to 20 simultaneous video streams.<br>• Can be plugged to a 20,000 (3-5mAh) battery bank | Yes, DIY possible | Raspberry Pi 3 B 1.4GHz 64-bit quad-core processor, dual-band w/LAN, Bluetooth 4.2/BLE, FastEthernet, PoE support (with separate PoE HAT)<br>64GB mSD / Raspbian OS |

**Figure 1** Features of the low cost, low power RACHEL-Pi.

## RACHEL-Plus 3.0

This RACHEL Server is designed for use in schools, community centers, health centers, or places of learning worldwide where internet access does not exist or is limited. This is the primary product used by hundreds of partner organizations in over 40 countries worldwide. RACHEL-Plus (Figure 2) would be the best option for schools looking at spending around K2, 000.00 including shipping costs.

| Type | Image | Cost* (excluding shipping) | Package includes | Features | Can it be customized | Hardware/OS |
|---|---|---|---|---|---|---|
| RACHEL-Plus 3.0 |  | $499.00 (USD) **1,624.47 PGK** | x1 Rachel Plus 3.0<br><br>x1 500GB or 1TB content (English). Further info can be found here | • Up to 20-50 simultaneous users*<br>• Remote access and updates if/when plugged into the internet<br>• No recurring fees of any kind<br>• 5 hour+ battery life<br>• Extended WiFi range<br>• Password protected teacher portal to easily upload PDFs, Movies, and other files<br>* 50 users with mixed-media usage, up to 20 simultaneous video streams<br>Other additional features come at a cost. | Yes, additional cost | Dual-core Intel processor, 4GB RAM<br>Dual Ethernet<br>32bit Ubuntu OS |

**Figure 2** A suitable option for schools with the budget. It can allow up to 50 simultaneous users.

## RACHEL-Corrections 3.0

RACHEL-Corrections (Figure 3) is a variation of the RACHEL-Plus intended to connect offline learners in prisons to educational material. This package of content is customized to remove 'objectionable' content, such as prohibited reading materials, medical content, Wikipedia content and more.

| Type | Image | Cost* (excluding shipping) | Package includes | Features | Can it be customized | Hardware/OS |
|---|---|---|---|---|---|---|
| RACHEL-Corrections 3.0 |  | $749.00 (USD) **2,434.50 PGK** | x1 RACHEL-Corrections device<br><br>x1 Power adapter | • Up to 20-50 simultaneous users* – Users need a tablet, laptop, or desktop computer to connect to RACHEL (wired or wireless)<br>• 500GB of available storage (~250GB is pre-loaded by us)<br>• Device does not come with a battery, included free if you need a battery<br>• Extended WiFi range<br>• Password protected teacher portal to easily upload PDFs, Movies, and other files<br>* 50 users with mixed-media usage, up to 20 simultaneous video streams | Yes, additional cost | Dual-core Intel processor, 4GB RAM<br>Dual Ethernet<br>32bit Ubuntu OS |

**Figure 3** Features of the RACHEL-Corrections 3.0.

## RACHEL USB

This version of RACHEL does not include any server software, but when connected to a network has the capability of sharing the content using the computer's built-in file sharing. It contains 32 gigabytes selection of RACHEL content on a USB (see Figure 4) stick designed to work easily on individual computers running Windows, Mac OS, or Linux without installing any software.

| Type | Image | Cost* (excluding shipping) | Package includes | Features | Can it be customized | Hardware/OS |
|---|---|---|---|---|---|---|
| **RACHEL USB** |  | $25.00 (USD) **$3.88 PGK** | x1 32GB selection of RACHEL content on a USB stick | • RACHEL USB sticks come with a physical switch to "write-protect" the device. We recommend gluing this switch to keep it locked. This will preventing viruses from infecting the stick (which happens frequently on old computers), as well as users accidentally deleting content. | Yes, DIY possible | RACHEL USB stick or any USB for custom builds |

**Figure 4** Consider this as a better alternative for trialing RACHEL.

What makes RACHEL revolutionary is it can turn unused computers into a learning center by connecting the RACHEL device to the Local Area Network (LAN). The server's digital content can also be accessed locally (offline) through compatible devices such as smart phones, tablets, or laptops. The RACHEL device creates a wireless hotspot when you turn it on. That is the only connection you need to turn on. It's often called a headless server since it has no other connection.

Simply plug a micro-USB power cable into the power socket of the RACHEL-Pi.

The LED light should turn from RED, AMBER to GREEN. This indicates server is running.


Additionally, a Wi-Pi module can be added to the Raspberry-Pi to enable connection to a Wi-Fi network. Especially for a Raspberry Pi 2.

**Figure 5** Here is an example of how the RACHEL-Pi can be turned on. This particular RACHEL-Pi was custom built using the Rasperry Pi 3B+ device with a 64GB microSD.

## Central Students Community Awareness to Kupiano Secondary School: RACHEL trial

From the 14 to 15 November, the Central Students Association of DWU conducted a community awareness project at Kupiano Secondary School. Approximately 180km away from Port Moresby taking around 4-5 hours' drive, the school is just within the vicinity of the Kupiano station in the Rigo-Abau district of Central Province.

The objective was to disseminate information about DWU and other tertiary institutions in Madang Province and to provide information on social issues communities face and how these issues could be addressed. Furthermore, they planned as part of this community awareness program to give

something to the school. The idea was to begin with Kupiano in 2018, and then do the same for other secondary schools around Central province.

**Figure 6** The Central Students gathering with the Grade 9 & 10 students of Kupiano Secondary for a photo shoot.

The main problem however was funding to carry out this project. Despite a proposal and letter seeking funding from the Central provincial government, no funding was forthcoming. The students organized themselves and started to raise funds with the support from staff, students and families within DWU and the Madang community. This presented an opportunity for RACHEL to be trialed. In fact, RACHEL came about as an option because there wasn't enough donated books received. The DWU students then planned to introduce RACHEL and then give the few donated reading books to add to Kupiano Seconday's existing library.

The next challenge was choosing the RACHEL server. For this project, we decided to trial the RACHEL-Pi. Funding was our biggest challenge, so we had to choose between two options; purchasing the pre-built device from the World Possible online store or purchase the raspberry pi device online with accessories and do a custom-build. We chose the latter as it was the inexpensive option as a pilot project.

**Equipment/software components**

We decided to custom build the RACHEL-Pi using the components listed and depicted in Figure 7.

| Item | Qty | Cost |
|---|---|---|
| Raspberry Pi 3 Model B+ Rev 1.1<br>5v power adapter included. | 1 | K120.00 (A$48.99) Bought here on Ebay |
| Wi-Pi USB Wireless adapter | 1 | K40.00 (A$19.95) |
| 64GB Micro-SD Card | 1 | K155.00 Bought at a local shop (Papindo) |
| Raspberry Pi clear case | 1 | K20.00 ($7.99) |
| 58GB of educational resources | N/A | Downloaded from (http://rachelfriends.org/downloads/public_ftp/rachelpi_64EN/) with the help of DWU ICT. |


**Figure 7** The custom-built RACHEL-Pi components: Raspberry Pi 3 B+ with the Wi-Pi, 5v power adapter and 64GB microSD card.

Raspberry Pi hardware specifications: Raspberry Pi 3 B+: 1.4GHz 64-bit quad-core processor, dual-band w/LAN, Bluetooth 4.2/BLE, FastEthernet, PoE support (with separate PoE HAT). The cost of purchasing the pre-built RACHEL-Pi is $169.00 (USD) or K550.77 which with shipping totaled to around K800. With our custom build RACHEL-Pi, cost was less than K500 with the accessories. The value of this option is that, given the limited processing power of the raspberry pi (to act as a server) used, it still has the capacity to allow at least between ten (10) to fifteen users to connect to it at any single time with either their own smartphone, tablet or laptop. More users than this would result in slower response time.

This is an inexpensive option if compared to the cost of purchasing at least ten secondhand desktop computers with monitor, mouse and keyboard. It is energy efficient and cost effective. An alternative and future plan is to purchase the RACHEL-Plus for the next school project.

**The implementation**

The idea was to have this setup in the library to complement the existing resources. Students do not need any special software or hardware in order to use Rachel Pi. Most high school students have smartphones they bring to school though not to use them at the right time and for educational purposes, for which they can be suspended for this according to an article on PNG Education News (“Impact of ICT Input on Schools”, 2016). In this article, the guidance and counselling division director whilst expressing her concerns on the negative impact of the mobile phones in schools also stressed that such devices should be used to enhance schooling.

**Figure 8.** (a) The RACHEL-Pi being tested. (b) Central Students Club President with the RACHEL-Pi device at the DWU, POM Campus.

This project hopes to give new meaning to the use of smartphones in schools by introducing Rachel-Pi. The challenge would be for teachers to integrate lesson plans that can make use of the resources provided by this tool. Additional teacher guide (from World Possible) and a documentation of this device were provided to support its use.

The raspberry pi device comes equipped with a wireless adapter that creates a hotspot environment that is suited for students to use in the library. Using a dual band (2.4GHz and 5GHz) antenna this device can transmit two simultaneous wireless signals reaching up to 150 feet (46 m) indoors and 300 feet (92 m) outdoors.

**Growing interest in RACHEL deployment**

This case study is not the only example of RACHEL use in PNG. There are similar projects that have or are being implemented across PNG, some documented, while others not. According to the RACHEL in PNG community forum (Comforto, 2018), a similar project was carried out in Western Province (Glass, 2018), and there is also interest in Bougainville. These projects are all focusing on providing the RACHEL resource to the rural schools.

**Integrating local resources as modules in RACHEL: Proof of Concept**

In the year 2018, the Department of Education announced the completion of the Grades 3, 4 and 5 Standard Based Curriculum (SBC) syllabus and plans to complete SBC syllabus for upper and secondary schools by 2020 ("SBC syllabuses", 2018). The elementary curriculum is delivered to schools on a DVD (digital versatile disc) for their use. The content included English, Mathematics, and Language, Culture and community scripted lessons plus teacher guides. Furthermore, DoE reintroduced shell books, school journals, flash cards, CD songs and legends (NDoE Curriculum Development & Assessment, 2015). All these resources are supplied to Elementary schools throughout the country. The same will be done for the middle and upper school syllabus materials when they become available.

Instead of providing these resources on a DVD or CD, RACHEL can be used to collate all these materials in one device. All that needs to be done in the RACHEL device is to create modules to

allow for easy accessibility to this content. The ideal scenario is to have the resources easily accessible by both teachers and students. With resources easily accessible, teachers have the flexibility to distribute the materials or have them printed and hard copies given during lesson time.

It can be demonstrated here that by customizing RACHEL we can add modules with local content. A RACHEL module is just an offline website with the requirement that it functions without an internet connection. For example, we can add PNG High School National Exam sample papers (Figure 9) for the following grade and years: Grade 8 (2010, 2011), Grade 10 (2016, 2015, 2014, 2013, 2011) and Grade 12 (2015, 2014, 2013, 2012, 2011). A couple of these exam papers come with their answer sheet for the teachers and students to download and do revision or mock exams. These exam papers can be downloaded online from the Education department website for schools with internet connection. However, for rural schools without internet connection, having these files stored locally helps in narrowing the accessibility gap.

Furthermore, curriculum resources and support material that the DoE makes available could also be added as modules (Figure 9). These also reduce the time and effort required to have documents printed hard copy or copied onto a CD/DVD for distribution to schools. Additionally, content that comes with the RACHEL build itself could also be used as support material to complement the curriculum. Figure 9 shows how these teacher guides and syllabus can be downloaded and stored locally on the RACHEL server and made accessible through a simple web directory.

- All it takes is to create modules for each set of resources and add them to the RACHEL distribution. This can be a bit too technical but with a support community of RACHEL users, you can receive help when faced with difficulties.

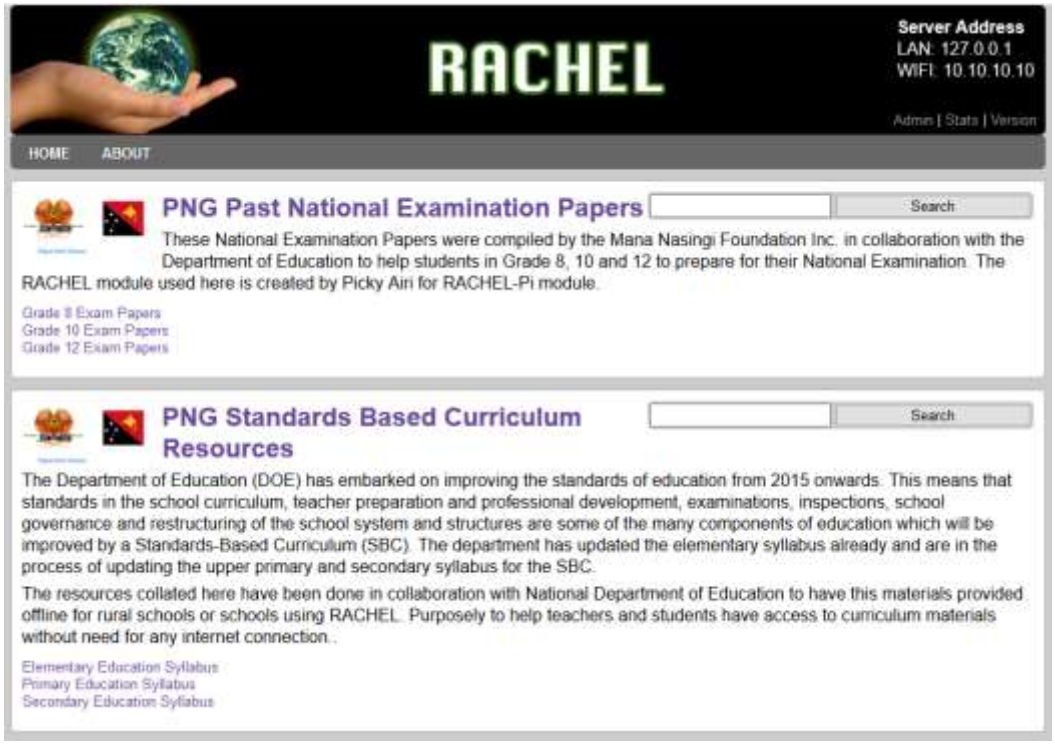

**Figure 9** This image is a screenshot of the RACHEL homepage showing the first two modules. The first module contains a directory of PNG Past National Exam Papers. The second module shows the PNG Standards Based Curriculum resources directory.

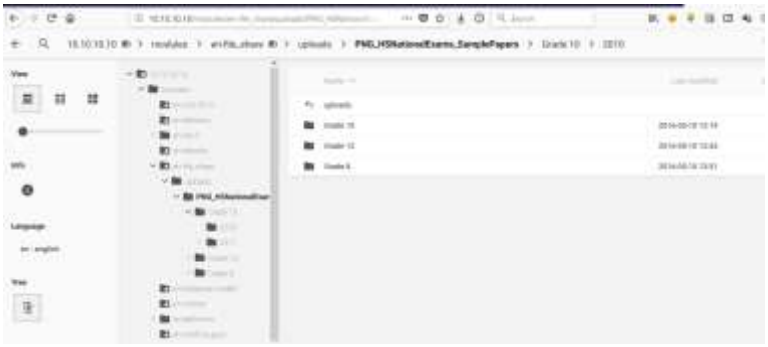

**Figure 10.** Alternatively**,** non-technical people using the RACHEL-Pi could use the File Share module and just upload any resources they want to share. By clicking on the folder, students and teachers can have access to those resources.

## Plans for next RACHEL Project

It is hoped that a follow up on the Kupiano RACHEL-Pi initiative will be used to evaluate how it is being used by the teachers and students, and the challenges faced and how the teachers were able to utilize the device. It will further seek to determine how students found the material provided in the device and its relevance to their studies. This will help to establish empirical data to support the adoption of this technology for other PNG schools.

This project was a pilot intended to trial out RACHEL in Kupiano. Lessons learned will help to establish best practices for other schools around Central province. Initially we are targeting secondary schools as part of the student's community awareness. The next device to use will be RACHEL-Plus because of its additional features and its ability to allow more users to access its content.

## Challenges of implementing offline OER projects

The potential benefit of offline OER projects is huge with a few highlighted earlier in the paper. However, there is also a host of challenges facing such projects (Marcus-Quinn & Diggins, 2013; OECD, 2007). It should not be assumed that just by making those materials available they will actually be used.

There is an abundance of literature available on challenges and issues with implementing OER. Accessibility is one issue, while computer basics skills, information literacy another, OER project sustenance, than teacher training (technological, pedagogical and content) are others (Marcus-Quinn & Diggins, 2013; Klieme & Vieluf, 2009; Cuadra, & Moreno, 2005).

Despite the argument that technological advances have made access to information easier, there is an ongoing concern that students are still not becoming information literate and that they cannot retrieve and evaluate the information required for problem-solving and decision-making in the workplace and in society generally (Moreira, 2010).

There are also copyright and open license issues. While information technology makes it possible to multiply and distribute content worldwide and almost at no cost, legal restrictions on the reuse of copyright material hinder its digital reproducibility. A proper legal and regulatory framework that will encourage open licenses like the creative commons used in other countries will encourage people to share and reuse copyright material without fear of being sued.

The actual costs of an OER project varies considerably. Some initiatives have institutional backing involving professional staff while others build on communities of practitioners and rely on their voluntary work. There are all sorts of in-between models as well (OECD, 2007).

All of these challenges and issues each have varying degrees of impact on the positive or negative outcome of OER implementation. Challenges are inevitable in any ICT project implementation, however, they can always be managed. At the early stage of any technology adoption failure is expected but it also contributes to development of best practices which in turn drive growth into maturity (Hall & Khan, 2003). So unless we try, we may never know what works and what doesn't. When best practices are established on working models, challenges can be managed.

## Conclusion

This paper discussed the use of offline OER for provisioning of educational content for rural schools in PNG. It discussed the challenges rural schools face and why Internet connection is not a viable solution at present. In doing so, it presented RACHEL as an offline OER suitable for implementation in rural schools.

The paper demonstrated a procedure for using RACHEL to deliver local content, the SBC curriculum and other supplementary resources that can enhance quality and accessibility of teaching and learning resources. It then discussed briefly the challenges of adopting RACHEL as an OER. Highlighting the need for trials to be done so that best practices are established to manage the inevitable challenges.

It seems that it is quite difficult for NDoE to properly and adequately coordinate, and advise on ICT infrastructure for e-learning as there is not much research and documented data available to assist decision making. To this end this paper proposed for a follow-up survey to be conducted on a trial RACHEL implementation to establish empirical data that can support further implementation and best practice.

While the NDoE is hopeful about ICT underpinning many of the improvements, there needs to be better coordination and collaboration between various authorities and policy makers responsible to provide an environment that will foster innovation and collaborate that will drive development.

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**Glossary**

**eGranary** "The Internet in a Box" -- is an off-line information store that provides instant access to over 35 million digital resources http://www.widernet.org/egranary/

**ICT** An umbrella term that includes any communication device or application, encompassing: radio, television, cellular phones, computer and network hardware and software, satellite systems and so on, as well as the various services and applications associated with them, such as videoconferencing and distance learning.

**MERLOT** provides access to curated online learning and support materials https://www.merlot.org/merlot/index.htm

**NDoE** National Department of Education

**OER** Digitized materials offered freely and openly for educators, students and self-learners to use and reuse for teaching, learning and research. OER includes learning content, software tools to develop, use and distribute content, and implementation resources such as open licenses. OERs can be offered online or offline.

**OER2Go** is a collection of educational websites re-packaged for download and offline use. https://worldpossible.org/oer2go Download websites like Wikipedia, Khan Academy, Fantastic Phonics, and over 100 more.

**OpenLearn** Free online learning from the Open University https://www.open.edu/openlearn/

**OpenStax** Free, online educational material such as courses, books and reports. https://cnx.org/

**RACHEL** Remote Area Community Hotspot for Education & Learning

**SBC** Standards Based Curriculum. The PNG government made the decision to phase out the Outcomes Based Education (OBE) and replace it with the Standards Based Education (SBE) in 2014.

**UNESCO collections** is a digital library of books and music albums.

**World Possible** An organization that provides free open educational resources https://worldpossible.org/

**RACHEL module** A template for putting together RACHEL modules. Sample templates can be accessed here https://github.com/rachelproject/module-template

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**Author**

Picky Airi was a former Senior IT Trainer with Daltron and is currently a Senior Tutor in the Department of Information Systems at Divine Word University. He holds a Bachelor of Information Systems degree and a Postgraduate Certificate in Higher Education Teaching & Learning. He received a Training of Trainers: Workplace Assessment Certificate from Daltron. He is the DWU Cisco Academy Coordinator and a Cisco Certified Academy Instructor. He is currently studying for a Master of Leadership in Business Administration at DWU. His research interests include IT technologies and training.