DL4D
DIGITAL LEARNING FOR DEVELOPMENT

How could digital learning at scale address the issue of equity in education?

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EXECUTIVE SUMMARY

The overall goal of this report is to examine how digital learning can be used at scale and the extent to which it can achieve equity and quality, by means of improving efficiency. The scope is the Global South, particularly the emerging economies.

Digital methods are unique in their capability for both enhancing the learning experience, and operating to orchestrate learning on the large scale, but the challenge is to develop digital innovation that can achieve both high-quality learning and low costs of development and support.

In particular, we explore ways in which teachers could embed their pedagogic expertise in digital methods that support independent learning and do not require their physical presence. The conditions for large-scale online learning to succeed in achieving equity are defined in terms of digital access, language and culture, gender, geographic location, and the quality of the learning experience itself.

To realize the potential of online learning for scaling up access to learning in the Global South, it will be essential to: 1) promote the investigation of techniques for improving formative assessment, and 2) work towards credit transfer from open online course certification to conventional university courses.

To understand and manage a valid cost-benefit approach to planning online learning at scale, it will be necessary to: 1) introduce activity-based costing for both conventional and online learning and teaching, 2) plan the return on investment accordingly in terms of viable income streams, and 3) assess and optimize the trade-offs between high/low cost designs and the value to the learners. In particular, it is important to experiment with reducing the costs of online production, rather than under-resourcing the teaching time needed for learner support. We need to develop policies for achieving equity in online learning at scale through government support for a cascade model of professional development online with locally supported blended learning. The paper concludes by suggesting some actionable solutions that exploit the potential of digital technology in the service of equity in education.

1

INTRODUCTION

The challenge of *equity* in education is to help all learners achieve their learning potential. The UNESCO Sustainable Development Goal (SDG) 4 is to achieve universal education by 2030. The scale of education needed is currently estimated to be 263m children, and the number of teachers needed by 2030 is expected to be 69m[1]. In one sense, we have the technology. Digital technology has the potential to reach every child, at a level of efficiency that no other technology can achieve. However, we do not yet have the installed base to achieve that potential, nor do we have the design capability to provide high-quality education at scale.

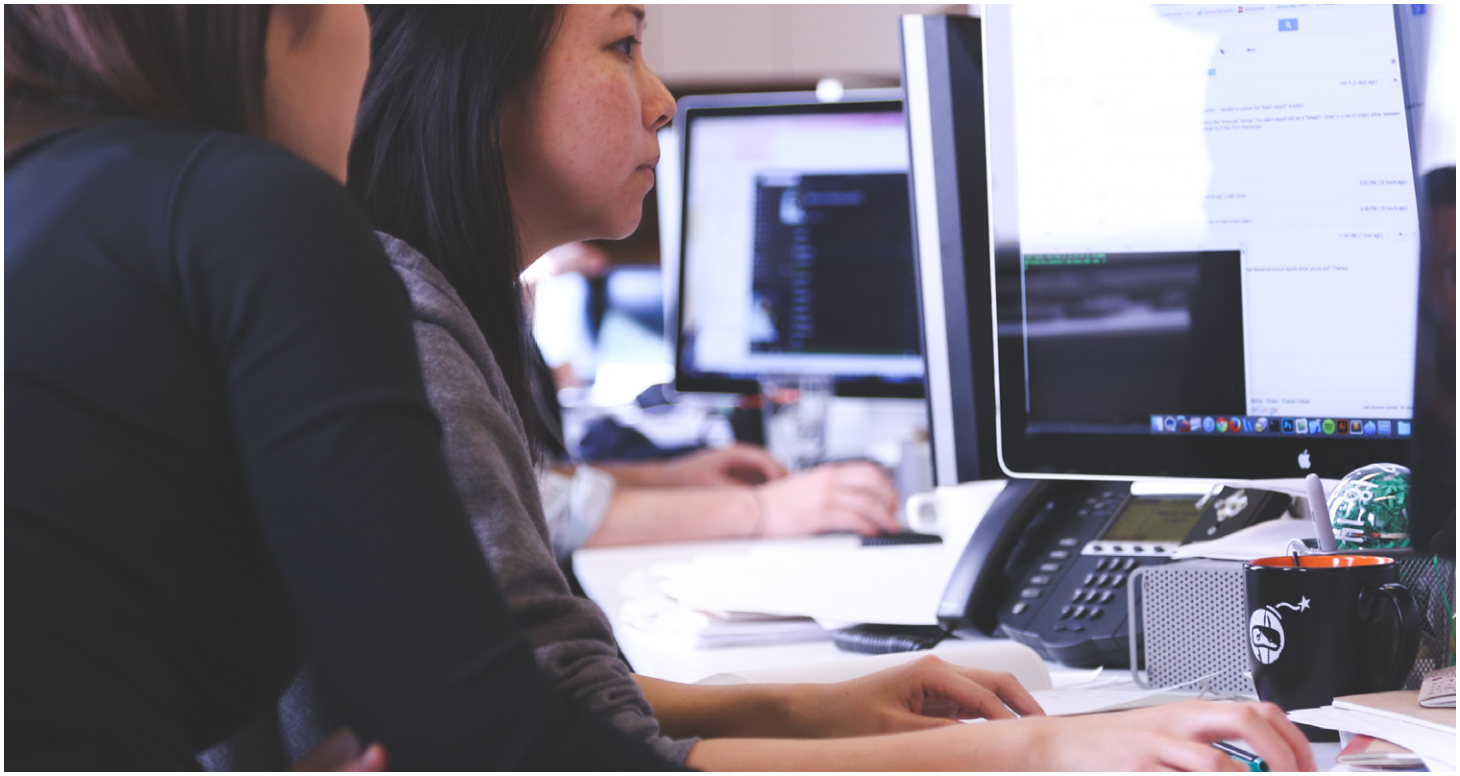
The challenge of *quality* in education is to recognize that all education sectors struggle to help learners achieve the high level of learning outcomes that modern economies need. Digital technologies have the characteristics of interactivity, adaptivity, communication, and user control that a good educational experience demands. However, the advances in technology have never been focused on education, which borrows and repurposes the technologies made for other industries. Consequently, the optimization of digital technology for the educational experience has yet to happen.

The challenge of *efficiency* is to work out how the worldwide teacher communities can achieve both quality and equity in an affordable way. Unfortunately, classical costing models for teaching with conventional methods have not been well developed for understanding the efficiencies of economies of scale, although this is critical for optimizing the use of technology. Digital methods for teaching and learning have the potential to deliver both equity and quality, but to do it in an affordable way at scale, demands a focus on efficiency as well. The aim of this paper is to clarify the extent to which global education is working towards achieving that potential.

1.1 Methodology

Our methodology for reviewing the field was to select papers and reports that are peer-reviewed or derive from sources with high-quality reputations, and official government documents. We focused on evidence from data collected from 2011 to 2016. The field is changing very rapidly, and the more recent sources are most likely to form a more reliable basis for understanding how it might develop in the near future. Further detail is in Appendix 1.

[1] *http://uis.unesco.org/en/file/784/download?token=150HBrZo*



1.2 Structure

Section 3 establishes the definitions and respective characteristics of the types of learning at scale, namely, online methods for *formal learning* via open universities, distance learning courses, Massive Open Online Courses (MOOCs), and courses from private providers. These are distinct from *informal learning* through open access web-based resources. Informal learning will not be our focus, although we will discuss its relevance to formal learning, and why it is of interest. We also distinguish *wholly online* from *blended learning* courses and activities.

Section 4 considers the extent to which online learning at scale achieves equity, the issues this raises, and the policy actions needed. These are taken further in Section 5 to clarify how we might achieve greater quality at low cost through greater efficiency, given the characteristics of online learning.

We work according to the following definitions of equity, quality, and efficiency, as they apply to online learning:

Equity – as parity of learning experience in relation to the barriers to inclusion such as access to technology, geographic location, language and culture, and gender (UNESCO, 2015).

Quality – as "quality of the learning experience" and "quality of the certification."

Efficiency – in terms of the relationship between the investment of time and money and the return on that investment in the form of, e.g., learning, credit, income, recognition for the student, the course or community team, and the provider institution.

There is a trade-off between the three issues, and in Section 6 we summarize the policy actions mooted in the previous sections to propose a way forward. We work towards what it takes to improve equity through online learning at scale and end with a summary of the conditions to be met if we are to secure sustainable and effective solutions for education.

2

WHY SHOULD LEARNING AT SCALE BE FEASIBLE THROUGH TECHNOLOGY?

The term "learning at scale" refers here to any form of learning that makes use of the specific characteristics of digital technology to both

- support and enhance learning, and
- reach large numbers of learners, in ways that conventional educational methods cannot.

This section begins by defining the different forms of online learning in terms of their main logistical and funding characteristics to clarify the challenges for achieving equity.

Digital methods cover a wide range of technologies, so we then set out the means by which they might enhance learning, and how they can improve the reach of education.

2.1 Characteristics of Online and Digital Learning

This paper focuses primarily on formal learning. The key difference between formal and informal learning is whether it leads to certification or a qualification or not. The current UNESCO (2016a) definition of informal learning is:

> "Self-directed, family-directed, socially directed learning: workplace, family, local community, daily life Incidental learning: reading newspapers, listening to [the] radio, visiting museums" (p. 8).

There are now digital equivalents of all these formats, which also count as informal learning. By contrast, formal learning, whether conventional or digital, leads to either a recognized award, or a non-formal certificate, and therefore must specify a curriculum, a program of work, and an assessment method for the certification. Informal learning has none of these characteristics.

There is an argument that there should be less division between formal and informal learning, and its implications for education:

> "… a blending of formal and informal methods of learning can create an environment that fosters experimentation, curiosity", and above all, creativity. In this sense, "an overarching goal is to cultivate the pursuit of lifelong learning in all students and faculty" (Johnson et al., 2016, p. 22).

This idea of "lifelong learning" is valuable because it strengthens the links between the two, to allow flexible entry and exit points, and the formal accreditation of informal learning and experience (UNESCO, 2016a). While our focus remains on formal

CONVENTIONAL	NEW MODELS	IMPLICATIONS OF NEW MODEL
Fee-paying	Free	attracts large numbers initially
VLE-based	MOOC-based	platform must manage large scale
Selective	Open admission	fewer may be able to complete
Accredited	No formal award	fewer are motivated to complete
Tutor feedback	Peer/automated feedback	keeps costs low
Tutor assessment	Peer/automated assessment	difficult to validate for credit

Table 1. *The dimensions contrasting the conventional/new model of online courses and the implications of the new model for the logistics and costs*

learning, as the domain where policymakers can effect most impact, the move to blend formal and informal learning will continue, and is likely to increase with greater access to open educational resources (McGreal, 2015), and the continuing trend to provide free online courses, which we discuss below.

The value of formal learning is that the provider takes responsibility for taking the learner from their current capability to a more advanced personally and economically valuable level. The value of informal learning is that the learner has free choice over what and how to learn, and what counts as having learned.

In terms of formal learning, there are several different types of online courses operating in different public and private contexts. As "courses" they all have in common the characteristics of a recognized award, or a non-formal certificate, a curriculum, a sequence of teaching-learning activities, and assessment for the certification. They differ in size of cohort, and this affects both logistics and funding model. To understand the potential for equity it is important to identify the principal dimensions defining the contrasts between the conventional and new models, and the implications of the latter for the logistics and costs of scaling up, as shown in Table 1.

These characteristics define the extremes for each dimension. Any particular course may combine, for instance, fees with free access to some parts, or mix VLEs with MOOCs.

The conventional formal online education model is at the left of all six dimensions, while the clear contrast is the MOOC model on the right-hand end of all dimensions. Some of the MOOC platforms are now developing models that place some courses more at the conventional end of the dimensions as they relax the free and open conditions in order to offer the expensive requirements of accreditation and tutor-validated assessment (Chuang & Ho, 2016). Some conventional university courses are now including MOOCs to enhance the teaching[2], making it a blended learning course that moves it to the right on some dimensions.

The dimensions are interdependent and interactive. Figure 1 shows how the long-standing conventional model of elite courses for small numbers of selected students compares with the new, potentially disruptive model of free courses for large numbers open to all, with respect to their implications for cost and benefit.

[2] *For example, the Post-16 Postgraduate Certificate of Education at UCL-IOE requires students to enrol in and study the Blended Learning Essentials: Getting Started course on FutureLearn at http://bit.ly/28RNQpl*

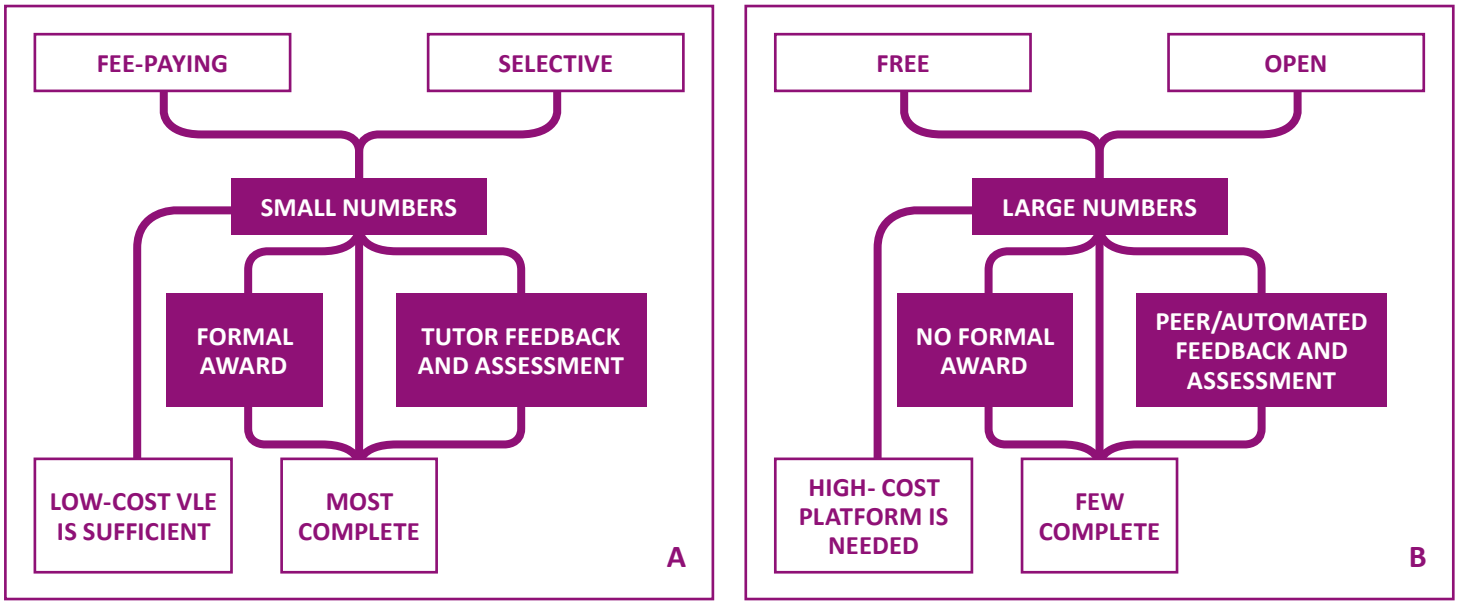


Figure 1. *Comparison of how the dimensions interact for the (a) conventional and (b) new models of online learning, with (a) viable, and (b) non-viable effects*

The conventional online course runs on a business model that works for small numbers but becomes unmanageable in most universities for very large numbers. Open universities are set up to manage the large numbers of tutors needed, but even these typically number their students only in hundreds per course, not the tens of thousands that MOOCs promise. However, these large cohorts are attracted by the free course, open to all, which produces no income to run the high-cost platform needed, and so cannot fund either the accreditation of an award or the tutor support that leads to high completion. Inevitably, therefore, the MOOC model is retreating to the classic conventional business model of fees for accreditation and support for some courses and participants.

This is the real challenge now: to find the ways in which digital innovation can achieve both high-quality learning and low costs for support. All versions of these courses may be offered at the level of professional, postgraduate, undergraduate, and wider public, and all are included in this review.

2.2 How Digital Technology Can Enhance Learning

Digital technologies support and enhance the process of learning by emulating all the types of teaching-learning activity through which learners develop concepts and practice, and the relationships between them. The main teaching-learning activities, for any sector of education, have been categorized as learning through acquisition, inquiry, practice, discussion, collaboration, and production, which can be applied to both conventional and digital learning (Laurillard, 2012). Digital learning is valuable because it can support independent and guided self-paced learning for each of the six learning types. For each one, there are properties unique to digital learning that are key to being able to achieve high-quality learning without the presence of a teacher:

- the use of video, multimedia, animation, augmented reality, virtual reality, etc., to improve understanding, and engage and motivate learning through acquisition;

- the ease of web searching for relevant high-quality sources and tools to support learning through inquiry;
- interaction with a digital simulation, game, analytical tool, assessment tool, or design tool, using learning analytics and adaptive feedback, for learning through practice;
- asynchronous and synchronous online groups and forums for negotiating ideas with others, to extend opportunities for learning through discussion;
- the combination of online discussion forums with digital design and production tools for developing a shared digital output, to support learning through collaboration;
- digital authoring to motivate learners to present what they have learned, for learning through production (Laurillard, 2012; Johnson et al., 2016; Sharples et al., 2014).

These are the digital features an online course must exploit to create a supportive and productive learning experience, regardless of the course category or sector. If the learner has well-designed resources and tools, and well-organized social interaction with other learners online, then digital methods can support effective independent learning, i.e., without the teacher being present. This is the key to digital technology enabling low-cost/high volume courses. However, this is conditional: it is only possible if the teacher's skill is represented in the "well-designed" and "well-organized" learning experience which the learners need. This point will be a recurring theme of the paper: the dependence on teachers as designers of the learning experience.

Teacher presence is important to learners, and so "*blended learning*" is significant, because it uses digital activities to supplement teacher-supported classroom work. The blend is optimal because it combines the value of the face-to-face interaction with teacher and peers, which is constrained in time and place, with the online environment, which is self-paced and less time-constrained. The lack of classroom presence means that "*wholly online*" courses lose some of the social and emotional value of the face-to-face, but the trade-off is the greater flexibility, the increase in time for peer discussion, and the more inclusive reach of online, thereby reducing the barriers of location, disability, age and even gender.

Therefore, there are ways of solving the dilemma of high quality/low cost *if teachers can use their expertise to embed their support in a digital method* that supports independent learning and does not require their physical presence, where the italics emphasize the critical condition that is not yet being met.

2.3 How Digital Technology Can Enable Learning on the Large Scale

Online technologies enable learning at scale because:

- online delivery of digital resources and activities reaches very large numbers of students, which campus-based delivery cannot, due to space and time restrictions,
- the learning activities can be created in the form of fixed cost resources, which achieve economies of scale over large numbers, and
- they can replace some of the variable cost services required in education with peer- and digitally-supported activities.

Teaching and learning resources, and activities, have to be carefully designed to a high standard if they are to engage and support the individual remote learner as effectively as the class teacher (Kennedy, Laurillard, Horan, & Charlton, 2015). These are high fixed cost resources and must embed teachers' expertise in the kind of support they offer, as argued in the previous section. It is possible to achieve economies of scale here if development is well managed: a campus lecture may reach 500 students, whereas the same lecture online can reach 500,000 or more, for a similar design cost.

If student numbers are high, however, the variable cost can be very high. This is the cost of teaching, per student, or per group, for services such as 1-1 tutoring, individual feedback, group tutorials and discussions, and individual marking. These services are client-centered, and explicitly *not* mass delivery. For this reason, the costs of supporting online learning are not necessarily significantly lower than those of campus-based learning. The opportunities for economies of scale in an industry like education are in the development of the fixed cost resources and tools discussed in the previous section. The variable costs of tutoring, feedback, tutor-supported discussions, and marking rise in a linear relationship with student numbers.

Therefore, as the previous section suggested, if we can replace some forms of variable-cost feedback, assessment, and support by teachers designing their expertise into interactive and adaptive digital resources and tools, capable of doing feedback, assessment, and adaptive support, then these would become fixed-cost resources. That is how we could potentially achieve further economies of scale. We do not yet have those technologies.

2.4 How Digital Technology Can Support Teachers Supporting Learners

The most important reason for considering learning at scale is equity, i.e., to understand how it might contribute to the most challenging Sustainable Development Goal (SDG) 4 of universal education at school level. It is not yet realistic to plan for wholly online learning being the solution. Children need the social and emotional interaction with teacher and peers that physical schools provide. However, we can think in terms of the teacher as a *mediator*, i.e., the teacher being supported online in their updating of the curriculum, pedagogy, and assessment that will improve their own learners' learning and outcomes.

That argument applies to all sectors, of course. One of the most important ways of using online learning is to support all teachers, at all levels, in the challenging task of adapting continually to the demands of policymakers, employers, and parents, changes in demographics, economies, social norms, technologies … teachers need significantly more support than they currently receive. Online learning can offer this through:

- teacher professional development through online courses;
- enabling teachers to engage in collaborative making and sharing of high-quality "open education" resources and tools for supported independent learning;
- helping teachers to complement classroom work by curating digital resources and tools, and organizing online social learning.

Collaborative learning is important for students. It is even more important for teachers. Teacher development is one of the critical conditions that any education system must address if we are to harness the benefits of online learning (Laurillard, 2015).

TO SUMMARIZE

- Digital methods are unique in their capability for enhancing the learning experience and operating to orchestrate learning on the large scale.
- The challenge is to find the ways in which digital innovation can achieve both high-quality learning and low costs of development and support.
- One approach is for teachers to embed their pedagogic expertise in digital methods that support independent learning and do not require their physical presence.

3

THE POTENTIAL FOR EQUITY THROUGH LEARNING AT SCALE

The global HE sector is now expanding provision to use online learning technology as a new model that can achieve greater equity of access to HE, affording "ever greater and more credible options for potential post-graduate taught (PGT) students to study in their home countries in leading international programmes" (Archer, 2016). Certainly, the use of technology is the only way education will achieve access on a scale that is anywhere near commensurate with demand in the sense of "need."

The need for improved education is high across the whole of the Global South, as reflected in UNESCO's *Sustainable Development Goal 4: Universal basic education*. Even in a modern and rapidly developing economy such as China, there is a high level of inequality of opportunity. The socially and economically disadvantaged groups are those in greatest need: they are living in rural regions, poor, female, disabled, or ethnic minorities – all of whom have little or no access to high-quality educational experiences (Tang & Carr-Chellman, 2016). Even the rapid economic growth and public health improvements in China will not change these inequalities because it is always the better educated who are able to take advantage of them, until the point of saturation (Song & Burgard, 2011). This is why "need" does not necessarily find expression as "demand."

In this section, we consider the conditions under which large-scale online learning succeeds in achieving equity, as defined in terms of digital access, language and culture, gender, and geographic location (UNESCO, 2015). We also consider how online learning can address these barriers to inclusion so that we optimize equity in relation to different aspects of access, and to the learning experience itself.

3.1 Access to Digital Technology

Access to digital technology for learning is dependent on the digital infrastructure in a country, which is still at a low level for many developing countries, in terms of both broadband speed and the availability of internet-enabled devices.

The eLearning Africa project reports a wide range of connectivity across African countries, where, for example, in 2015 the proportion of schools with internet access varied from 0% in many countries, with most below 20%, to 100% in Botswana. Personal access to broadband connection was very difficult; the highest % of broadband provision being 13% in Seychelles, with the majority being below 2%. Access is even worse for women, who prefer to use the poor service of public libraries rather than private cybercafés for internet access because they are safer (Gomez, 2014).

However, mobile penetration has made great progress to 100% or more in some African countries, such as Tunisia, South Africa, Namibia, and Zimbabwe. As smartphones begin to penetrate as well, this will transform access to online learning. Already, smartphone access is above 20% in Ghana, Kenya, Nigeria, and South Africa (Manji, Jal, Badisang, & Opoku-Mensah, 2015).

The digital divide between the Middle East and Western countries is closing, but there is a wide range of provision in this region as well. Countries such as Syria, Lebanon, and Yemen have limited investment capital and more government intervention in technology regulation, while Bahrain, Jordan, and Kuwait have been able to build up their telecommunications, having a more liberal approach to digital technology (Shirazi, Gholami, & Higon, 2009). The changing conditions of public infrastructure within a country affect the nature of access. In Syria, as more people become displaced there is a reduction in computer usage and an increase in mobile usage for internet access, where a recent survey showed that one of the principal uses, given high-speed connectivity, would be for online education (Xu & Maitland, 2016).

Access to adequate broadband speeds and internet-enabled devices either for free or at affordable cost, is the *sine qua non* for the potential of online learning to be achieved (Warugaba, Naughton, Hedt-Gauthier, Muhirwa, & Amoroso, 2016), along with teacher development, and it has to be the job of governments to ensure this happens. At present, it is highly inequitable, within and between countries in the Global South.

The increasing use of smartphones for education across the Global South (Curioso & Mechael, 2010; Sahu, Grover, & Joshi, 2014; Shrivastave & Shivastava, 2014), is accelerating now as open online course providers such as FutureLearn and iTunesU ensure delivery on all platforms (J. Chen, 2013).

ACTIONS TO CONSIDER

For policymakers: the online devices industry, and the broadband industry to provide wider access to viable internet-enabled devices and high-speed broadband as a route to education.

For course designers: the resources and activities should be designed to also be accessible in settings that are less well-equipped by offering options for low definition videos, audio only versions with slides, video transcripts, and other ways of reducing access requirements.

3.2 Access to Online Courses

Countries in the Global South may now be providing digital access in some areas, but the digital content is still driven largely by the Western countries. The need for online distance education at degree level has previously been met by the open universities (Daniel, 1996), and during the 21st century development of this kind of provision has expanded greatly in the countries in the Global South (Jung & Yoo, 2014). Inevitably, it was the open universities that were among the first to take on the challenge of the open, free, short course model of the MOOC. The Open University of China is one such example, driven in part by a strong influence from government.

Government involvement is characteristic of many of the Asian online learning initiatives, for example, in Malaysia, Thailand, the Philippines, and South Korea, as well as China. In Japan, on the other hand, the JMOOCs project was the initiative of a consortium of universities, corporates, governmental institutes and academic societies (Kim, 2015). Progress towards offering online learning is rapid now in these Asian countries, exemplified by Tsinghua

University's development in 2014 with its own MOOC platform *Xuetangx* for Chinese students, now used by over 200 universities across China[3]. Change may be slow, but progress is unmistakable now.

Governments in Africa are also moving faster now. The e-Learning Africa project has tracked progress across the continent, published in comprehensive reports that detail some disparity between 55 African countries in terms of the implementation of digital learning infrastructure and courses. As infrastructure improves, so does course provision, and many countries have made great progress towards online education, some in partnership with the African Virtual University[4], and others, as part of government support and planning. For example, the Republic of Congo has a digital learning strategy, Cote d'Ivoire uses online learning for teacher education, Djibouti has opened a digital learning Center in the capital, a digital learning university in Cairo offers blended learning courses, and there are many other similar initiatives across the continent, demonstrating the willingness of governments to plan with digital solutions in mind.

While local provision is developing slowly, the African countries represent an opportunity for IT companies such as Google to experiment with online courses[5], mainly focusing on digital and vocational skills for management and computing. Udacity and 2U may also increase their offers for fee-paid online courses in these subjects for professionals. However, this does nothing to assist the broadening of opportunity for the great majority of learners who need more and higher quality education (Haggard, 2017).

An alternative model is cross-national provision by IT-oriented company partners in Kenya, Ghana, Tanzania, and Zimbabwe, which are collaborating to offer K-12 courses that fit the local curricula and certification requirements. With 2m registered learners, *Eneza Education*[6] is offering affordable education via short lessons and quizzes to smartphones and other devices, a model that could potentially move more into higher education as well (Haggard, 2017).

The improving digital infrastructure in many countries, even with only informal access to open education resources, adds value for users as a form of informal learning. A survey of public access computing in 25 countries in the Global South found evidence of clear personal benefits in users' comments about their new-found pride in accomplishment and a sense of self-efficacy afforded by their access to open educational resources, although such benefits are never captured in standard usage metrics (Gomez & Pather, 2012), and only become evident through qualitative studies.

Local provision of high-quality online education that fits local requirements is slow to develop in the countries in the Global South, therefore, with faster development coming from private companies, which inevitably prioritize education for professionals in Business and IT. This does not help to generate the models for equitable access to high-quality education and higher education for the great majority of learners.

ACTIONS TO CONSIDER

For policymakers, educators, and researchers to explore ways of enabling local development of online courses, once the digital infrastructure is available.

[3] *http://www.prnewswire.com/news-releases/one-and-half-million-chinese-students-are-using-xuetangx-cloud-lms-platform-300433028.html*
[4] *http://www.avu.org/avuweb/en/*
[5] *https://learndigital.withgoogle.com/digitalskills/*
[6] *http://enezaeducation.com/*

3.3 Language and Culture

Online learning currently originates in countries in the Global North, which was the first to experiment with large scale online learning. By contrast with the approach in Asia and Africa, the expansion of online learning in Western countries has been initiated entirely by a relatively small proportion of universities and private providers, many of which reach primarily students in their own regions (Allen & Seaman, 2010). The recent expansion of MOOCs to provide free and open access to short courses in HE has transformed access, at least to this limited form of provision, to many millions of mainly degree-holding professionals across the globe (Laurillard, 2016a).

The origin of MOOCs being the Global North creates a language barrier to access because most MOOCs are developed in English, albeit with subtitles for some languages (T. R. Liyanagunawardena, Adams, & Williams, 2013; Sharma, 2013). Nonetheless, access to Western University MOOCs by learners from China, India, and South Africa, for example, is rising, though from a very low base (Macleod, Haywood, Woodgate, & Alkhatnai, 2015).

Language is a problem, but it is not sufficient simply to make the language more accessible, as there are cultural differences that argue for taking greater care of the localization of courses. In some cultures, for example, higher quality learner engagement means more time given to direct student interaction by the teacher (Che, Luo, Wang, & Meinel, 2016). A study that compared online and onsite versions of a short course found no difference in student performance or evaluation of the course features except for the quality of instructional interactions, which were rated significantly lower for the online course (W. Chen & Jia, 2016), impacting on both teacher-student and peer-to-peer interactions. If wholly online learning is not acceptable, then an alternative approach would be to use such courses, within a blended learning model, by integrating the resources they offer with the more traditional classroom mode. This would enable students to ask questions with a teacher present, and so improve their engagement and completion of intended outcomes (Yu, 2015).

It is clear that "distance learning" and "online learning" have not been acceptable in some cultures. While demand for the flexibility and accessibility of online learning may be high, if it is not seen as legitimate high-quality education, then the return on accreditation fees will be low, keeping the price down, and the business model limited. It is important, therefore, to work on improving the acceptability of this form of learning in the countries of the Global South. The spread of open educational resources and online courses from Western universities has enabled the emerging economies that are in need of highly skilled graduates to make an innovative leap into adopting new digital methods, but this has happened without any intervening phase of localization or adjustment to new styles of pedagogy. Western models of group learning that make no provision for how group roles should work, for example, may need a redesign if they are to be a culturally appropriate pedagogy (Nguyen, Terlouw, & Pilot, 2006).

The nature of the cultural differences that are most important was explored in a study of Asian students studying an online MBA, which found that although the students appreciate the opportunity to broaden their cultural experience of study, there are several ways in which course redesign would assist them:

- more flexible and varied assessment to help with a misunderstanding of the rules,
- more audio-visual aids to help with language problems, and
- a better balance in the use of local and global cases (Liu, Liu, Lee, & Magjuka, 2010).

The international mobility of students that has driven trans-national education (TNE) does not push Western universities to orient curricula and pedagogy towards

other cultures, because by being prepared to travel to another country there is a tacit assumption that the students have to adjust, rather than the host. By contrast, online courses bring the host institution to the student's local cultural context, where they have no other access to the host culture, so it is the host that should adapt. An online course, such as a MOOC, will be reaching students in up to 200+ countries, so adaptation to all is impossible. But there are ways of localizing the content, as we discuss below. More sensitive approaches to supporting learners from different social, economic and ethnic groups can deliver substantial improvements to completion rates (Kizilcec, Saltarelli, Reich, & Cohen, 2017)

This creates an imperative for MOOCs to make good use of their discussion forums to enable the negotiation of ideas, approaches to learning, and personal encouragement.

ACTIONS TO CONSIDER

Universities, colleges, and other education providers to develop studies and exemplars of effective online learning that demonstrate its value, and how this can be optimized.

Researchers and designers to promote the techniques that make online learning design more effective for all types of learners.

3.4 Gender

Gender segregation in some countries means that women have lesser access to high-quality university education. For example, there are reports that many of the top research universities in China discriminate against women[7], and universities in Saudi Arabia have far fewer teachers with doctorates for the women students than the men have. With segregation, such inequalities persist. One solution has been to use video conferencing, although this reduces the quality of teacher-student interaction. The more recent developments in online learning provide a better alternative if they are well-designed to promote social learning. This method uses the quality of video lectures, and the social value of MOOC-based discussions, in a blended learning format: the video is used prior to classroom sessions, followed by further lectures and group work within the class, and online discussion after the class. Social media sites can support local group discussions beyond the MOOC itself (Almutairi & White, 2015). This blend of the online and the classroom gives the women access to more senior experts as well as having the benefits of social learning online and in class.

New technologies level the playing field, particularly among the better educated women, who take on jobs that use their comparative advantage in non-physical work. Recent evidence from the United States shows that it is the better educated and women who are able to get the high-paying jobs that are intensive in non-routine skills as the middle-skilled jobs shrink (Cortes, Jaimovich, Nekarda, & Siu, 2014). However, online learning is no solution when women have much less access to the technology infrastructure:

> Over 1.7 billion women in low- and middle-income countries do not own mobile phones. Women in those countries are 14 percent less likely to own a mobile phone than men, on average. Women in South Asia are 38 percent less likely to own a phone than men. (World_Bank, 2016, p. 134)

Besides poorer access, women in developing countries have much less control over their use of the internet, where it can be considered culturally inappropriate, and more than 8% did not access it more often

[7] *http://www.chronicle.com/article/In-China-Universities/141275/*

because family or friends would disapprove[8]. For some developing countries, women – unlike men – prefer using the internet in public libraries rather than in private cybercafés because they are safer, despite poorer service (Gomez, 2014). Their situation would be improved if more public access were available and if more blended learning were used in women's education to give them better access to more senior experts as well as the advantages of social learning.

ACTIONS TO CONSIDER

Policymakers to promote both blended learning and better access to IT as a means for improving the gender inequalities in educational opportunity.

3.5 Location

Digital learning offers access to education for people in rural and remote locations for whom onsite learning is unaffordable. For many generations in countries with large rural populations, technology offered children "blended learning" via radio, and more recently television, as it was used to support local adults in teaching their children. The internet, (where it exists), is the current technology for distance education, and again, it offers direct education for adults and supports them in providing blended learning for their children. Throughout the latter part of the 20th century, the "open universities" that provide remote learning for adults have been successful in their mission to overcome the inequalities of location for millions of adults. In the 21st century, campus universities also provide wholly online courses, but in addition to their campus courses, and not necessarily as part of a mission to reduce inequality. US universities, for example, mainly offer online learning in-state, with only a 2% reach to international students. We have to examine, therefore, the extent to which such courses are well-designed for a global audience. One study investigated the equity of location explicitly by comparing the digital learning experience of a target group of adult learners who self-reported an inability to afford a formal education, with a comparative group drawn from the rest of the cohort. They were studying six Coursera MOOCs over a year. The target group of low earners had a significant portion of learners with less than a 4-year degree, (34% vs. 19%), but they were more likely to be awarded a certificate of achievement (9% vs. 6%) than those in the comparison group. For them it was a critical opportunity: they were five times more likely to be motivated by geographic isolation and twice as likely to be using the course to decide if they wanted to take college/university classes on the topic. The majority were males over 25 (Dillahunt, Wang, & Teasley, 2014). Similarly, the value of a certificate is clearly demonstrated in a comparative study of students on a history MOOC: those who were on the credit-bearing version scored significantly higher than those on the non-credit-bearing version, in terms of achievement and perceived course value (Kursun, 2016).

For the millions of people who are capable of studying online, and are motivated to use life learning and professional development opportunities, but live too far from affordable campus education, online learning is their only hope. Given that the digital world now enables remote employment as well as remote learning, online learning would be a lifeline to a level of prosperity that has never before been possible.

ACTIONS TO CONSIDER

Universities and other providers to design and invest in online learning and accreditation to build up more "localized" learning opportunities while operating at scale.

[8] *http://www.intel.com/content/dam/www/public/us/en/documents/pdf/women-and-the-web.pdf*

3.6. The Learning Experience

A consequence of the large cohorts in learning at scale is the difficulty of ensuring that the course adds genuine value for every student, by adapting to their language, cultural and local needs.

Online courses that run on the large scale are essentially "one-to-many" operations, and this makes it difficult for providers to offer equity by addressing a wide range of needs. Traditionally, HE runs on the small scale and tends to be provider-led rather than market-led in its offerings, primarily because of the cost of developing resources that are contextualized (Laurillard, 2000). Online learning offers economies of scale where the fixed cost of developing a video lecture, for example, is offset by the large numbers of people using it, over many course runs. Clearly, economies of scale would reduce if the resources had to be adapted to a wide range of local contexts. However, the social learning made possible by a MOOC platform such as FutureLearn means that generic video content can be contextualized through the "localization" that takes place in the peer "co-learning" conversations that follow the video (Laurillard, 2016a). Encouraging learners to create face-to-face communities in their local contexts would also help learners engage with and improve their interactions with the global MOOC courses, especially when they need to overcome the language barrier of delivery in English only, or to improve the opportunity for collaborative learning (Firmansyah & Timmis, 2016).

We have discussed several aspects of equity in this section. The education industry cannot itself achieve equity with respect to access to internet-enabled personal devices, as that is the province of governments and the telecommunications, and IT industries. Online learning serves the issue of location very well, as long as the internet reaches everywhere. The existence of online learning can ameliorate the problem of gender inequality, but the platform design must develop better ways to embrace local languages and cultures (Liyanagunawardena, Williams, & Adams, 2013). The responsibility for the equity of the learning experience, in terms of transition, completion, and achievement, lies firmly with the provider as much as the "client," and is only likely to be met by establishing local partners who can modulate the design of the curriculum, pedagogy, and assessment, so that they respect the needs of the student of any locality, language, culture, and gender. In some cases, they could be local ministries of education, universities, NGOs, or commercial partners, depending on the nature of the course and its audiences. Models of delivery that essentially mimic the traditional classroom format, such as TNE and online masters' courses, with tens or at the most hundreds of students, will not exploit the opportunities that digital technologies offer. Large-scale distance learning from the open universities moves beyond that model when they manage to achieve both economies of scale in the development of activities and resources, and support for teacher-student interaction by managing large-scale local tutor provision. MOOCs are moving further still from the traditional model by replacing teacher support with peer support, which can be managed on the large scale if well-designed. But this does not address the need for reliable certification of the learner's achievement. As a result, MOOC platforms are moving towards premium models that do provide tutor-assessed credit awards, essentially returning to the traditional paid-for model of assessment, while reliable automated assessment remains difficult for most academic subjects.

We cannot yet envisage the UNESCO goal of universal education being achieved by direct interaction with school-age learners because that model still requires tens of millions of as-yet

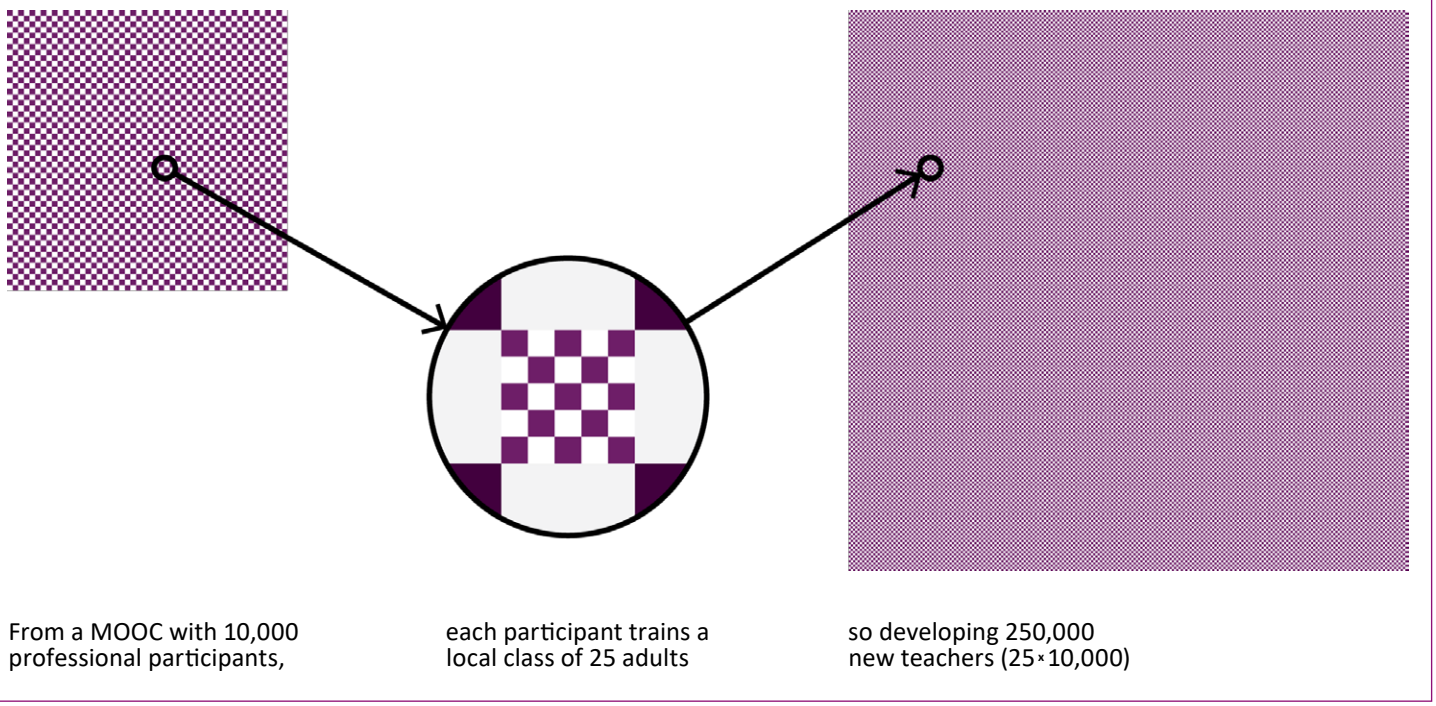


Figure 2. *The 'Cascade Model' Where 10,000 Highly Qualified Professionals are Trained on the Large Scale to Each Train a Class of 25 Local Adults Using Blended Learning*

untrained teachers. But perhaps online learning could train non-professional adults to be those teachers. Could we envisage a "cascade model" of online learning for professional adults who could then support the development of a much larger teaching workforce, as illustrated in Figure 2?

The MOOC approach is beginning to show how we can achieve large-scale education for professional adults if it can provide equitable pedagogies and peer assessment through social learning, and localize the generic teaching through co-learning to make it more widely acceptable and equitable. By cascading this model to local adults and less qualified teachers, using a blended learning mode, the large-scale development of tens of millions of teachers might ultimately be feasible (Laurillard, 2016b).

ACTIONS TO CONSIDER

Education providers to design in the "localization" of a MOOC, and affordable options for access to resources and activities as a matter of policy.

Educators to use and refine the "cascade" model to reach larger numbers of learners by supporting the professionals in large-scale online courses in supporting their smaller groups of learners who can use blended learning.

Ministries of Education to take advantage of MOOCs by promoting them to assist with the development of local teachers and professionals' to improve local educational opportunities.

4

REALIZING THE POTENTIAL FOR LEARNING AT SCALE

The aim must be to achieve high-quality learning that reaches all learners, i.e., that achieves equity in terms of high value and low cost to the user. The model must be more efficient than the current model, to be sustainable on the large scale long term. Is this feasible?

The need for learning at scale, across the world, is clear. To take just one strand of application, we know that to achieve the SDG4 goal of universal education requires the development of some 69m new teachers by 2030 (UNESCO, 2016b). Digital technology is the only means by which we could manage this immense task and it is now clear that MOOCs could be part of the solution: of the 25 million people enrolled in MOOCs between 2012 and 2015, 39% were from less-developed countries (Kizilcec et al., 2017).

Sections 2.2 and 2.3 argued that it could be feasible to design into online learning the pedagogic and support expertise that would achieve the necessary economies of scale. Section 3 established the conditions for achieving equity of provision, with respect to high value and low cost to the user:

- Low cost access to personal internet-enabled digital devices with high-speed broadband, with explicit action to improve women's access to online courses
- Online courses that are localized in terms of curriculum, pedagogy, assessment, and certification of learning to ensure relevance and personal value for all types of learner groups
- Online course designs that offer options for access to resources and activities in locations with poor broadband connectivity, or low-powered devices
- Development of a "cascade + blended learning" model to extend the reach of online learning beyond highly qualified professionals

Now we consider what can be done to meet these conditions for equitable online learning. Low cost access to digital infrastructure is an issue that has to be addressed at the level of national policy, perhaps with industry and philanthropic support, as its success will depend on local policy priorities and imperatives.

In section 3, we discussed ways of designing in the localization of courses to improve equity through orchestrating co-learning conversations, encouraging local community groups, recruiting local partners, and offering adaptable resources.

In this section, we focus on the further problems of affordable assessment and certification, and how the cost to the individual learner can be kept low, by taking a realistic analytical approach to costing online learning.

4.1 What Kind of Assessment is Feasible and Valid?

The challenge for scaled-up online learning is to make the assessment of learning objectives feasible for massive cohorts without creating unrealistic burdens on teacher or facilitator time. While tutor-marked assignments are largely seen as unsustainable as learning scales up (Chauhan, 2014), one of MIT's most popular MOOCs has recently added this option to complement the automated elements, with a $300 identity-verified certificate (Straumsheim, 2016). This model of higher fees for certification pays for tutor time to mark assignments, which of course is a retreat to the classical model of HE that reduces equity, which so far remains the only reliable way to assess for credit.

Alternative ways of reducing the cost of assessment are now being investigated: peer, self, and automated assessment, but these are used for formative assessment, rather than for any high-stakes summative assessment.

It is common in MOOCs to use peer assessment of learner participation in discussion forums, learner produced digital outputs shared publicly, and structured peer-to-peer review of assignments (de Waard, 2015; Luo, Robinson, & Park, 2014). To improve the validity of peer assessment some providers include processes to calibrate and develop learners' capacities to review their peers' assignments according to scoring rubrics, for example, in EdX and Coursera. This approach enables peers' scores to be proportionally weighted or discounted according to marking expertise and provides feedback to learners on their reviews of others' assignments, as well as on their own assignments. Scaffolding the process of giving and receiving peer reviews has the potential to both reduce learner resistance to peer assessment, and harness its value for learning (Balfour, 2013). The acts of giving and receiving peer reviews are both rated highly as productive learning activities, especially the former, as it promotes more critical analysis of the student's own output (Laurillard, 2016a).

A similar approach can be used for self-assessment, where the individual learner assesses their own work in relation to the marking criteria, and then against an assessed model answer, in order to sharpen their awareness of what they should aim for.

Both peer and self-assessment are uncertain methods in terms of validity, which makes it difficult to use them for building up credit for transfer to accredited university courses. In the attempt to address this issue, technology for automated assessment is developing rapidly. It has the potential to range from computerized adaptive testing tailored to individual performance to continuous integrated assessment, intelligent measurement, and personalized feedback, drawing on data provided by learner analytics (Redecker & Johannessen, 2013). A combination of these approaches is being pioneered, e.g., by using text mining in a Global Blindness MOOC aimed at health care providers in the Global South, to monitor the extent to which participants are commenting on key learning themes in discussions, and to provide feedback to learners and course developers (Parsley, Patel, Stroud, & Lynch, 2017).

Learning analytics can also be of value to the individual learner as feedback on where their current performance lies in relation to their peers who were previously on a trajectory for a particular grade (Laurillard, 2015).

Other options for avoiding expensive tutor time include Automated Essay Scoring (AES). AES systems use statistical models to predict instructor scores for specific essay features, for example, essay length, grammar, vocabulary, organization. While AES has been offered by EdX since 2013, comparisons of AES and tutor marking show statistically significant

differences (Reilly, Stafford, Williams, & Corliss, 2014), making such systems arguably more appropriate for formative feedback, which improves the outputs to the tutor for marking, rather than for direct summative assessment.

None of these methods address the problem of summative assessment for credit, but by improving the quality of output to the tutor they help to reduce the marking and feedback workload. Tutor-based assessment, whether formative or summative, is a high cost because its value is in the personalization to the learner. It is this nurturing of the individual mind that makes education a "client-centered" industry, rather than a mass delivery industry. The human interactions scaffold the maturing of concepts and high-level skills, and the intellectual confidence to deploy them. Education is no more a mass delivery industry than is parenthood. Whatever techniques we use to reduce the personal tutor support in order to keep costs down, there is the likelihood that we reduce quality, and therefore equity.

ACTIONS TO CONSIDER

Promote the investigation of techniques for improving formative assessment:

- Peer assessment
- Self-assessment against a model, or peer performance
- Automated essay scoring

4.2 Accreditation of Learning at Scale

Accreditation of learning means that learning providers, awarding bodies and universities must work to recognize prior learning so that participants in MOOCs can use this kind of certification for credit transfer to degree programs, or for professional development.

The validation of assessment of online learning on this scale is difficult, but important because it paves the way for the provision of University credit for participation. Governments and Universities are propelling the global growth in credentialing MOOCs (Chauhan, 2014), with EdX offering MicroMasters that can be exchanged for credit on an accelerated Master's program with a number of University partners (Agarwal, 2017), and other platforms developing similar initiatives. The provision of formal credit for open, online and distance education can in itself improve learners' perception of the quality of the teaching and learning experience, and their level of achievement (Kursun, 2016).

As the need for lifelong learning becomes widely accepted, there is a growing interest in the "recognition, validation and accreditation [RVA] of the outcomes of non-formal and informal learning" or (Singh, 2015), such as skills developed in the workplace or in personal time. Recommendations for making visible previously unrecognized skills and competences developed outside the formal education systems emphasize the need for agreed standards or benchmarks, clear assessment criteria, competent assessors and robust validation procedures. The capacity to have prior learning accredited has been shown to be a factor in the take-up of further education and training (Singh, 2015), and the ability to do this at scale could be of great benefit across the Global South. Within a nationally agreed strategy for scaling up RVA, it may be possible for online learning to conduct automated, self- and peer- assessment

efficiently. The Open Badges movement (The Mozilla Foundation and Peer 2 Peer University in collaboration with The MacArthur Foundation, 2012) offers a way of capturing a learning journey and achievements by using the capacities of digital technology to record and share specific criteria and outcomes linked to individuals. Such an approach would require a robust RVA strategy, and widespread monitoring and calibration to ensure acceptance of the value of these digital accreditation mechanisms.

ACTIONS TO CONSIDER

Universities to develop a policy for working towards credit transfer from online certificates to conventional courses.

4.3 Analyzing the Costs of Scaled up Learning

If we are to find viable solutions to making online learning affordable and sustainable, then it is essential to understand its true costs. The costs of providing large scale learning have tended to be opaque, since cost has not been the central motivation for scaling up education for many institutions, and lack of attention to costing is a historical characteristic of much tertiary education (Hollands & Tirthali, 2014). Classical costing models for teaching in conventional methods have not been well developed for understanding the efficiencies of economies of scale, and this is critical for optimizing the use of technology. Nevertheless, scaled up learning will not be sustainable without realistic planning for the costs, particularly in relation to the quality of the learning experience provided (Kennedy, Laurillard, Horan, & Charlton, 2015).

There are three kinds of cost to consider – recurrent costs, fixed costs, and variable (scaling) costs. Recurrent cost items are activities that have to be costed in for every run, such as marketing, recruitment, platform set-up for the course run, sending emails and course announcements, tutor induction, and evaluation. A fixed cost item may have a high cost (such as video or animation) or a low cost (such as text). The important point about an online digital resource is that it only has to be produced once, no matter how many people use it. By contrast, a variable cost item (such as 1-1 tutoring, tutor feedback, marking), is costed in terms of teacher time per user, or per user group (Kennedy et al., 2015), so that its costs rise in proportion to the size of the cohort, with no economies of scale. A teaching-learning session usually has elements of both fixed and variable costs, but if the fixed cost elements are sufficient for learning (such as a good video explanation or demonstration), then most of the learning activities can be done on the large scale. If not, then effective learning will require some variable cost elements, such as tutoring and individual guidance as well, which will increase the per learner cost, and therefore reduce the scale.

Conventional costs of teaching are not well understood, so there is no reliable baseline. An activity-based costing approach (Cropper & Cook, 2010) that models the true costs of both conventional and online learning, would be the optimal way to ensure a financially and pedagogically viable transition from conventional to blended to online learning (Laurillard, 2006; Nicol & Coen, 2003). This provides a realistic comparison between the two modes of teaching because the method identifies all the activities associated with a course in terms of

staff time, for teachers and support staff, for both development and delivery, instead of deducing the costs from a top-down historic budget.

The recurrent costs of administration can be kept low if the host operation is efficient; evaluation costs are low for MOOCs as much of the data is collected by the platform; marketing and recruitment costs should boost numbers, so the right balance is important.

The fixed costs of resources can be kept low. There is evidence to suggest that reducing the costs of the most expensive content items (usually video) may not result in overall loss of the quality of learning. Some of the most powerful learning experiences of MOOC participants involve low-cost audio-video interventions in the MOOC, e.g., an educator's audio comment, a pre-recorded lecture, or a short video encouragement to participants (Adams, Yin, Vargas Madriz, & Mullen, 2014). These often self-made multimedia resources add a sense of intimacy to the learning on a MOOC, akin to a personal tutorial experience. Moreover, in many developing countries, reliance on streaming or downloading high-quality video can be a problem for low bandwidth internet connections, and for MOOCs to work in such contexts, the capacity to study offline is essential (Oyo & Kalema, 2014a).

The estimated costs of providing a MOOC range from $38,980 to $325,330, depending in part on the quality of the video and special features, and the number of people involved in production teams (Hollands & Tirthali, 2014). Videos do not have to be lengthy, and talking heads with slides can be done at very low cost and file size. However, if the full power of video is used, such as location filming that shows the professionals in action, or the contextualized theory in practice, then higher production values are important because they are more likely to motivate participants, and achieve the intended learning outcomes. They can be very good value, especially as the costs of re-runs diminish substantially when expensive content is reused and new costs relate only to mentoring and technical support (Hollands & Tirthali, 2014).

Variable costs can be reduced, as we have seen, by using peer, self, and automated assessment, but with the serious loss of human tutor nurturing and encouragement that are so important in education. One alternative is to reduce these costs by recruiting volunteers. The volunteer facilitators, who are qualified staff, are recruited to run face-to-face sessions for local groups, or to support learners pro bono or as part of their existing role in field supervision of students (Oyo & Kalema, 2014b; Warugaba et al., 2016). The facilitators played a significant role, for example, in boosting the completion rate to a high 53% (Warugaba et al., 2016), underlining the importance and value of the human tutor presence. If the model were integrated into public education provision, without relying on volunteers, it would ensure the sustainability of the MOOC approach. However, if the variable cost of learner support is shouldered by volunteers, this is neither a sustainable nor scalable solution.

In addition to reducing the cost of developing and supporting online learning, we can also consider the returns on this investment. Financial returns are low because completion rates and the take-up of certification is low. However, this is in the context of the main demographic of MOOCs being highly-qualified professionals, who are more interested in what they need from a course than in completing it, and who do not need the certificate. For example, only 54% of MIT and Harvard MOOC participants indicated an intention to earn a certificate, and 16% actually did (Chuang & Ho, 2016). Certification alone is thought to be unlikely to be a significant source of income, a view endorsed by other studies (Macleod, Haywood, & Woodgate, 2015).

Alternatively, if marketing and recruitment were to aim for wider participation from lower-qualified professionals or professionals who have little access to good opportunities for professional development, then this could change. MOOC platform providers are exploring the concept of differential pricing for different countries, and this would improve equity for those from low-income countries. Recruitment would be higher if policymakers were to embrace the value of a program of MOOCs for their educational staff, in a strategic move towards a cascade model of supporting educational provision. Nothing of this kind has been tried as yet, as learners participate on a personal basis, not as part of any organizational or governmental strategy.

The return on investment in education is high and must be measured in more than the income from certified learners. An analysis of the potential intangible returns on a program of teacher development MOOCs, for example, would be a valuable contribution to our understanding of what kind of investment would be worthwhile in the context of equity and online learning.

The new trends are towards collections of MOOCs, with capstone projects, combining to offer credits towards degrees and recognized qualifications.

Inevitably, it is the variable costs, the client-centered support activities carried out by costly teachers, which mark the quality of the teaching and the learner's achievement, that provide the return. And inevitably, in doing so, they push up the cost to the learner and reduce equity.

ACTIONS TO CONSIDER

Use an activity-based costing approach to the cost-benefit analysis of both conventional and online learning and teaching, in order to fully represent the comparative cost and benefits of both, and plan the return on investment accordingly.

Model and plan for income streams that will offset the true costs of online learning.

Evaluate the trade-offs between high/low cost designs and the value to the learners.

Experiment with reducing the costs of online production, rather than under-resourcing the teaching time needed for learner support.

Develop policies for achieving equity in online learning at scale through government support for a cascade model of professional development online with locally supported blended learning.

5

CONCLUSIONS – WAYS FORWARD

This paper has discussed several aspects of what it takes to improve equity through online learning at scale. To give a practical edge to our findings, we have grouped the actions that need to be worked through if we are to secure sustainable and effective solutions for education. These are grouped by type, in terms of the *technology* – the need to bridge the extensive digital divide, the *pedagogy* – the need for teachers to be able to own and develop the digital pedagogy innovations that will continue to be needed as digital innovations progress, and the *community* – the need for shared and localized versions of generic principles of practice.

Technology infrastructure

Provides for wider access to viable internet-enabled devices and high-speed broadband as a route to education for all countries across the global south.

Policymakers to promote both blended learning and better access to IT as a means for improving the gender inequalities in educational opportunity.

Digital pedagogy design tools

To achieve both high-quality learning and low costs of development and support, develop the digital tools that would enable teachers to embed their pedagogic expertise in digital methods that support independent learning and do not require their physical presence.

Universities, colleges, and other education providers to develop studies and exemplars of effective online learning that demonstrate its value, and how this can be optimized.

Community-based localization

Set up local structures to support local professionals in collaborating on the development of online courses that meet local needs.

Researchers and designers to promote the techniques that make online learning design more effective for all types of learners.

Providers to invest in online learning and accreditation to create more localized learning opportunities, while teaching at scale, and to design in localization as a matter of policy.

Educators to use and refine the “cascade” model to reach larger numbers of learners by supporting the professionals in large-scale online courses in supporting their smaller groups of learners who can use blended learning.

There is great potential for scaling up effective digital learning, but with no coherent strategic focus on ensuring equity as a fundamental principle for educational innovation, there are many current limitations to be addressed. Our findings offer actionable solutions that exploit the potential of digital technology in the service of equity in education.

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APPENDIX: METHODOLOGY

A systematic literature review (SLR) method was employed in this study (Levy & Ellis, 2006). The aim of using SLR is to find as many primary studies and reports relating to the research question as possible using planned search strategies. SLR research steps, namely: planning, selection, extraction, and execution, (Okoli & Schabram, 2010) were followed. The electronic databases searched in this review included those identified as relevant to education, information technology, and social science. Relevant literature was therefore identified by searching on the ERIC, CiteSeerX, ScienceDirect, Web of Science, ProQuest, JSTOR, Scopus, SpringerLink, and Google Scholar electronic databases. As the notion of "learning at scale" is relatively new, the selection of papers was therefore not restricted to peer-reviewed journal papers but included reports from reputable sources (private providers, government agencies, large organizations) as well as high-quality media articles in the English language published between the years 2008 to 2017 (up to the time when this review was being conducted).

The title, abstract, and keywords were searched for the terms and phrases we identified that related to "learning at scale" with respect to equity, quality, and efficiency in education. Synonyms (e.g., "input," "investment"), antonyms (e.g., "completion rates," "drop-out rates"), abbreviations (e.g., "massive open online course," "MOOCs"), singular/ plural/ verbal/ adjectival forms (e.g., "MOOC," "MOOCs"), different spellings (e.g., "student-centred," "student-centered"), and broader/narrower terms (e.g., "disadvantaged," "ethnic minority") were also checked.

The title and abstracts of the search results were assessed for relevance as the first selection. The duplicated records between databases were removed. Those reported in the context of the Global South/developing countries were retrieved for further relevance/quality evaluation. Where there was limited information about developments in these countries, the more extensive studies of trends in Western countries were considered for what they could reveal.

Such a screening process resulted in the identification of over 100 distinct articles and reports. The references and citations of the most relevant studies were followed through to add those with more robust or more recent findings. Thematic analysis (Creswell, 1994) was then carried out to derive themes for inclusion in the intended outline of the report and to generate further themes for analysis.

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