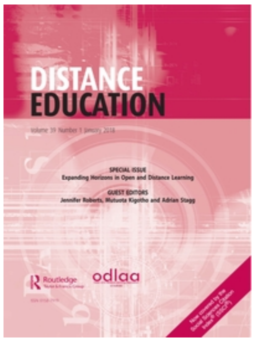

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Bridging the digital divide with off-line e-learning

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ABSTRACT

This paper explores a proposal for an off-line e-learning platform that will provide a bridge for digitally unconnected students and educators to join the contemporary information and communications technology (ICT) intensive world. Individual remote and unconnected learners face a chicken and egg problem for engagement with contemporary e-learning offerings. Without connectivity, remote learners have no way of engaging with now common ICT intensified learning materials that are intended to teach them how to engage in an ICT intensive world! The paper takes systems approach to developing a solution that will fit into the world we have, and not one we wish we had in terms of infrastructure, economics and skills available in remote and developing regions. Digital learning courses are placed onto a portable e-learning environment that is not reliant on a constant network connection to function but retains interactivity, analytics and the ability to synchronise data with an educational institution when a connection is found.

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Offline; e-learning; open source

The digital divide

Groups such as the United Nations Educational, Scientific and Cultural Organization (UNESCO) have expressed a desire to bring the advantages promised by Massive Open Online Courses (MOOCs) including high-quality, affordable education to the developing world where Internet connectivity is limited or non-existent (Patru & Balaji, 2016). This represents a challenge to the current modus operandi of major online educational programs such as EdX, Coursera and FutureLearn who started out with the promise to bring high quality education to the masses but have largely ended up serving the needs of the already highly educated (Christensen et al., 2013; Emanuel, 2013; MOOCs@Edinburgh Group, 2013; Norman, 2014), affluent (Hansen & Reich, 2015) and connected. Similarly, many higher education providers in the developed world are increasingly moving to online platforms. The problem of delivering a contemporary learning experience to students located away from the main campus, located in remote areas, or in developing regions is that the significant issue of connectivity still needs to be addressed. MOOCs are just the latest in a long line of initiatives that continue the distance education tradition. Since at least the 1800s paper based materials have been used for correspondence courses in many parts of the developed world (Matthews, 1999).

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Further information about the MOLEAP described in this article can be accessed at http://moleap.org.

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In the early twentieth century researchers and practitioners in distance education started using technology tools with the aim of addressing the gap between educational haves and have-nots. In the United Kingdom the British Broadcasting Corporation broadcast a series of televised short lectures in the 1920s. The Open University of the United Kingdom was ultimately established in 1969 (Weinbren, 2014) using radio, television and printed course materials. In Australia the "School of the Air" (https://www.assoa.nt.edu.au/) started in 1951 using pedal powered radios linked to the Royal Flying Doctor service (The Advertiser, 1951). It provided workbooks and a means of connecting students on remote farms spread across hundreds of kilometres together in a virtual classroom of the airwaves in group learning sessions. In the Australian higher education sector, the Open Learning Initiative begun in 1991 (OUA, 2017). It started with paper based materials and educational TV broadcast by the Australian Broadcasting Corporation along with recorded videos on tape and later DVDs. The project has since evolved into Open Universities Australia (http://www.open.edu.au). The advent of personal computers saw the use of Floppy disks and CD-ROMs that included interactive learning sequences and resources that could be posted to students. The Internet and the World Wide Web heralded the most recent wave with students able to access materials at a time of their choosing and enable them to make direct connections between remote students and distant teachers.

Yet the problem of unequal access to education persists in the digital age. The number of people connecting to the Internet worldwide is still increasing, but as of 2014 there was an estimated 4 billion people (53% of the global population) still offline with the vast majority of those, 90%, in the developing world (International Telecommunication Union [ITU], 2016a).

We need to avoid a widening "digital divide" (Attewell, 2001) between those that are able to take advantage of what e-learning, MOOCs and digital learning have to offer and those that are unconnected.

The nature of the problems faced by remote learners, teachers and institutions can provide insights as we attempt to address this growing inequity. Remote teachers and students have a number of constraints that need to be considered in developing suitable ICT enhanced teaching and learning facilities. In India, Sharma (2015) speaks of the potential for MOOCs to expanding the availability for basic education but laments that many students still do not have access to schools, let alone an internet connection and so currently miss out on an education. The United Nations Sustainable Development progress report states that as of 2013, globally 59 million children do not have access to basic primary education (UN, 2016). Where schools do exist, problems on the road to adopting e-learning include poor or non-existent access to Internet connectivity, limited budgets, limited IT support resources, limited access to professional development for teachers and a variety of legacy computer hardware (Lyons, Cooksey, Panizzon, Parnell, & Pegg, 2006; Tytler, Symington, Malcolm, & Kirkwood, 2009). In developing regions access to infrastructure, electrical power, computers, limited financial resources, problematic regulatory oversight, suitably trained teachers, local capacity building, culturally and socially appropriate learning materials and methods are all issues to be addressed in delivering e-learning or MOOCs on the ground (Adomi & Kpangban, 2010; Castillo, Lee, Zahra, & Wagner, 2015; Chinn & Fairlie, 2006; Trucano, 2013). Even in developed countries like Australia, students in rural and remote areas still frequently need to deal with poor connectivity, small data quotas and high data costs (Bell, 2010; Owen, 2016). Research by Alam and Salahuddin (2015) in the Western Downs rural region of Queensland, Australia found that 15% of respondents to their survey said connectivity was unavailable or too slow while 12% cited high costs as reasons for going without an Internet connection.

In the case of teachers wanting to learn the ropes of e-learning, it is now increasingly common that professional development materials are being provided as blended or online courses. Laurillard (2014) argues that MOOCs could be part of the solution to training an estimated 1.6 million extra teachers that will be needed to meet the UN (2016) sustainable development goal of universal primary education. If considering the even wider gap in secondary schooling, the number increases to 26 million new teachers needed by 2030 (ibid.). Thus the "chicken and egg" problem arises for unconnected teachers wanting to up skill via a MOOC or to learn how to apply e-learning techniques for use in their own classes. Teachers in areas of low connectivity are therefore at a disadvantage to their metropolitan or developed country colleagues, creating further barriers to the use of ICT for learning in remote areas and widening the digital divide in education.

Exploring requirements

In order to leverage ICTs for enhanced education, suitable solutions that are congruent with the conditions of remote learners and institutions need to be taken into consideration. Requirements that must be met include being inexpensive to acquire and maintain, relatively simple to operate, largely independent of Internet connectivity and being compatible with a range of existing and sometimes out-dated computer hardware. A case in point is reported by Larson (2017) who's valiant attempt to bring the riches of the MOOC world to English teachers in Mozambique. In a country where Wi-Fi is expensive and rare, and where computers are owned by just 6% of households (International Telecommunication Union [ITU], 2016b) there are large barriers to accessing online learning. The generally low level of ICT literacy of the student teachers in the program also created additional barriers to learning. In this case the approach was to form a social MOOC group who worked on the course together. Not all in the group had access to a laptop so the group shared laptop computers, printed copies of MOOC materials, watched videos and only had Internet access only at the venue. In the end the participants were successful in completing the course through persistence and mutual assistance. However they were highly reliant on the group facilitator for access to learning materials and Wi-Fi at the learning venue for assessment submission. This made the approach to doing e-learning unviable on a larger scale, away from the main learning facility such as for remote community or home based study.

In terms of delivering e-learning capabilities in remote and isolated contexts, Farley et al. (2015) have demonstrated that an isolated network can be used within prisons to enable e-learning like courses. Learning material is delivered periodically by uploading a static copy of a Moodle course to an isolated network server. Similarly Jacka and Booth (2012) used Sim-on-a-Stick to allow primary schools located behind firewalls to run a virtual world building application. The virtual environment works by starting up a server on board the USB stick after it has been loaded inside Windows. Students at both these sites were able to use modern e-learning tools to create digital artefacts, highlight ICT skills and build knowledge relevant to the contemporary ICT intensive world.

In the cases highlighted by Larson (2017), Farley et al. (2015) and Jacka and Booth (2012) limited resources, out-dated hardware, limited IT support and skills, as well as poor or non-existent Internet connectivity, were all a reality. However in the latter two cases organisations provided the technology hardware and local administration of networks. As such issues of equipment and power provision were "solved" but this is not the case for the majority of the developing world, as per Larson (2017), or where learners are on their own in a remote area. Over the past couple of decades there has been number of projects to design, build and deploy low-cost computers intended for use in harsh conditions. In 2008 The World Bank through InfoDev (2008) listed dozens of such projects and in 2010 revisited the list (Vota, 2010) with around half moved into the discontinued category. The ability for communities to support and pay for customised equipment would be limited where financial resources and skills are already in limited supply. The need to self-provision suitable computers and network connectivity in order to access e-learning tools is an issue to overcome. One approach is to bring the equipment into the field. Several projects are developing high-tech classrooms in a shipping container (Dell, 2016; Wanshel, 2016) that are equipped with computers, servers, a satellite link and solar power. Transporting the technology to the learners is one approach to adding a computer lab to a school or providing a local Internet hub for a community. Whilst this is a big step up from no access and does consider the lack of local infrastructure in its conception, such access is still limited to the immediate surroundings and is only part of a possible solution. Similarly using the container for road show style access is not particularly suited to long term and sustained learning required to give students the skill base students need to engage in the modern economy. Further, such efforts are relatively resource intensive in local terms of capital, satellite connectivity costs and ongoing maintenance and so far are dependent on donations. With only several dozen rolled out worldwide in the last five years there is a long way to go and are ultimately not scalable to the 59 million primary school age children who are missing out on an education.

Learning management systems (LMS) as an e-learning tool set are commonplace in universities and are beginning to be utilised in a number of pre-tertiary schools and community education programs. Such systems enable the integration of learning materials, digital books, learning activities, assessment tasks and record keeping. Online platforms for MOOCs and systems such as LMSs feature tools to facilitate a social dimension to learning that was not available in the days of paper based correspondence courses. Walji, Deacon, Small, and Czerniewicz (2016) looked at how students utilise such features in a MOOC platform and found that peer learning, peer assessment and social interaction, even if as a passive observer, were appreciated by students. This created a richer study environment but it can quickly become ineffectual if interactions and expectations are not designed into the course or are not well facilitated. For those in remote areas it is currently difficult to provide synchronous interactivity at scale due to connectivity issues. However, Walji et al. (2016) also pointed out that the majority of the messages were posted by a small core group with the majority still benefiting from "lurking" (cf. Nonnecke & Preece, 1999) in forums. It remains unclear if an asynchronous back-up plan for remote learner connections would satisfy all remote learners. There is a risk that this may leave learners within the role of lurker (ibid.) or at least coming in late to some conversations.

Of the available LMSs, Moodle is the most commonly used LMS worldwide (Menard, 2013) largely because it is open source and free to obtain. The Total Cost of Ownership (TCO) still needs to be examined on a case-by-case basis taking into consideration the whole life cycle from software acquisition and support through to retirement. Research by Shaikh and Cornford (2011) found that open source can return significant monetary savings and benefits such as using open data standards and avoiding vendor lock-in. The economics in developing countries may well be in favour of open source software systems. In developing countries the labour used to support a self-hosted system is relatively cheap while the alternative commercial licence and support contract fees are relatively expensive, especially when purchased from a developed country vendor. Market research in Africa suggests this to be the case with open source and in particular Moodle being the most common choice for LMS adoption by higher education institutions in Africa (Adkins, 2013, p. 8). The availability of suitably skilled personnel for education delivery and technical support also needs to be taken into consideration. Moodle features all the common tools available in contemporary online learning environments, is based on common software technologies (i.e., the programming language PhP and MySQL databases) and has a large community of teachers and technical support. Therefore the selection of popular open source tools and commodity hardware will help minimise the requirement for specialist components and niche knowledge.

Oyo and Kalema (2014) have argued for an offline capability for MOOCs delivery. Moodle could serve this purpose and has been made to run "offline" or "portable" by a number of prior projects. The realisation of an off-line e-learning capability that leverages an already popular LMS is tantalising. Examples include "Poodle" (MAF-LT, 2016) and "Portable Moodle" (Attwood, 2015) both of which run as "portable apps" within Microsoft Windows plus the aforementioned work by Farley et al. (2015) on an offline Moodle for Prisons. However, all of these solutions were a one-way transmission of learning material, essentially an off-line backup of the course material. There was no means for students to communicate back their responses or to actively participate in an online community of learners. Furthermore, most of these solutions either rely on a local network or rely on Windows to act as a host operating system on user computers. While Windows is a common platform for many institutions, using it as a host means that the software package is left open to interference and is not able to function natively on Apple platforms. A dependency on the commercially licensed Windows operating system presents additional costs (or the temptation of piracy) for developing countries, smaller institutions and students. If a local network is required to operate an off-line Moodle system then it excludes its use by individual users in remote areas or in small schools where a client-server network is not available. Ideally, a truly off-line e-learning system should not require a network to function at all for a reasonable duration. However, when an Internet connection becomes available it must enable two-way communication to occur. This will allow a much greater degree of freedom of movement for learners.

A way forward

An alternative solution that builds on a number of existing projects is proposed as a way forward in addressing the issues of economics, hardware provision, multi-hardware compatibility and integration of assessment in a modular software environment. The recent "e-Exams System" project led by Monash University in collaboration with nine other Australian university partners and funded by the Australian Government Office for Learning and Teaching developed a prototype portable e-Exam platform designed to work on a variety of student owned hardware (Hillier & Fluck, 2013). It was designed to be independent of the operating system present on the host computer to ensure security and compatibility. The e-Exam System (demo available from http://transformingexams.com) is based upon the free to obtain Ubuntu operating system that can be run "live" on a range of computer hardware.

The e-Exam System is used by "booting" the computer from a USB stick rather than running the software from within Windows or OSX. This completely by-passes the operating system present on the computer to create a controlled software environment. Further, the Ubuntu operating system with the addition of the WINE (a "Windows" emulator for Linux) is compatible with a range of software applications used in education and business. The inclusion of a server stack within each USB means that each user enjoys an isolated instance of Moodle that can run offline without the need for a live network connection. Therefore, this project provides a good base from which to develop the means of delivering e-learning capabilities that do not require a constant Internet connection or a local network. Further work needs to be undertaken to enable the platform to accept updates and become a two-way communication tool for remote students.

A modular offline learning education assessment platform (MOLEAP)

The MOLEAP concept combines the features of an offline learning management system using Moodle and adds supporting tools such as an office suite, graphics editor and multimedia players, plus the ability to enable two-way communication and updates when a network is present. Additional software tools capable of running within a Linux or Windows environment can be run as plug-in modules. A set of custom components tie these together and provide administrative tools to help teachers and IT support to configure, create, update and duplicate copies of the system. The multi-hardware compatible Ubuntu operating system has been used to provide a consistent software package that will run on the majority of Intel based hardware produced in the last five years that typically runs "Windows", Apple OSX or Linux (other processor architectures can also be used but require a separate build of the operating system). Further, because the system itself runs "live" from commodity USB sticks it is very cheap to distribute via the terrestrial postal service. The system can be used on old computers and even computers where the hard disk drive may have been damaged or removed.

The status of each of the software components of a MOLEAP package provided on a USB stick as well as commodity hardware for administration is outlined in Table 1.

All software components are available on open source licence terms and all hardware components are readily available "off the shelf" making the development and long-term maintenance of the package more sustainable than would be the case for a completely custom built solution. The whole software bundle will be made available as a downloadable disk image (IMG or ISO) file that can then be "burnt" to a USB stick on-site or delivered via the postal service. Once burnt to a USB stick the software components and assessment materials are fixed in place and cannot be damaged by curious users. However, the user can optionally download additional learning material, news messages and discussion board messages when a network connection becomes available.

The output of student activity such as, replies to forum posts, assessment responses and formative results can be saved to the same USB for later submission and collation. Submission may occur when a network connection becomes available, or by exporting individual assessment responses to secondary storage, to a printer or by sending the completed course on the USB stick back to the institution via the post. The ability for the platform to work under different scenarios of connectivity, from fully offline, through occasional connections to

Table 1. Modular offline learning education assessment platform components.

Component	Status	Role
Ubuntu	Mature – The most common version of the open source Linux operating system	Base operating system that forms the "Live" USB that can be used to start most computer hardware. Network connections are also possible but not required. When present a network allows for syncing, updates and submission of responses
Moodle	Mature – Worlds most common LMS. Several offline uses have been proven in the past. e-Exam project has this working on a live USB	Learning management system to house learning resources, activities, assessment submission and gradebook
AMP stack	Mature – the most common "web server" software bundle containing Apache web daemon, MySQL database and PhP language	This is capable of running a wide range of web applications. In this case, it will enable Moodle to run from the USB stick
Sync Scripts	Custom – proposal (similar techniques have been used for services such as "DropBox" or "OwnCloud"). The sync software will use a common programming language or existing tools	These work in a similar manner to "Dropbox" in that it will sync content to and from USBs and the home base server when a network connection is detected. This will be configurable by the user to prevent unwanted data usage
Configuration scripts	Custom – concept stage (similar techniques have been used in the e-exam project). These use "Bash" script or a common programming language with graphical interfaces also available	Used to configure and control the software environment. Custom user interface features can also be developed including an automated start-up process for users. Users respond to prompts to use these scripts
Admin scripts	Custom – in beta development. These have been developed for the e-Exam project. These use "Bash" scripts and have graphical interfaces available	Used to set-up and administer multiple USBs at once. Used in conjunction with USB hubs for greater efficiency. Users respond to prompts or press buttons to activate functionality
USB sticks	Common – Commodity components that are economical, easy to obtain and are reusable	A USB stick is used to house the MOLEAP software that students will use to start-up their computers. One USB stick per student
USB Hubs	Common – Same as above	Used to set-up new USBs and where required, retrieve student responses. This reduces the repetitive work that would otherwise be required to individually set-up each USB stick
Home base server	Proposed – Common hardware and LAMP stack, Moodle host, file storage	Interacts with client USBs when they come on-line. Acts as a repository for content and responses. Can also receive manually uploaded responses exported from client USBs or when USBs are returned and processed via USB hubs using the admin scripts

completely online allows it to serve a wider group of students and teachers than existing solutions that are either "always off line" or "always online".

A representation of how the MOLEAP solution would work is depicted in Figure 1.

When no network is available, the e-learning materials can be used within the Moodle LMS on-board the USB stick. Similarly the included office suite, graphics editors, media players, plus other software tools chosen by the teacher, can be used to create and edit documents or play stored media files. The student's work is saved to a section of the USB stick and can be optionally copied to local storage on the host computer.

When a network becomes available the system alerts the user and asks if they would like to update or submit work done so far. This places the choice in the hands of the student hence avoiding any unwanted data transmission costs. This is important where Internet access accounts may have small data quotas. If the user chooses to submit data then it is sent to an institution server to be collated with the work of other students in the course. This could include submitting a Moodle quiz, assignment file or updating forum posts. Should network based transmission not be possible then the student has the option of exporting data, printing work or posting the USB stick back to the institution for processing.

Given the reality of the connectivity and resources available to remote learners, tools such as MOLEAPs are required for students to be able to fully engage with the learning approaches afforded by contemporary software tools of the trade and modern learning management systems. MOLEAP could also form part of a wider education strategy with local Internet hubs providing support for a given region, local support groups, localisation of course materials and opportunities to connect with other community members. For example, an IT classroom in a shipping container (Wanshel, 2016) may serve as the local hub. MOOC style groups (Larson, 2017) could be used to on-board less computer literate learners. While MOLEAP will allow teachers to be up-skilled in digital learning and permit students to take their e-learning work far away into the surrounding countryside. Therefore MOLEAP can play a key role in creating a much wider reach and multiplier effect for education investments towards meeting sustainable development goals and in fostering increasing access to modern e-education in rural and remote areas.

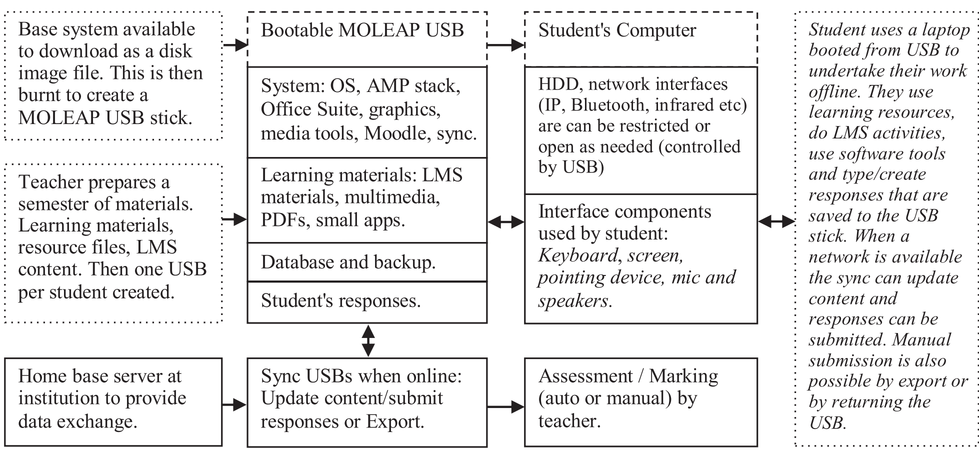

Figure 1. Representation of the modular offline learning education assessment platform.

Conclusion

The need to enable the most isolated and unconnected students to join the connected world of the twenty-first century can be characterised as a "chicken and egg" problem. The skills required to engage with ICT are now commonly taught via ICT enhanced learning. The issue faced by those who are unconnected is that they lack access in a world where increasing amounts of learning is being delivered online with the assumption that everyone has a stable and high capacity Internet connection. This is particularly so in the case of institutions wishing to leverage their e-learning courses for a wider audience. The trend to MOOCs has made this material available widely online but this wealth of material has not reached those most in need – those who are offline in remote and developing regions.

It is clear that the use of e-learning tools such as LMSs have already been established in most higher education institutions in the developed world in one format or another. This trend will continue. Yet how each educational institution uses e-learning systems is varied and multi-disciplinary. As such the solutions delivered must be similarly flexible to cater for institutions and learners in a range of contexts. As we endeavour to pragmatically work around the limitations faced by remote learners and teachers we will inevitably face further challenges. This concept of the MOLEAP presented in this paper requires further technical development, research and refinement to bring it to fruition. It needs to "just work" in the harsh and unforgiving environment of remote communities and developing countries to be of use to those most in need. We must continue this work and find innovative ways to enable those on the fringes to be able to engage in learning experiences of the twenty-first century or we risk an ever widening digital divide.

The proposed MOLEAP outlined in this paper can provide a platform and tool set for remote students to engage with learning materials via twenty-first century e-learning technologies and more authentic forms of digital assessment. MOLEAP is a means by which we can better equip remote learners and teachers to participate in an increasingly ICT intensive world, taking advantage of the vast resources of the online space regardless of their current level of connectivity. Those located in the rural and remote areas of developed countries such as Australia as well as those in developing regions could benefit greatly from the digital bridge that MOLEAP offers.

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Notes on contributor

Mathew Hillier is a Senior Lecturer at the Office Learning and Teaching at Monash University, Australia. Mathew leads the academic development program theme "Technology and space". He specialises in e-assessment and is leading a half million dollar national project on e-Exams funded by the Australian Government, encompassing ten Australian universities. He also co-hosts the Transforming Assessment monthly online seminar series. Prior to joining Monash, Mathew held positions in Higher Education support at the University of Queensland and the University of Adelaide, and has worked as a discipline academic in Business Systems, Multimedia Art Design and Engineering Project Management in Australia, Singapore and Hong Kong.

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References

Adkins, S. S. (2013, January). *Ambient insight regional report: The Africa market for self-paced eLearning products and services: 2011–2016 forecast and analysis*. Ambient Insight. Retrieved from http://www.ambientinsight.com/Resources/Documents/AmbientInsight-2011-2016-Africa-SelfPaced-eLearning-Market-Abstract.pdf

Adomi, E. E., & Kpangban, E. (2010). Application of ICTs in Nigerian secondary schools. *Library Philosophy and Practice, 345*. Retrieved from http://digitalcommons.unl.edu/libphilprac/345/

Alam, K., & Salahuddin, M. (2015). *Assessing digital divide and its determinants: A case study of households' perception in the western downs region of Queensland*. Toowoomba: Australian Centre for Sustainable Business and Development, University of Southern Queensland.

Attewell, P. (2001, July). Comment: The first and second digital divides. *Sociology of Education, 74*(3), 252–259. American Sociological Association. Retrieved from http://www.jstor.org/stable/2673277

Attwood, J. (2015). Portable Moodle [Software]. SourceForge. Retrieved from http://sourceforge.net/projects/portablemoodle/

Bell, G. (2010). *Getting connected, staying connected: Exploring Australia's digital futures*. Adelaide, SA: Government of South Australia.

Castillo, N. M., Lee, J., Zahra, F. T., & Wagner, D. A. (2015). MOOCs for development: Trends, challenges, and opportunities. *Information Technologies & International Development, 11*(2), 35–42.

Chinn, M. D., & Fairlie, R. W. (2006). The determinants of the global digital divide: A cross-country analysis of computer and internet penetration. *Oxford Economic Papers, 59*(1), 16–44. doi:10.1093/oep/gpl024

Christensen, G., Steinmetz, A., Alcorn, B., Bennett, A., Woods, D., & Emanuel, E. (2013). *The MOOC phenomenon: Who takes Massive Open Online Courses and why?* (Working paper). Social Science Research Network. doi:10.2139/ssrn.2350964

Dell. (2016). *Solar-powered classrooms harness the power of technology and teamwork to educate youth*. Corporate Social Responsibility, Communities. Retrieved from http://www.dell.com/learn/us/en/uscorp1/corp-comm/solar-power-youth-learning

Emanuel, E. J. (2013). Online education: MOOCs taken by educated few. *Nature, 503*(7476), 342–342. doi:10.1038/503342a. Retrieved from http://www.nature.com/nature/journal/v503/n7476/full/503342a.html

Farley, H., Dove, S., Seymour, S., Macdonald, J., Abraham, C., Lee, C., … Patching, L. (2015). Making the connection: Allowing access to digital higher education in a correctional environment. *Proceedings of ASCILITE 2015*, Perth (pp. 432–439).

Hansen, J. D., & Reich, J. (2015). Socioeconomic status and MOOC enrollment: Enriching demographic information with external datasets. *Proceedings of the Fifth International Conference on Learning Analytics and Knowledge*, Poughkeepsie, NY, March 16–20. doi:10.1145/2723576.2723615

Hillier, M., & Fluck, A. (2013). Arguing again for e-exams in high stakes examinations. In H. Carter, M. Gosper, & J. Hedberg (Eds.), *Electric dreams*. Proceedings ASCILITE 2013, Sydney (pp. 385–396). Retrieved from http://www.ascilite.org.au/conferences/sydney13/program/papers/Hillier.pdf

InfoDev. (2008). *Quick guide: Low-cost computing devices and initiatives for the developing world*. InfoDev, World Bank. Retrieved from http://www.infodev.org/articles/quick-guide-low-cost-computing-devices-and-initiatives-developing-world

International Telecommunication Union. (2016a, June). *ICT facts and figures*. Geneva. Retrieved from http://www.itu.int/en/ITU-D/Statistics/Documents/facts/ICTFactsFigures2016.pdf

International Telecommunication Union. (2016b). *ICT development index, Mozambique*. Geneva. Retrieved from http://www.itu.int/net4/ITU-D/idi/2016/#idi2016countrycard-tab&MOZ

Jacka, L., & Booth, K. (2012). *What about the firewall? Creating virtual worlds in a public primary school using Sim-on-a-Stick*. Paper presented at the Australian Computers in Education Conference, Perth.

Larson, K. (2017). *MOOC groups for improving access to MOOCs in developing countries: Lessons from a MOOC group in Mozambique for English teachers*. Presentation at Open and Distance Learning Association of Australia conference, Melbourne, February 5–7.

Laurillard, D. (2014, July 11). Which problems could MOOCs solve, and how? *University World News*, Issue 328. Retrieved from http://www.universityworldnews.com/article.php?story=20140708091436155

Lyons, T., Cooksey, R., Panizzon, D., Parnell, A., & Pegg, J. (2006). *Science, ICT and mathematics education in rural and regional Australia*. The SiMERR National Survey: University of New England. Armidale: National Centre of Science, ICT and Mathematics for Rural and Regional Australia.

MAF-LT. (2016). *Poodle* [software]. Mission Aviation Fellowship Learning Technologies Division. Retrieved from https://web.archive.org/web/20160927222450/http://www.maflt.org/products/poodle

Matthews, D. (1999). The origins of distance education and its use in the United States. *Technological Horizons in Education Journal, 27*(2), 54–60.

Menard, J. (2013). *World map of learning management systems*, 08/2013. List Education Technology. Retrieved from http://listedtech.com/content/world-map-learning-management-systems-082013

MOOCs@Edinburgh Group. (2013, May 10). *MOOCs @ Edinburgh 2013: Report #1*. The University of Edinburgh. Retrieved from http://hdl.handle.net/1842/6683

Nonnecke, B., & Preece, J. (1999). *Shedding light on Lurkers in Online Communities*. Proceedings of Ethnographic Studies in Real and Virtual Environments: Inhabited Information Spaces and Connected Communities, Edinburgh (pp. 123–128).

Norman, A. (2014). The who, why and what of MOOCs. In B. Hegarty, J. McDonald, & S. K. Loke (Eds.), *Rhetoric and reality: Critical perspectives on educational technology*. Proceedings ASCILITE, Dunedin (pp. 717–721).

OUA. (2017). Where we've come from. Retrieved from https://www.open.edu.au/about-us/jobs/history/

Owen, M. (2016, May 21). Satellite data limits stymie NBN's great expectations. *The Australian*.

Oyo, B., & Kalema, B. M. (2014). Massive Open Online Courses for Africa by Africa. *International Review of Research in Open and Distance Learning, 15*(6), 1–13. doi:10.19173/irrodl.v15i6.1889

Patru, M. & Balaji, V. (Eds.). (2016). *Making sense of MOOCs: A guide for policy-makers in developing countries*. Paris: United Nations Educational, Scientific and Cultural Organization (UNESCO). Retrieved from http://unesdoc.unesco.org/images/0024/002451/245122E.pdf

Shaikh, M., & Cornford, T. (2011). *Total cost of ownership of open source software*. A report for the UK Cabinet Office supported by OpenForum Europe. London: UK Cabinet Office. Retrieved from http://eprints.lse.ac.uk/39826/

Sharma, Y. P. (2015). Massive Open Online Courses (MOOCs) for school education in India: Advantages, challenges and suggestions for implementation. *Microncosmos International Journal of Research, 1*(2), 1–5.

The Advertiser. (1951, June 9). World's first school of air opened. *The Advertiser* (Adelaide, SA: 1931–1954). Adelaide: National Library of Australia, p. 2. Retrieved from http://nla.gov.au/nla.news-article45718205

Trucano, M. (2013, December 11). More about MOOCs and developing countries. *EduTech Blog*. The World Bank.

Tytler, R., Symington, D., Malcolm, C., & Kirkwood, V. (2009). Assuming responsibility: Teachers taking charge of their professional development. *Teaching Science, 55*(2), 9–15.

UN. (2016). *Progress towards the sustainable development goals*. Economic and Social Council, United Nations E/2016/75. Retrieved from http://www.un.org/ga/search/view_doc.asp?symbol=E/2016/75&Lang=E

Vota, W. (2010, July). *Updated quick guide to low-cost ICT devices for educational systems*. InfoDev, World Bank. Retrieved from http://www.infodev.org/articles/updated-guide-low-cost-educational-ict-devices

Walji, S., Deacon, A., Small, J., & Czerniewicz, L. (2016). Learning through engagement: MOOCs as an emergent form of provision. *Distance Education, 37*(2), 208–223. doi:10.1080/01587919.2016.1184400

Wanshel, E. (2016, June 11). This container brings internet to people in need, refugees in remote areas. *The Huffington Post*. Retrieved from http://www.huffingtonpost.com.au/entry/solar-powered-zubabox-internet-shipping-container-rural-areas-refugee-camps_us_5757155ce4b0b60682df2435

Weinbren, D. (2014). History of the Open University. Retrieved from http://www.open.ac.uk/researchprojects/historyofou/