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The SEE Box: Creating new learning opportunities across STEM disciplines in developing countries. In
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The SEE Box: Creating new learning opportunities across STEM disciplines in developing countries (Short Paper)

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Abstract: *The Internet is loaded with high quality resources that can make a difference to how students develop conceptual connections across STEM disciplines. However, connectivity is a major challenge for many users throughout the world. In many cases even after connectivity is achieved, the quality of the connection dictates how the technology is used. Connectivity in developing countries is even more significant as a problem. This paper specifically focuses on the SEE Box as a tool for addressing the problem of connectivity and the progress that has been made. The SEE Box device has evolved from the Rachel Pi, which is an offline resources library. The SEE Box has almost 35 gigabytes of resources that are suitable for STEM and other disciplines. The ongoing development of the SEE Box has primarily been driven by the engagement of staff and students from an Australian university in outreach service learning projects in Fijian and Malaysian schools.*

Keywords: STEM Education, SEE Box, Developing countries, Internet connectivity

1. Introduction

STEM Education presents new challenges for teachers and students. For teachers, they need to not only know their disciplinary knowledge, but they also need to understand how it relates and how it is applied in other disciplines. Teachers also need to understand appropriate pedagogical practices. Underpinned by this challenge is teacher quality in schools. A position paper published by the Australian Office of the Chief Scientist notes the following: "Great teachers are intellectually capable, passionate and knowledgeable about their subjects, rigorously prepared and well supported and resourced" (Prinsley & Johnston, 2015, p. 1). While the points raised by Prinsley and Johnston is neither new nor unknown to other jurisdictions around the world, what is significant is the need for high-quality resources. Both teachers and their students need good resources to learn. When these resources are used appropriately, they can facilitate teaching and learning activities both inside and outside the classroom.

The Internet has made significant advances. The diverse array of resources can have a positive impact on education (including STEM). These possibilities have been recognised for some time (e.g. Leu, Leu, Leu, 1999). However, the real challenge for schools is having access to the Internet. In the U.S., ten years ago nearly all public schools and libraries were connected to the web (Ross, 2016). While achieving internet connectivity is a desirable outcome, the quality of the connection impacts directly on usability. In many countries, the quality of connections is an issue. As a consequence, a connectivity gap is created. In the U.S., this impacts on 40 million students in K-12 public schools because more than half of schools do not have enough bandwidth to meet the needs of learning with technology (Education Superhighway, 2016). The challenges faced in the U.S., reflect the complexity and enormity of the task. Given the challenges faced by a wealthy nation such as the U.S., there is no doubt that for many poorer countries, connectivity would be an even bigger issue.

2. Context

The Share, Engage, Educate (SEE) Project (https://theseeproject.org/) was initiated to enhance students' print and digital literacy in rural and remote schools in developing countries. The project donates print (e.g. library books) and digital resources (e.g. computers) to schools. It also facilitates teacher professional development. Since its inception, the project has had a broad impact on rural and remote school communities in countries such as Fiji, Malaysia, Papua New Guinea, Bhutan and South Sudan. Through the in-kind support of organisations and the voluntary collaborative participation of individuals, the project has: 1) provided more than 10,000 students in 40 schools access to digital technologies for the first time; 2) transformed e-waste to e-opportunity recycling 'retired' university assets (value ~$400,000), and 3) enhanced the capacity of some teachers in developing countries so that resources can be efficiently embedded in classrooms. These partnerships have also provided pathways for university students to participate in outreach projects in some of some of the schools where they work in multidisciplinary and multinational teams to design and deliver classroom activities (based on the local curriculum) that showcase the integration of digital technologies. Such international experiences facilitate real world learning as they engage in concrete experiences, reflective observations and abstract conceptualisations which leads to active experimentation in the classrooms (Kolb & Kolb, 2008).

Almost all the schools that have been supported by the SEE Project have connectivity issues. Thus, the use of computers has been limited to the onboard software (e.g. Edubuntu suite) that was installed on them. While some of the software (e.g. Libre Office) created new opportunities for teachers to develop classroom activities that used digital technologies, there was also a need to explore other ways of using the computers. Concepts in and across STEM and other disciplines can be more effectively delivered if students have access to online resources that are widely available on the internet.   As a consequence, the SEE Project team sought to explore options that would give teachers and students in remote and rural areas in developing countries access to Internet resources without connectivity.

3. The SEE Box

Through ongoing problem solving, a creative outcome of the SEE Project has been the development of a wireless device known as the SEE Box, which enables access to high-quality offline resources for schools. The idea draws and builds upon the Remote Areas Community Hotspots for Education and Learning (Rachel Pi) project - an initiative of World Possible (RACHEL PI, 2014). The objective of the Rachel Pi project is to enable users in developing countries access to a range of "open and free educational courseware and libraries" without the need for connecting to the internet. It uses low-cost hardware such as the Raspberry Pi and an SD card to make the device affordable. The resources include: thousands of Khan-Academy videos, a comprehensive version of the Wikipedia Encyclopaedia, thousands of eBooks from Project Gutenberg and a varied range of other resources. World Possible makes these resources available to users under a Creative Commons Attribution-Non-Commercial-Share Alike 3.0 Unported License (RACHEL PI, 2014). Rachel Pi has been used in some countries including Ghana, Kenya, and Uganda.

The work from this project has led to further development of the device. For example, more Wikipedia content has been added. Backend modifications have also been made to support a wider range of hardware including different forms of storage media and wifi adapters. Perhaps the most significant change has been the addition of the Etherpad (open source software which allows collaborative editing in real-time) and a portal for uploading user- created content (e.g. digital stories and reports). Such capabilities enable users to function in a dual mode - they can be users and also creators of content. Given the simplicity of the hardware, locally created content can easily be shared through regular exchange of the SD card (Figure 1).

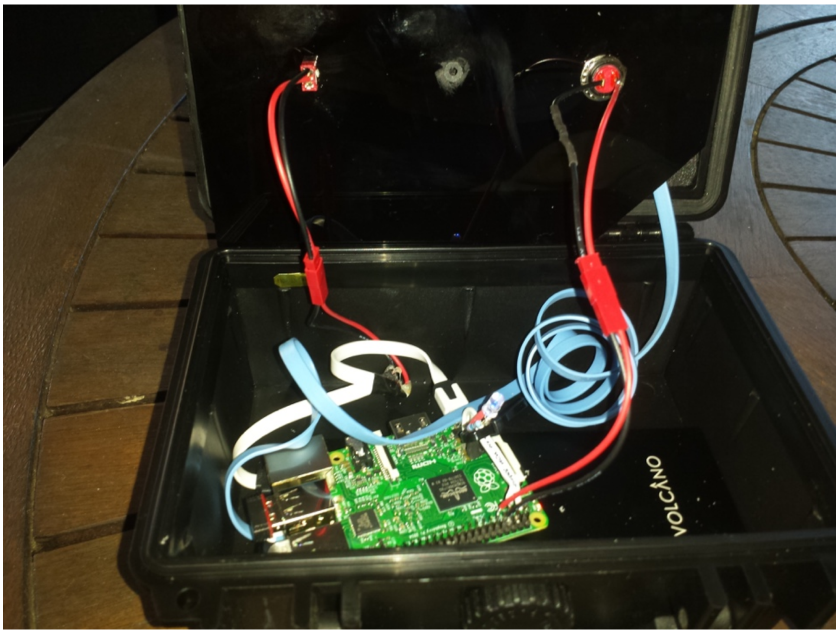

Figure 1: View inside the SEE Box

Research on two deployments in three countries are underway, and these will be discussed in future publications.

4. Implications for STEM Education

Our initial findings have highlighted some challenges regarding resourcing in developing countries to advance the STEM agenda. In many classrooms in these countries, the pedagogical approach to teaching science and mathematics has made minimal progress over decades. The focus is predominantly on chalk and talk teaching, and this is consistent with the findings that have been observed in other countries (e.g. Goodrum, Hackling, Rennie, 2001). Students' active engagement enhances the quality of learning when compared to a more passive approach that is associated with chalk and talk teaching (Pal, Roy, & Gangopadhyay, 2014). For many schools in developing countries, it is the lack of physical resources (e.g. science equipment) that prevents active engagement.

The adopted pedagogical approach in these classrooms can also be attributed to the quality of teacher training and professional development. While the physical environment presents opportunities for students to engage actively in developing conceptual understanding in some areas - this does not seem to occur regularly. In some instances, it can be the teachers lack of understanding of the content and pedagogies that leads them to adopt chalk and talk teaching because it keeps them in their comfort zones.

Even when chalk and talk practices are supported by locally produced print resources, they are content focused. The publications (in monochrome) are very poorly developed. The quality of the activities with hand-drawn illustrations can be challenging to comprehend - both for the teacher and the students. In addition, the lack of quality resources in libraries (e.g. reference books) presents a further challenge to accessing information and resources.

The SEE Box opens a new world in terms of resources. For students, apart from the knowledge gained from teachers, there are new opportunities for developing ideas about a concept from another source. For example, Khan academy videos (Figure 2) open a new world for students in these contexts. Students not only view a video that explains a concept, but they can also do this at their own pace and at their convenience as long as they have access to a computer that is connected to the SEE Box.

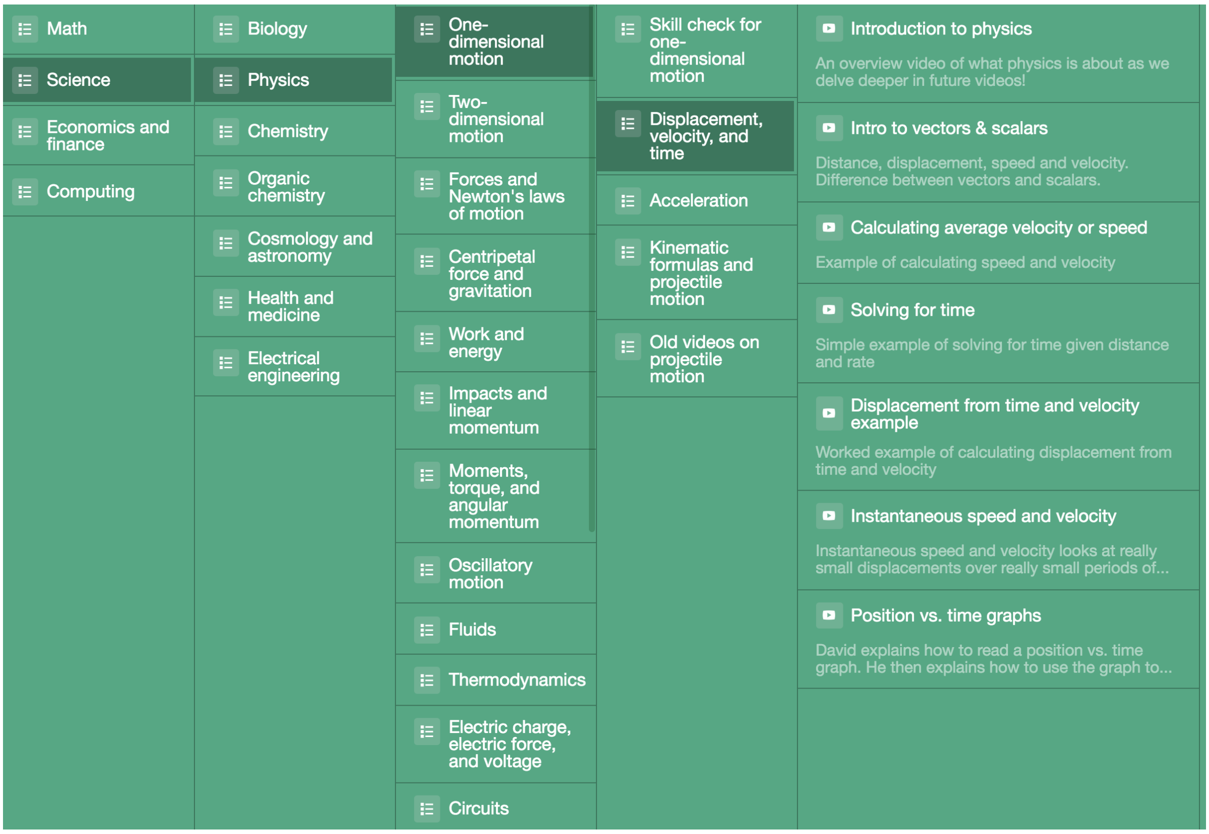

Figure 2. A menu option for selecting a Khan Academy video

Students can also explore related topics from some of the digital books. From example the "CK-12 Physics Intermediate" textbook written by Ira Nirenberg and John Kim can lead to further conceptual understandings (Figure 3).

Figure 3: Part of the content page of the CK-12 Physics Intermediate textbook (http://www.ck12.org/saythanks)

This presentation will highlight how other resources in the SEE Box can address some of the issues that are faced in STEM Education in developing countries. It will also provide evidence of how such resources can add value to both teachers' and students' knowledge and understanding of STEM concepts. It will show how pedagogies can shift from teacher driven to student-centred approaches.

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