

MOOCs for in-service teachers: The case of Uganda and lessons for Africa

Los MOOC para profesores en ejercicio: el caso de Uganda y las lecciones para África

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Abstract:

In recent times, computers and internet have penetrated secondary schools in Africa but with greater attention to students' computer literacy than teachers. At the same time, previous studies on digital literacy of teachers are unsustainable and mainly skewed on pre-service teachers than in-service teachers. These realities point to the need to investigate and implement effective and sustainable initiatives for improving digital literacy and online life-long learning for in-service teachers in Africa. This paper therefore presents a specialised MOOC platform known as TEP (Teachers' E-learning Portal) for digital literacy and online life-long learning for in-service teachers in Uganda. TEP is built for environments with inadequate access to computers, internet and technical assistance. As such, TEP is accessible online or offline, managed by accredited local universities in collaboration with beneficiary secondary schools, and runs on existing resources in schools (technical personnel, computers and internet). Results from initial implementation of a computer literacy MOOC through

TEP indicate that irrespective of age, when teachers are adequately supported internally by their schools and externally by a university, can improve their digital literacy and subsequently engage in online life-long learning. In addition, the results both in terms of high percentage of teacher participants' completions (89%) and high volume of educational e-content generated, confirm TEP as an effective, attractive, and self-sustainable MOOC platform for in-service teachers' in resource constraint environments. The paper finishes with an analysis of the relevance of TEP to Africa.

Keywords: MOOC, digital literacy, in-service teachers, life-long learning, Africa.

Resumen:

En la actualidad, los ordenadores e Internet han penetrado en los centros de secundaria en África, pero con un mayor énfasis en la competencia digital del alumnado que en la del profesorado. Al mismo tiempo, los es-

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tudios previos sobre competencia digital docente son insuficientes, con un enfoque más acusado en la formación antes del ejercicio docente que durante la práctica profesional. Esta situación impele a la investigación e implementación de iniciativas efectivas y sostenibles para la mejora de la competencia digital y el aprendizaje a lo largo de la vida durante la práctica profesional del profesorado africano. Este artículo presenta una plataforma MOOC conocida como TEP (Teachers' E-Learning Portal) enfocada a la competencia digital y el aprendizaje a lo largo de la vida para el profesorado en ejercicio de Uganda. TEP está construido para ambientes con un acceso deficiente a los ordenadores, Internet y asistencia técnica. Por este motivo, TEP es accesible *online* y *offline*, está dirigido por universidades locales acreditadas en colaboración con centros de secundaria y funciona con los recursos existentes en las escuelas

(personal técnico, ordenadores e Internet). Los resultados del desarrollo de un curso MOOC en TEP indican que independientemente de la edad, cuando los profesores reciben una atención adecuada dentro de las escuelas y de forma externa por la universidad, pueden mejorar su competencia digital y, por consiguiente, garantizar una formación continua. Además, los resultados muestran que las tasas de finalización del profesorado son altas (89%) y se genera un gran volumen de material digital, lo que confirma al TEP como una plataforma MOOC efectiva, atractiva y autosostenible para la formación del profesorado en ejercicio en contextos de especial dificultad. El artículo finaliza con un análisis de la incidencia del TEP en África.

Descriptor: MOOC, competencia digital, profesorado en ejercicio, aprendizaje a lo largo de la vida, África.

1. Introduction

Research on teachers' digital literacy in Africa is limited and skewed on challenges of teachers' information technology adoption (Mooketsi & Lwarence, 2014; Ngimwa & Wilson, 2012; Oyo & Kalema, 2014; Olson and others, 2011). Olson and others (2011) for instance, present two key observations regarding the dynamics of teachers' technology adoption. First, when teachers are faced with mandates on the use of technology, they tend to use the technology for personal productivity rather than learning. Second, teachers often resist the use of technology and e-learning because of an insufficient amount of time needed to prepare new

lessons or rework existing lessons using ICTs. Indeed, the issue of limited time for teachers to learn and use ICTs in their teaching has been widely reported in other country specific case studies, eg, South Africa (Mathipa & Mukhari, 2014), Kenya (Jobe, 2013), Uganda (Markon, 2013) and Ghana (Buabeng-Andoh, 2012). In the area of content development, Ngimwa and Wilson (2012) blame stagnation of open educational resources (OERs) adoption in Sub-Saharan Africa on low teachers' computer literacy. Buabeng-Andoh (2012) further claims that in-service teachers generally perceive ICTs as new technologies whose relevance to them is marginal. What is clearly missing

in this discourse is the role of schools in supporting digital literacy and online life-long learning for their teachers in order to fully utilise available computer infrastructure in schools.

In contrast, the Massive Open Online Courses (MOOCs) being courses designed for large numbers of participants with internet connection and without entry requirements, makes them most suitable for in-service teachers who do not only access internet but also receive technical support from their schools. The priority of our MOOC on in-service teachers has two important benefits. First, it minimises the well documented high dropout rates in traditional MOOCs due to open enrolment strategy (Jordan, 2014; Maceod, Haywood, Woodgate & Alkhatnai, 2015). Second, it gives an opportunity for local universities to offer MOOCs within their limits as opposed to traditional MOOCs that are dominated by a few platforms supported by international elite universities.

Motivated by the issues described above, in this paper, we investigate and implement an effective digital literacy and life-long learning MOOCs for in-service teachers through a participatory approach involving accredited local universities and secondary schools, and powered by a platform optimized for resource constraint environments called teachers' e-learning portal (TEP). This platform enables teachers to enrol and complete online computer literacy certification and other relevant programmes offered and supported by local universities. Teachers enrolled for MOOCs through TEP also receive additional

hands-on support from technical staff in their respective schools as well as access an offline cached content on their schools' local server. The offline server synchronises with the online server (TEP) when connectivity is established. A full account of TEP is discussed in a later section of this paper after strategies for implementation of MOOCs in resource constraint environments are presented next.

2. Strategies for MOOCs in resource constraint environments

Following from the previous section and recent findings in which MOOCs offered on the Coursera platform were found to be successful only in developed countries among the young, male, well-educated and employed students (Christensen and others, 2013), in this section, we explore strategies for implementation of MOOCs for in-service teachers in resource constraint environments of Africa.

Recent studies in Africa show that in-service teachers are not only intimidated by computers in schools but are also afraid to damage them (Mooketsi & Chigona, 2014; Oyo & Kalema, 2014). Other studies blame the low digital literacy of teachers on a number of issues, namely; lack of self-driven initiatives (Buabeng-Andoh, 2012; Markon, 2013), weak school management support for teachers' computer literacy programmes (Mooketsi & Chigona, 2014; Byabazaire & Oyo, 2014), and lack of enabling policies for holistic digital literacy initiatives for teachers, students and school administrators (Walls,

Santer, Wills & Vass, 2015; Mathipa & Mukhari, 2014).

At the same time, the state of ICT integration initiatives in African secondary schools is improving, with several on-going activities on acquisition of computer infrastructure and training of students in basic computer skills. In effect, ICT has become one of the core secondary school subjects, having been introduced in most African countries over the last decade, ie, Uganda in 2004 as an optional subject before becoming compulsory in 2011 (Markon, 2013) while South Africa in early 1990 with further reinforcements in early 2000s (Mdlongwa, 2012; Mooketsi & Chigona, 2014); Nigeria in 2005 (Adomi & Kpangban, 2010); Ghana in 2008 (Amenyedzi, Lartey & Dzomeku, 2011); Cameroon in 2002 (Mbangwana, 2008); and Tanzania in 2006 (Furuholt & Kristiansen, 2007). To date, however, computers are generally accessible in

most secondary schools and yet in-service teachers have remained largely computer illiterate.

Rather than engage in fault finding debate over who/what is responsible for low digital literacy of in-service teachers in Africa, effort should be directed to exploring effective digital literacy and life-long learning initiatives through MOOCs that leverage available resources in schools. To this end and from the above contention, we distil five strategies, namely: school management support, enabling policy, availability of infrastructure, internet access and funding models, necessary for successful implementation of MOOCs for in-service teachers in Africa. Based on these strategies, Table 1 gives lessons for MOOCs implementation for in-service teachers in Africa. These lessons are drawn by comparing current situations in Africa against international baselines.

TABLE 1. Strategies for MOOCs for in-service teachers in resource constraint environments.

Strategy	Current situation in Africa	Baseline case	Lessons for MOOC implementation
School management support (Byabazaire & Oyo, 2014; Oyo & Kalema, 2014)	School managers are generally computer illiterate and therefore attach less value to teachers' digital literacy. Moreover, the prevailing perception is that ICT can be self-learned (Mooketsi & Chigona, 2014)	School administrators are responsible for creating environments to facilitate the teachers' integration of ICT in teaching and learning (Ottestad, 2013)	The ideal MOOC implementation model for teachers starts with support from the school administrators. As such, digital literacy of school administrators should be top priority if other related programmes for teachers are to succeed (see, Lorenz, Eickelmann & Gerick, 2015).

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Strategy	Current situation in Africa	Baseline case	Lessons for MOOC implementation
Enabling policy (Walls, Santer, Wills & Vass, 2015)	Policy and implementation strategy of computer literacy of students is widespread, unlike computer literacy of teachers (Mathipa & Mukhari, 2014; Oyo & Kalema, 2014)	Holistic digital literacy strategy for students, teachers and teaching support staff, eg, DigiLit Leicester project (Hall, Atkins & Fraser, 2014)	The rising penetration of computers in schools should propel holistic digital literacy and online life-long learning for teachers and school administrators
Infras-structure readiness (Ngima & Wilson, 2012; Warugaba and others, 2016)	Computer-to-teacher ratio is unknown. However, mobile phones are widely accessible across all sections of society (Walls and others, 2015)	One-to-one laptop programme for teachers, eg, digital education revolution initiative by the Australian government (Howard, Chan & Caputi, 2015).	Shared access to computers in schools between students and teachers. MOOCs can leverage mobile phones that are ubiquitous.
Internet access (Jordan, 2014; Labbas & Shaban, 2012)	Internet access is expensive, slow and unreliable in most parts of Africa (GSMA, 2014; Mooketsi & Chigona, 2014; Oyo & Kalema, 2014).	Broadband internet is accessible both at home and schools in developed countries (Voogt, Erstad, Dede & Mishra, 2013).	Offline and online access modes are important for MOOC platforms. These have been argued as the baseline for e-education programmes in Africa (see, Walls and others, 2015).
Funding mechanisms (Adomi, 2014)	Computer access in schools is largely improving. Internet is still expensive and computer literacy programmes for teachers are scarcely funded by African governments or schools themselves.	Funding of ICT infrastructure, internet and teachers' computer literacy in the developed world is driven by governments and/or schools themselves (Hall, Atkins & Fraser, 2014; Lorenz, Eickelmann & Gerick, 2015).	Affordable broadband connectivity currently available to higher education institutions, eg, through <i>Ubuntu-Net Alliance</i> for Eastern and Southern Africa (https://www.ubuntunet.net/), should be extended to secondary schools

Source: prepared by the authors.

Teachers in Africa have generally been brought up in a world with limited technology and therefore find it difficult to use

technology in e-education. The readiness analysis in Table 1 is consistent with the findings of a large international study

(2010-2014) on computer and information literacy of secondary school students in 21 countries, that, ICT infrastructure in schools on its own is not enough to enhance the ICT competency but the efforts of the teachers and administration are more important than any other factors (Lorenz, Eickelmann & Gerick, 2015). This insight is depicted in other related studies in Africa that were initially promising but are currently unsustainable. Two of these studies are briefly discussed here.

First, the Teacher Education in Sub-Saharan Africa (TESSA) research and development initiative established by Open University UK in 2005 and currently implemented in 15 institutions in sub-Saharan Africa. By 2012, seventy five adaptable open educational resources (OER) TESSA units had been produced covering key topics in five primary school subject domains, including literacy, mathematics, science, life skills, and social studies and the arts; in four languages Arabic, English, French and Kiswahili (Murphy & Wolfenden, 2013). Since 2010, TESSA extended material development to secondary education covering science subjects, including biology, chemistry and physics (Murphy & Wolfenden, 2013). Whereas OER TESSA units have been largely portrayed as successful in a number of studies (see Murphy & Wolfenden, 2013; Wolfenden, Wolfenden, Umar, Aguti & Addel, 2010), the actual secondary science resources available on the TESSA website (see www.tessafrica.net) have stagnated on only a few topics

since its initiation in 2010. In fact, the coverage in the respective subjects is rather shallow as the average number of pages for the available content is 2 pages across the five content units in all the three subjects. Moreover, new content does not seem to be available since the existing one was last uploaded by second quarter of 2012.

Second, the Kenyan cloud school (KCS), which is a MOOC containing all courses taught at the secondary school level in Kenya. KCS MOOC consist of online, on-going subjects in both English and Kiswahili with self-testing and peer assessment functions as well as digital badges and certificates awarded on completion to recognize and validate non-formal learning (Jobe, 2013). KCS is built with responsive web design to increase ubiquitous access from any device and its access is free and open to any student. The content development process is on-going collaboratively using researchers from developed western countries and Kenya. Clearly KCS is built on a solid technology and design standards, however, its long term impact depends on appropriateness of the content (notes, tests, revision exercises and video lessons) that will be developed by the Kenyan teachers, but the majority of these teachers are not computer literate.

The implementation strategies for MOOCs for in-service teachers as presented in this section, have been argued against the backdrop of challenges at the level of sustainability, accessibility and

teachers' digital illiteracy. The next section builds on these discussions and presents the Ugandan MOOC platform for in-service teachers.

3. The Ugandan MOOC platform for in-service teachers

In this section, we present a specialised MOOC platform known as TEP (Teachers' E-learning Portal) for digital literacy and online life-long learning for in-service teachers in Uganda. The section begins with TEP background and its justification, then the design and adoption strategy for TEP is presented. Subsequently, the preliminary results following TEP's initial roll-out are discussed.

3.1. Background

The TEP idea is linked to a series of activities that followed the Google's Computer Science for High School (CS4HS) 2012 project implemented by Gulu University and coordinated by the first author of this paper. The aim of the latter project was to re-tool secondary school ICT teachers in northern Uganda with knowledge and skills in: (1) web development using HTML5 and CSS; (2) database development using MySQL and PHP; and (3) multimedia development using Flash and Action Script. Emerging from this project was the need for further content sharing among the participants' schools which lead to the development of Mwalimu open educational resource (now accessible at

www.mwalimu.ug) by Gulu University with additional grant from Google's 2013 CS4HS grant towards its roll-out across different regions in Uganda. Details of the participants distribution and roles in these two Google's CS4HS projects can be found in Byabazaire and Oyo (2014, p. 36-37). Through the Google CS4HS-2013 project's post workshop survey, the perspectives of digital literacy issues by all the 89 participants were sought. The perspectives rated as *strongly agree* or *agree* by at least 60% of the participants were, that in-service teachers:

- Have access to computers in their schools.
- Are aware of the usefulness of computers in teaching and learning and are awaiting external support to get them started.
- Prefer to engage computer literate users for computer services such as typing and printing tests, notes, etc, but are reluctant to perform these tasks themselves.
- Own and can operate mobile phones effectively.
- Use computers mainly for leisure, eg, playing music and watching movies.
- Need basic computer skills but are not decided on when to start acquiring these skills and how best to proceed.
- Feel that computers are not for their generation.
- Have not grasped how computers and computer applications can support teaching and learning in their respective subjects of specialisation.

- Fear that pervasive use of computers in schools places their jobs at risk and over time computers will replace them.

- Believe that computer literacy is a special skill for ICT professionals or teachers who have undergone rigorous training in ICT.

- Believe that digital literacy does not affect their productivity as classroom teachers.

- Imagine that there are no significant added advantages in adoption of ICTs in teaching and learning.

The above perspectives depict marginal benefits to in-service despite increasing computerisation in their schools. As such, the teachers' digital literacy and online life-long learning MOOC powered by TEP was conceptualised.

3.2. TEP design

TEP is designed as a community outreach initiative for universities to support digital literacy of teachers in collaboration with schools. The universities, schools and teachers are the pillars of TEP and as such, the design of TEP is based on their roles. Universities and not higher education institutions are emphasised because of the overarching community outreach requirement of universities. In particular, the university roles within TEP include:

- Identifying and initiating training collaboration with target schools including registering the schools and managing their logins on TEP.

- Identifying and contracting schools that are strategically located and with the necessary computing facilities as examination centres. For integrity of the online examination process, registered teachers (participants) attend their online certification examinations at their convenient examination centres. For each participant attached to an examination centre, a unique code is sent to the examination centre that activates the underlying examination. As such, participants cannot access the online examinations outside their respective examination centres.

- Managing and/or providing content in form of notes, audio books, presentations, video lessons and other forms of learning objects. The teaching content on TEP is provided by the collaborating university. The baseline content is informed but not restricted to the highly regarded International Computer Driving License (ICDL) curriculum. As a prerequisite for final certification examination, teachers registered for the TEP initiative are required to develop and submit subject specific content in reflection of skills acquired. The latter content is in turn uploaded on TEP as a benchmark for other teachers intending to enrol for TEP as well as a resource for additional electronic content access to enhance teaching and learning.

- Providing and managing examinations. New examinations are uploaded and scheduled on TEP while past examinations are archived by

year and examination period. The final course examination accounts for 50% from 50 multiple choice type questions that are marked automatically on submission. Prior to the final course examination, the participants complete their course assignments which also accounts for 50% and thus on submission of the final online course examination, a digital certificate is generated for participants whose final score is at least 60%.

- Generating and analysing reports on academic performance, completions and participants' (teachers) feedback.

Within TEP design, schools are responsible for providing access to computers and internet as well as technical personnel to their teachers. These roles include the following:

- Setting up and managing an offline server for local access by teachers undertaking TEP programmes. The offline server automatically synchronises with the online server when connectivity is established.

- Monitoring teachers' online and offline activities to ensure higher participation and completions in TEP programmes.

- Managing teachers' login accounts. A participant/teachers' login is created from the registration page but remains inactive until approved by the respective school administrator.

- Providing important feedback to the collaborating university on overall usability of TEP.

Figure 1 gives an overview of TEP underpinned by the roles of its three pillars. As shown in Figure 1, the preferred training curriculum for the teachers is at the discretion of the implementing university, but focus should be on giving teachers authentic and relevant experiences with the available tools in their subject teaching contexts and thus going beyond the traditional computer literacy training which is based solely on ICDL curriculum. For instance, a chemistry teacher needs the basic computer skills from ICDL curriculum and specific skills in using *ChemDraw* software. Similarly, a geography teacher would need specific skills in using *Google Maps*.

As depicted by Figure 1, TEP can be implemented in two ways: first, through a one university to many schools collaboration, in which the university is the main implementing entity. Secondly, through many universities to many schools collaboration, whereby an external entity e.g., the education ministry or a funding agency would coordinate its implementation by supporting a consortium of universities and schools.

Further analysis of TEP's adoption strategy is given next.

3.3. TEP adoption strategy

The focus of TEP is to support improvement of digital literacy and online life-long learning especially among in service teachers. This is possible using the existing operational structures in schools whereby digital literate teachers and the school administration work together to

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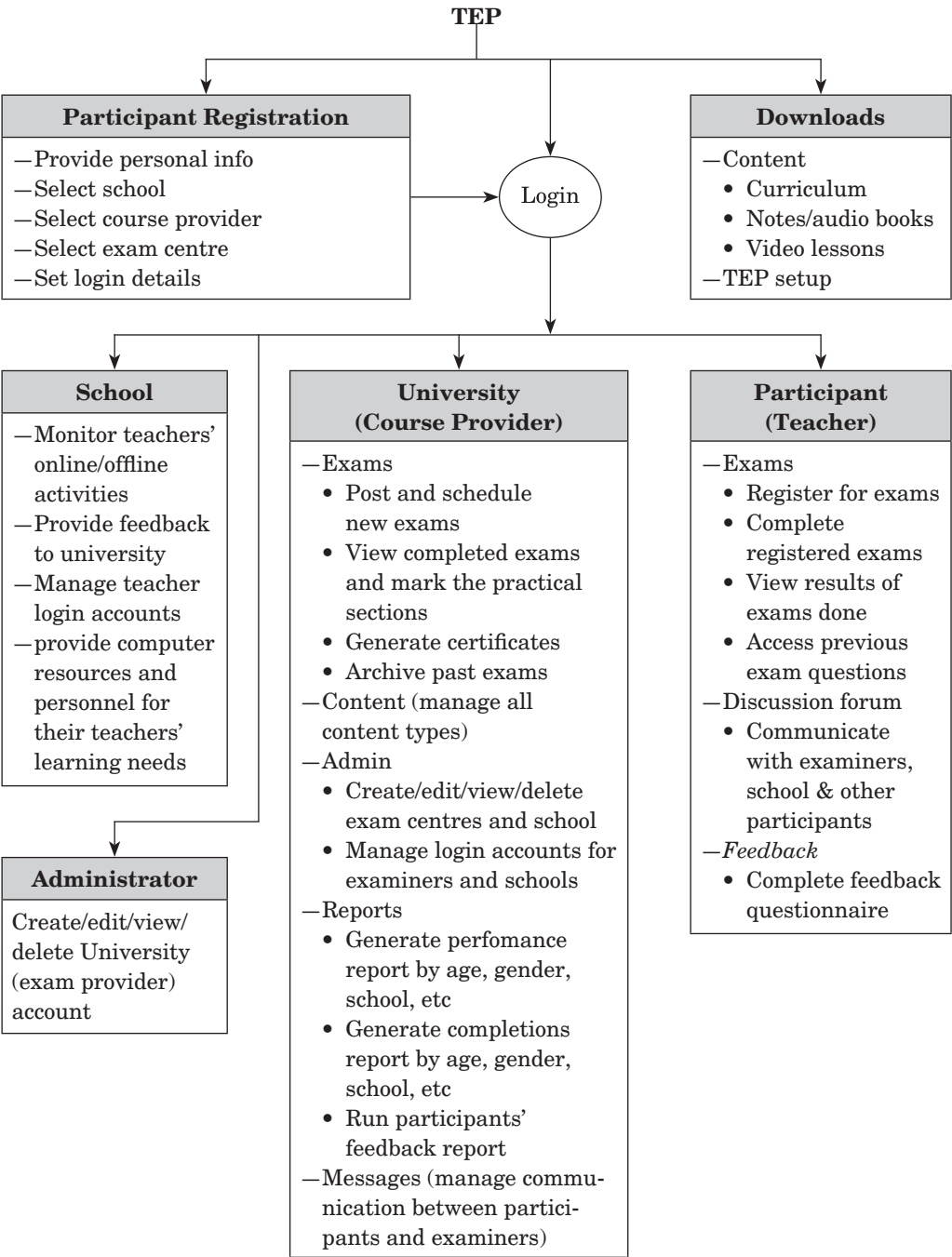


FIGURE 1. Overview of teachers' e-learning portal (TEP).

support their digital illiterate colleagues. In effect, TEP as a MOOC platform for environments with limited resources is more successful when integrated within the internal school academic structures by promoting teachers' access to available computing resources and technical personnel.

At the same time, the traditional relationship between universities and schools through the school practice programme for university education students provides additional opportunity for the in-service teachers to benefit from the school practice students' digital knowledge and skills. Indeed, anecdotal evidence suggests that students on school practice have adequate digital knowledge because they undergo double ICT training during their secondary school education and first year of university education.

Given the bandwidth and connectivity challenges in Uganda and off course Africa, offline support is a necessary requirement for MOOC platforms. In the context of TEP, offline support is possible in three ways. First, by promoting a new culture in schools whereby the digital literate teachers freely support their digital illiterate colleagues. Second, by the collaborating university encouraging their students on school practice to engage with registered teachers under their university's digital literacy programme. Third, through a technological solution whereby the collaborating school sets up an offline server for local access by their teachers enrolled for MOOCs under TEP. The offline server automatically synchro-

nises with the online server when connectivity is established.

4. The initial MOOC implementation through TEP

The initial MOOC offered on TEP was under the many universities to many schools implementation strategy as already highlighted. In this respect, TEP was integrated into the prominent secondary school online space called *Mwalimu* open educational resource (OER) and accessible at www.mwalimu.ug. Within this space, Gulu University as the pioneer MOOC implementer, was linked to secondary schools already registered under Mwalimu OER and in the same region as Gulu University. Gulu University was preferred because the Mwalimu OER was developed under a Gulu University - Google CS4HS project as already highlighted. Following the introduction of TEP on the Mwalimu online space, the original Mwalimu OER was conveniently renamed *secondary education e-learning tool* (SEET). To date, both SEET and TEP are accessible from the same Mwalimu URL (see www.mwalimu.ug). This is because of the symbiotic relationship whereby SEET provides a consortium of schools for TEP, while TEP generates content for SEET. In addition, the *Mwalimu App* which gives access to SEET and TEP will soon be available on the Google Play Store.

4.1. Participants

Participants for this study were drawn from an existing pool of 172 schools reg-

istered under SEET and distributed over 48 districts in Uganda. The top four active schools were identified based on school login analysis and number of examination materials downloads during the peak period of July and September 2014. July and September are peak months because of mock and post-mock examinations downloads respectively, in preparation for the Uganda national examinations in October/November. The schools were required each to identify 30 teachers from the lowest age bracket (<26 years) to the highest age bracket (>50 years) to participate in this study.

The emphasis on age was informed by Google C4HS-2013 project (Byabazaire & Oyo, 2014, pp. 15-16) and other previous research where age was found to influence digital literacy initiatives among in-service teachers (Andema, Kendrick & Norton, 2013; Mathipa & Mukhari, 2014; Labbas & Shaban, 2012). Table 2 presents the participants details. The schools labelled A to D in Table 2 are from the districts of; Gulu, Lira, Soroti and Serere, respectively. The respective population of full-time staff in these schools are 64, 76, 58 and 39, giving the percentage enrolment as shown in Table 2.

TABLE 2. The MOOC participants' enrolment by age.

School	Enrolment by age							% enrolment
	<26	26-30	31-35	36-40	41-45	46-50	>50	
School A	2	2	5	5	6	7	3	46.9
School B	2	3	5	5	6	7	2	39.5
School C	1	3	5	6	4	9	2	51.7
School D	2	3	4	7	5	5	4	76.9

Source: prepared by the authors.

Given the significant percentage enrolment variation as shown in Table 2, and the fact that teacher participant selection criteria was fixed on 30 persons, the selected schools in this study were evenly distributed across smaller school population (eg, school D) to larger school population (school B) continuum.

pletions by school and age group. This was based on the understanding that support from schools as well as participants age affect enrolment and completions in digital learning programmes (see Buabeng-Andoh, 2012; Mathipa & Mukhari, 2014).

5. Results

Findings were organised by comparing digital literacy training com-

5.1. Computer literacy course completions by school

One of the known challenges of MOOCs is low course completion rates of



between 10%-20% (Jordan, 2014). This was not the case with the computer literacy MOOC delivered on TEP that recorded high completions, i.e., 78%, 90%, 87% and 100% completions for the schools A to D respectively. A plausible explanation for the high completion rates is the effective implementation structure involving teachers, schools and universities as already discussed. In effect, high teachers' withdrawals from TEP programme, implies weakness of the respective schools in supporting the teachers. As such, school D that had 100% completions is considered more effective in supporting digital literacy of its teachers compared to School A with 78% completions.

5.2. Analysis of course enrolment, completions and scores by age group

The issue of age and digital literacy is a well-researched topic with some claims on the one hand, that older teachers who were born before computers are less likely to adopt computer applications compared younger teachers who were born in the computer age. Results from our study on the influence of age on digital literacy initiatives as shown in Figure 2 indicate that age difference was not a determinant in completions and average scores (79%) for computer literacy MOOC offered to teachers in the four secondary schools teachers by Gulu University.

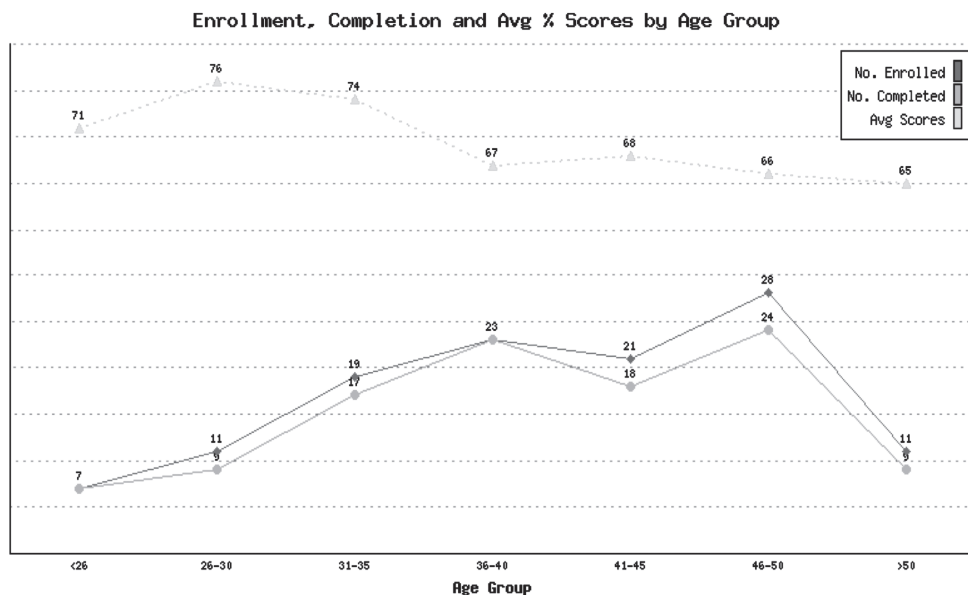


FIGURE 2. Analysis of course enrolment, completions and average scores (%) by age group.

In effect, Figure 2, reiterates the importance of effective support mechanism for teachers involved in digital literacy MOOC by their schools, without which the teachers' course completions and final scores would decline.

6. Discussion

Teachers' digital literacy is at the centre of e-education since digital literate teachers do not only influence students' access to e-resources but are directly responsible for development of e-resources. As for Uganda, the small number of active computer literate teachers is responsible for the low volume and quality of educational e-resources. In the context of the initial MOOC implementation in this paper, digital literacy of in-service teachers was addressed concurrently with development of e-resources. This is reflected by results from 120 teachers who enrolled for the basic computer training MOOC for which 107 completed, generating 107

content units. After further moderation of the content generated for duplication and to ensure relevance and quality, the units were reduced to 73, distributed over 7 subjects including mathematics, chemistry, physics, biology, geography, commerce, history and English. The moderated content units (notes or animated tutorials) are accessible without any restrictions from TEP's 'companion' application called secondary education e-learning tool (SEET).

Compared to other related initiatives in Africa, eg, TESSA's secondary education e-resources, as already discussed, that has existed since 2010 but with stagnated content, the initial TEP results both in terms of high ratio of teacher participants' completions (89%) and high volume of e-content generated, makes TEP an effective and attractive MOOC platform for in-service teachers' digital literacy and life-long learning needs.

TABLE 3. Analysis of TEP effectiveness for resource constraint environments.

Challenge	Evidence of the challenge	Mitigation strategy	Context of TEP
Sustainability	Content on TESSA's online platform has stagnant since 2012.	Explore self-sustainable strategies such as school management support and commitment of the target group (see, Warugaba and others, 2016)	Explicit emphasis on commitment of the collaborating parties (universities and schools) as well as the target teachers.

Challenge	Evidence of the challenge	Mitigation strategy	Context of TEP
Accessibility	In the context of Africa, internet access that enables MOOC participation is expensive, slow, unreliable and often unavailable (GSMA, 2014; Oyo & Kalema, 2014).	Offline and online access should be promoted concurrently for MOOCs. Walls and others (2015) maintain that offline platforms are more important than online platforms for building sustainable South African (and indeed African) e-education strategy.	Implementation of both online and offline access modes. Offline access is by design managed by the school through a local cached content server that synchronises with the online server when connectivity is established.
Digital literacy	There are no explicit digital literacy support strategies for in-service teachers in previous studies, ie, TESSA emphasises digital literacy of pre-service teachers and KCS engages already digital literate teachers.	Teachers' digital literacy initiatives are more successful when integrated into school programmes.	Digital literacy and life-long learning of in-service teachers are at the centre of TEP.

Source: prepared by the authors.

In order to comprehend the importance of TEP results, a comprehensive comparison with related initiatives in Africa is necessary. To this end, the generic challenges to MOOCs in resource constraint environments in the context of sustainability and accessibility (Warugaba and others, 2016) as well as digital illiteracy of teachers (Oyo and Kalema, 2014) is examined in Table 3.

Whereas the primary focus of TEP is supporting digital/computer literacy of in-service teachers, its implementation strategy involving teachers, schools and a local university, creates a unique op-

portunity for teachers' lifelong learning. The collaborating university under TEP is challenged to develop and deliver other relevant short courses for teachers' continuous educational development. Gulu University that pioneered TEP has developed other short courses for teachers including learning objects development, computer networking, computer repair, computer security, business process outsourcing and project management. These can be adapted by other intending universities in Africa.

From the feedback on user satisfaction, namely on how the teacher participants'

made use of the learning resources and how TEP influenced peer-to-peer collaboration, we learned that the teachers who participated in the training programme attracted other teachers who were either resistant to or afraid of computer skills training. Furthermore, through word of mouth, other schools that were not initially part of the training programme, requested for inclusion in the next training phase. The focus now is to create more awareness among schools and universities on MOOCs driven by TEP for digital literacy and online life-long learning of in-service teachers. This will create a critical mass of digital literate teachers and ultimately impact on existing and future e-learning initiatives in schools. We now end this discussion with the relevance of TEP to Africa.

6.1. Relevance of TEP to Africa

Africa is known for scarcity of resources in the key development areas including education. New interventions are therefore challenged to maximise impact with minimal funding. TEP is specifically designed to thrive in an environment of limited funding and/or limited internet access provided the collaborating partners (local universities and schools) are committed to their roles. The importance of TEP as a platform for implementing MOOCs for in-service teachers, in the context of Africa's situations is underscored by the following:

1. Enabling access through online and offline modes. One of the key premises of TEP is provision for caching

of digital content on an offline content server of the participating school for local access by teachers' on MOOCs. The offline server functions without constant internet connection and synchronises with the online server when connectivity is established. This is particularly important since internet access in many communities in Africa is expensive, slow, unreliable and often unavailable (GSMA, 2014; Oyo and Kalema, 2014).

2. Empowering schools to monitor and support study progress of their teachers thereby ensuring high completion rates. TEP as a MOOC platform for teachers' digital literacy and life-long learning is not immune to low completion rates in MOOCs (Christensen and others, 2013; Jordan, 2014). However, the high completion rate expected from TEP enabled MOOCs as already demonstrated by the preliminary results in this paper is partly due to the support by schools to their teachers. As such, the magnitude of teachers' withdrawals from TEP enabled MOOCs reciprocate into the quality of support and monitoring by their schools.

3. Minimising or eliminating costs by leveraging existing resources. TEP is designed to use existing resources to support digital literacy and life-long learning of in-service teachers. From the university side, part of the existing web hosting space for university website and academic staff time under outreach provisions are the main resources. The schools resources are the existing computers, internet subscrip-

tion, and ICT personnel. Through devotion to TEP enabled MOOCs by the collaborating university faculty/unit and school coordinators, greater teachers' digital literacy and other forms of literacy is achievable.

4. Flexible implementation options for the university as the main driver of TEP enabled MOOCs. Any university wishing to implement MOOCs under TEP has several initiation options, e.g., through existing school practice programme whereby undergraduate students majoring in education promote and support TEP in secondary schools during their school practice. Alternatively, the university can engage schools with relevant ICT resources directly as community outreach activity.

5. Life-long learning opportunity. TEP primarily supports basic computer literacy of teachers on which other skills programmes can be addressed. Other planned programmes beyond digital literacy currently include: development of learning objects, computer networking, computer repair, computer security, business process outsourcing and project management. New programmes can be initiated as their need arise.

The outstanding advantage of TEP enabled MOOCs is its unique sustainability strategy which is based on solidarity between its implementers (universities and schools) and reliance on existing resources (eg, university staff time, and computers and internet in schools), and not direct funding.

7. Conclusion

In this paper, we have presented TEP as a specialised MOOC platform for in-service teachers' digital/computer literacy and online life-long learning. TEP supports life-long learning through short course programmes in or at the interface of education, management studies, and information technology. For greater effectiveness and long term sustainability, TEP uses a unique implementation strategy involving teachers and their schools' support (technical personnel, computers and internet), and a local university. This extends the relevance of TEP beyond Uganda, where it has been successfully piloted, to the wider African situation. Moreover, TEP is also accessible offline through a local content managed under school account.

The effectiveness of TEP was tested in a pilot study involving four schools, each with 30 teachers. Percentage completions against age of these teachers were investigated and an average computer skills training completions of 89% was recorded for the four schools combined. These results confirm that teachers' digital literacy MOOCs are successful when teachers are adequately supported internally by their schools and externally by a university. In other words, as the participating schools provide the push force and the collaborating university the pull force, the resulting effect is teachers' improved digital literacy.

Judging from the findings reported in this paper, this study may be viewed as a model case, however, in depth analysis shows disparities in completions between teachers of mathematics and science sub-

jects versus the rest of the arts subjects. In fact the 11% completion deficit in this study, were all teachers of arts subjects. In light of this revelation, future research should investigate the effect of subject specialisation on teachers' use of technology to engage and support learning. Furthermore, digital/computer literacy is only the entry point into teachers' literacy needs. Other types of literacy, eg, multimedia literacy need to be addressed if teachers are to fully integrate ICTs into teaching and learning.

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