A Model for MOOC Implementation in Areas of Low Bandwidth in Developing Countries

Khuliso Sigama, Tshwane University of Technology, South Africa

Billy Mathias Kalema, University of Mpumalanga, South Africa*

iD https://orcid.org/0000-0002-2405-9088

ABSTRACT

Massive open online courses (MOOCs) could have been leveraged to bridge the education accessibility inequality gap in many developing countries, however many of the MOOCs platforms are developed to work in areas with good internet connections and high bandwidth leaving many rural areas excluded. The goal of this study was to develop a MOOCs model for areas with low bandwidth in developing countries. Literature search of technology implementation factors was carried out from which a conceptual model was designed. Using design science approach, the conceptual model was based on to developed an artifact of MOOCs platform that could be used in areas of low bandwidth. The artifact was evaluated using data collected from learners of tertiary institutions in South Africa. Results indicated that the developed artifact is suitable for use in areas of low bandwidth and that the model is a good guideline to the implementation of MOOCs platforms.

KEYWORDS

MOOCs, Online Learning, Developing Countries, ICT4ed

INTRODUCTION

The end of 2019 saw the advent of the coronavirus "Covid-19" that spread like wildfire, killing thousands of people and causing havoc in all sectors of life, including in education. Covid-19 and its acceleration to a pandemic forced many countries abruptly to close down education institutions, leaving those who were economically able to depend on digital environments in using online learning. However, even when some higher learning institutions in developing countries such as South Africa were prepared to teach in digital environments, lockdown held learners captive in their communities. Many communities are areas of low bandwidth, having intermittent networks and suffering from constant electricity interruptions. Such challenges aggravated the already existing education inequalities in developing countries and rendered online learning less effective.

Education inequalities in many developing countries have been a major challenge and are attributed to various aspects. Aspects are so numerous that even those learners who pass their final high school examinations sometimes fail to join tertiary institutions. This failure comes about for a variety of reasons, ranging from distances from the nearest higher education institutions (as many are located in

major cities) to lack of accommodation for those who are admitted for studies. These heterogeneous challenges have led to many capable students being denied higher education or suffering delays in joining these institutions (Botha & Swanepoel, 2015). These challenges could best be counteracted by leveraging the massive open online courses (MOOCs). According to Liyanagunawardena et al. (2017) and Zhu and Bonk (2019), MOOCs are a model of education delivery that has no limit to enrolment. MOOCs are open to everyone, usually with no tuition costs, and with a curriculum that leads to an award after completion. The introduction of MOOCs can be seen as an extension of various approaches used in teaching and learning in terms of open online access and scalability. MOOCs have become commonplace in the e-learning landscape and have attracted learners from a variety of backgrounds (Alamri, 2022).

Oyo and Kalema (2014) observed that the advent of MOOCs could have solved the education inequalities in developing countries, such as access to education. This is because MOOCs could allow rural learners to register affordably and to obtain qualifications with accredited institutions far from their homes at relatively very low cost. However, most MOOCs platforms were developed to operate in areas with good bandwidth. Such a limitation has led many rural areas, especially those in developing countries, to remain educationally excluded (Deng & Benckendorff, 2021; Liyanagunawardena et al., 2013; Zhu & Bonk, 2019).

According to Marques and Azevedo (2017), the primary aim of MOOCs is to open up education that provides free access to courses at a tertiary level to as many students as possible. Two key features of MOOCS give them an advantage over university online courses: Anyone can access MOOCs free of charge; courses are developed to support a very large number of students (i.e., scalability). MOOCs are developed to support the idea that knowledge can be shared freely and the desire to learn can be met without demographic, economic, and geographical constraints (Zakharova, & Tanasenko, 2019). Two major forms of MOOCs exist, namely, the cMOOCs and the xMOOCs. The cMOOCs are based on the theory of learning that allows learners to construct the learning process through interactions. Conversely, the xMOOCs are structured in the same way as the traditional online higher education courses (Zhu et al., 2018). Apart from providing an enhanced tool for education delivery, online learning also promotes flexibility, accessibility to open educational resources, and good communication among learners and facilitators. Hence, this allows opening up boundaries for tertiary education to those learners who are less privileged and have traditionally been excluded (Traxler, 2018). Most notably, these new learning technologies are bringing about massive change in tertiary education worldwide.

BACKGROUND OF THE STUDY

Developing countries still have the majority of their citizens from indigent backgrounds, with limited or no means of steady income. Such are the main reasons for many of the youths staying at home after completing their high school studies (Zakariah et al., 2016). Furthermore, institutions of higher learning in many developing countries have a problem of space. Institutions are thus unable to accommodate half of the students who qualify from high schools for tertiary education (Oyo et al., 2017). Additionally, many developing countries' high school students fail to progress to universities and other tertiary institutions. This is not because they are academically weak; reasons for this are economic, social, and environmental (Liyanagunawardena et al., 2017; Sigama & Kalema, 2020).

Universities are seen as the torchbearers, when it comes to the implementation of innovations. However, many institutions of higher learning in developing countries are still behind, when it comes to the use of these innovations. For instance, African institutions of higher learning are not only slow in implementing MOOCs, but they are also silent spectators of the ongoing MOOCs revolution (Zakharova & Tanasenko, 2019). Several researchers (Jouicha et al., 2020; Oyo et al., 2017;) have identified developing countries' major barriers to e-learning as including poor technological infrastructure, for instance, low bandwidth and intermittent networks. These researchers believe

that much effort has been put into solving the traditional challenges, such as lack of information and communication technology (ICT) skills, high costs, lack of support, and poor electricity supply. However, little has been achieved towards solving the problem of low bandwidth. Many countries in Africa have widely implemented rural electrification. Many university projects for community engagement have concentrated more on providing ICT skills, leaving the network and bandwidth issues in abeyance. This points to the need for developing a model to guide the implementation of the MOOCs platform in low bandwidth areas.

MOOCs in Developing Countries

Oyo and Kalema (2014) argued that, with limited funding in many developing countries, a more effective approach to e-learning technologies is necessary, as some challenges cannot be solved overnight. Oyo and Kalema's argument motivated this study in that MOOCs implementation could be studied from a different perspective, that of benefiting developing countries. Today's prevalent MOOCs tend to appeal to people who are already well-educated. These persons have access to adequate Internet bandwidth, allowing such access and the viewing of well-crafted videos and other learning materials without further optimization (Sigama & Kalema, 2020; Stracke & Trisolini, 2021). Such is the developing countries' wide call to enhance e-learning platforms to enable learners in the geographically and politically disadvantaged areas (Liyanagunawardena et al., 2017). Besides furthering education, learners from these disadvantaged areas also face the problem of attaining quality education. Many prospective students ultimately register with private colleges that are, in most cases, not accredited—this reduces graduates' employability. Marques and Azevedo (2017) noted that MOOCs can be developed to the point that learners can complete their qualifications with accredited institutions. This will not only improve enrolment in traditional institutions, but will also reduce the high unemployment rates in many developing countries.

O'Connor (2014) noted that some developing countries' traditional universities, such as the University of South Africa, Nelson Mandela University, Witwatersrand, Kenyata University, University of Zimbabwe, and the University of Cape Town, have begun to use MOOCs, while others have shown little interest. However, much as these universities have shown interest and have gone a step ahead to utilize MOOCs platforms, use is still limited to urban areas with good network connectivity and reliable bandwidth. The already disadvantaged learners in rural settings are thus excluded (Al-Rahmi et al., 2019). This has solved few problems of the traditional challenge of limited accessibility to quality education. Additionally, Kalema and Oyo (2014) highlighted the lack of standardization of MOOCs across pedagogies and curricula. These researchers indicated that such lack has challenged many traditional universities' adoption in developing countries. Recently, Stracke and Trisolini (2021) echoed the lack of standardization; indeed, they indicated that, judging by the many types of MOOCs with varied providers having different standardization purposes, quality control is still a challenge.

Another impeding factor for MOOCs' implementation in developing countries, especially those in Africa, is the language barrier. It should be noted that many known MOOCs platforms have been developed in English, which is a challenge to many Francophone countries not originally British protectorates (Zhu & Bonk, 2019). Amidst these challenges, Oyo and Kalema (2014) provided the strategy for implementation of MOOCs in Africa, clustered under the following five baseline requirements:

1. A national accredited MOOCs curriculum that takes into consideration the challenge of language barriers as well as accreditation of the awarding institution.
2. Electronic content development that encompasses the suitability of the learning content.
3. Development of a central e-learning platform to deal with uniformity and cross-cutting modules.
4. Establishment and funding of MOOCs coordination units at public higher education (HE) institutions.
5. Establishment of MOOCs access hubs at strategic locations, also referred to as e-learning satellite centers.

However, many of these suggestions for MOOCs' expansion in developing countries still do not solve the problem of unsuitable infrastructure and low bandwidth (Jouicha et al., 2020; Sigama & Kalema, 2020).

Oyo et al. (2017) examined the future of higher education in the developing world. These researchers highlighted that there are low returns of estimates in education. This brings imbalances in higher education in developing countries. Oyo et al.noted that such imbalances may only be overcome if developing countries increase the numbers of highly skilled people, in order to thrive in the emerging knowledge-based economy. However, some researchers (Ali et al., 2018; Zajda & Rust, 2016) allude to mass enrolment at tertiary institutions in many developing countries being challenged by various factors. These factors include constrained government budgets to support education, lack of space within the institutions, low socioeconomic status of learners, as well as brain drainage that leaves many tertiary institutions with few educators when qualified personnel leave to seek greener pastures. All such challenges may be reduced or overcome if developing countries leverage MOOCs. Education can then benefit by its advantages that include, but are not limited to, provision of high quality, low cost, and high-scale education, increased access, as well as flexibility (Li et al., 2018; Lin & Hwang, 2018; Liyanagunawardena et al., 2017).

Theoretical Foundations

The authors discussed theoretical frameworks and reference theories for this study from two perspectives, namely, theoretical perspectives related to e-learning and those related to technology implementation and adoption. Ghavifekr et al. (2016) observed that, from the e-learning perspective, earlier models emphasized the role of technology in providing content, delivery, and electronic services, whereas the later models acknowledged the importance of pedagogical issues. Another basis for the discussion of this theory the authors highlighted in the study was that Web-based learning, also known as e-learning programs, had been designed to include groups of learners. These include working adults who are unable to attend face-to-face classes, isolated communities far from institutions, economically disadvantaged people, and undergraduate students who need to attend classes spontaneously (Picciano, 2017; Zhao et al., 2022). This understanding made the discussion of technology application in learning, together with the pedagogies involved, important factors in MOOCs implementation. Based on this understanding, the authors discusse the three theories of connectivism (Siemens, 2005), the framework for Web-based learning (Khan, 2001), and the demand-driven learning model (MacDonald et al., 2001) to inform the foundations of e-learning perspectives.

The connectivism theory provides an understanding of the learning skills and tasks learners need to cope with technology integration for teaching and learning (Siemens, 2005). The theory elucidates that, with the advent of technology, the traditional approaches of behaviorism, cognitivism, and constructivism are essential for explaining the creation of instructional environments. Such approaches suffice in the digital era. The learner needs to communicate during the learning process while taking cognizance of the underlying social environments. Connectivism views the individual as the center of learning, followed by technology and the environment. Other factors include social negotiation, a wide variety of perspectives, ownership, and self-awareness.

On the other hand, the framework for Web-based learning indicates that, with the use of the Internet, there is an increased opportunity of developing learning-on-demand, based on learner-centered instruction and training (Khan, 2001). Hence, online learning should take into consideration technological aspects as well as resources and pedagogies. This theory categorizes factors in online learning into technological, institutional, pedagogical, interface design, management, ethical, resource support, and evaluation (Khan, 2001). Lastly, the demand-driven learning model was developed as a unifying theoretical conceptualization that places a high-quality standard on Web-based learning programs. It emphasizes that online learning should provide timely response to a learner and that higher education must be made more accessible, convenient, flexible, and effective (MacDonald et al., 2001). These three pedagogical theories highlight the importance of including the individual

characteristics, technological factors as well as the environment, in the conceptual model of this study, in addition to the realization of openness of learning and learning networks.

From the technological implementation and adoption perspective, in this study the authors applied the notion of Kwon and Zmud (1987), who alluded to the readiness concept being paramount for an educational environment. In their study of the unification of fragmented information system implementation models, Kwon and Zmud (1987) found that technological innovations are adopted, accepted, and used in a variety of ways, depending on the technological aspects, organizational and structural characteristics, environmental factors, and individual characteristics. They further indicated that the technological context may include both equipment and processes, as well as users' and organizations' perception of technology. Later, De Pietro et al. (1990) and Rogers (2003) echoed this notion and developed the technology, organization, and environment model and the diffusion of innovations theory, respectively. The technology, organization, and environment model addresses the non-behaviour concepts of technology, organization, and environment, whereas the diffusion of innovations theory looks at the perception of individuals towards technology in terms of relative advantage, complexity, trialability, and observability, as well as the technology characteristic of compatibility. As Al-Rahmi et al. (2019) noted, the effectiveness of MOOCs is dependent on collaborative learning and communication that allows learners for the flexibility to interact with others. This implies that pedagogical theories need to be combined together with technology adoption and use theories to embrace the concepts of network, complexity, self-organization, as well as the organizational and environmental aspects.

METHODOLOGY

The authors conducted this study in three phases that formed the methodology. The first phase was carrying out a search for the factors needed for successful implementation of MOOCs, whose results informed the development of the conceptual model. The second phase was conducting the traditional data collection and analysis. The last phase was designing the MOOCs platform for a low bandwidth artefact.

The authors used MOOCs' content search to find factors listed in the literature on MOOCs and other online learning implementation in higher education institutions. The authors reviewed 36 scholarly articles that included conference proceedings, journals, Web articles, and Internet magazines. The databases they searched included Google Scholar, Emerald, Elsevier Science Direct, ProQuest, and IEEE Xplore. The selection depended on the language for the databases, which, in this case, was English, and the access of the selected databases from 2013 to 2020. The search terms used included "MOOCs implementation," "MOOCs in developing," "MOOCs factors," "MOOCs implementation factors," "MOOCs and higher education factors," "challenges of MOOCs implementation," "MOOCs in developing countries," "failure of MOOCs implementation," and "MOOCs implementation issues." The authors used the operators "AND," "OR," as well as their combination when searching the databases. They adopted Microsoft Excel to tabulate the results and to count the frequency of appearance of each factor. They categorized similar factors; theye renamed and gave a common name to those with the same meaning. Table 1 illustrates the summary of the identified factors in their respective categories.

CONCEPTUAL MODEL

Besides the content search from the literature, the authors leveraged the reviewed models and theories of technology implementation and the e-learning pedagogies theories to act as a lens underpinning this study. These theories also helped in the categorization of factors under the constructs that formed the basis of the conceptual model design. Hence, from the identified factors and their categorization, as illustrated in Table 1, the researchers developed a conceptual model (Figure 1). The categories

Table 1. Factors influencing MOOCs implementation in developing countries

Category	Factor	Frequency
Organizational	Scale of massiveness	36
	Policies	34
	Technological support	33
	Funding	33
	Openness	21
	Credits recognition	20
	Change management	15
Technological	Infrastructure	33
	Network reliability	32
	Hardware	31
	Software	30
	Maintaining and upgrading hardware and software required for e-learning	30
	Technical support	29
	Internet quality	29
	System quality	27
	Online platform	27
	Perceived ease of use	25
Environmental	Top management support	37
	Vendor support	32
	Geographical location	27
	Government and political support	20
	Policies and standards	16
Individual	Attitude	40
	Experience	34
	Trust	31
	Motivation	30
	Awareness	30
	Behaviour	21
Pedagogical	Flexibility	33
	Quality resources	31
	Content development, organization, and access	30
	Interactivity and peer-to-peer pedagogy	29
	Focus of subjects	28
	Pre-course information	20
	Timing	13

of the factors formed the constructs of the conceptual model and the factors their measuring items or attributes.

Operationalization of Constructs

As Figure 1 illustrates, the constructs of the conceptual model include individual, organizational, technological, environmental, open learning, learning communities, and distributed learning factors. They are detailed below.
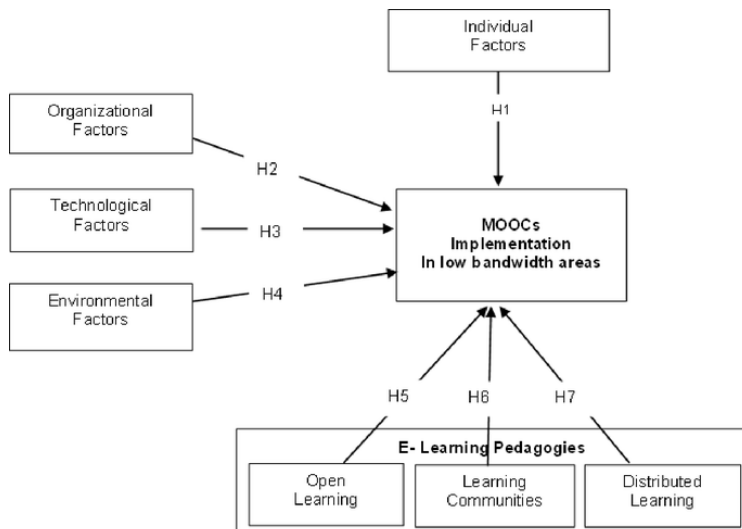
Individual Factors

These are nontechnical factors individuals possess on the technology implementation team. Such factors may arise through the differing sociotechnical backgrounds, diverse cultural and ethical beliefs, as well as educational background of the users. These factors include attitude towards technology and new innovative ideas, experience in using Web-based resources, trust of the online system, motivation and eagerness to use technology, awareness of the use and benefits of MOOCs, and behavior towards new innovations. This understanding led to the development of the first hypothesis.

Hypothesis One: Individual factors influence MOOCs implementation in low bandwidth areas.

Organizational Factors

In the context of this study, organizational factors refer to the institutional determinants that play any role in the implementation of MOOCs (Al-Rahmi et al., 2019; De Pietro et al., 1990). These factors are aligned with the organizational strategies derived from the mission, goals, objectives, and the guiding principles. As Table 1 shows, the organizational factors encompass: The scale of massiveness, including the number of learners and instructors that are to use the MOOCs platform; policies and standards that may also include operational procedures and technological support in terms of human resource; subscriptions to new technologies and financial funding of IT budgets; openness to new ideas and innovations; credits recognition of innovative ideas, as well embracing new changes that supports innovations. From this understanding, the authors developed the second hypothesis.

Figure 1. The conceptual model

Hypothesis Two: Organizational factors influence MOOCs implementation in low bandwidth areas.

Technological Factors

These factors relate to users' perceptions of the technology, innovation characteristics, and organizational preparedness to implement technology (Kwon & Zmud, 1987). The technology attributes in relation to MOOCs may include, but are not limited to: infrastructure, which refers to both online and offline devices settings that are needed in order to use MOOCs; network reliability, which means the nature of the network determines the effectiveness of the operation and this fits well with the goal of this study to optimize the MOOCs material based on the available bandwidth, hardware, and software working hand in glove and institutions having to ensure that they use the latest and most compatible hardware and software; maintaining and upgrading hardware and software required for e-learning; technical support from both the institutional IT team and vendors; Internet quality, system quality, online platform, as well as perceived ease of use. Several studies have indicated that an easy-to-use technological system will attract users, whereas a system complex to navigate will hinder them (Liyanagunawardena et al., 2017; Sigama & Kalema, 2020). This led to the formation of the third hypothesis.

Hypothesis Three: Technological factors influence MOOCs implementation in low bandwidth areas.

Environmental Factors

These are factors seen to have an effect on physical activities within an organization. This study identified four factors that fall into this category: Top management support, vendor support, geographical location, government and political support, and policies and standards. As with the technological factors, in various studies of technology adoption and pedagogy have highlighted the environmental factors being core for an online learning environment (Khan, 2001; Jouicha et al., 2020; Lin & Hwang, 2018; MacDonald et al., 2001). Based on this understanding, the authors developed the fourth hypothesis.

Hypothesis Four: Environmental factors influence MOOCs' implementation in low bandwidth areas.

Open Learning Factors

This construct elaborates that open learning allows learning materials to be freely available on the Internet and accessible to anyone who is interested (Khan, 2001). This makes them a suitable option for anyone who would like to conduct studies online. Openness also embraces the aspects of flexibility, interactivity, peer-to-peer pedagogy, and precourse information (MacDonald et al., 2001). From this construct, the authors developed the fifth hypothesis .

Hypothesis Five: Open learning factors influence MOOCs implementation in low bandwidth areas.

Learning Communities Factors

These are the groups of people who support one another in learning, working together on projects, learning from one another, and becoming involved in sociocultural experiences to transform new experiences into new learning. Below is the sixth hypothesis.

Hypothesis Six: Learning communities' factors influence MOOCs implementation in low bandwidth areas.

Distributed Learning Factors

This implies the use of one or more technologies to deliver education anytime anywhere to various locations, which helps in gaining the buy-in of implementers. Distributed learning embraces the aspect of different groups of professionals working together to provide online learning assistance in the form of such computer programmers, security and testing specialists, as well as instructors who are to develop the electronic learning content. This led to the seventh hypothesis.

Hypothesis Seven: Distributed learning factors influence MOOCs implementation in low bandwidth areas.

Data Collection

Based on the conceptual model, the authors designed a measuring instrument in the form of a questionnaire with closed-ended questions for data collection. The researchers designed the questionnaire in such a way that the constructs of the conceptual model formed the sections of the questionnaire, whereas they used the attributes for each construct to formulate the questionnaire measuring items.

Validity and Reliability

During the design of the questionnaire, the researchers ensured that the questionnaire conformed to modes of validity. They ensured face validity by checking that the questionnaire was free from errors of syntax, grammar, and typography, whereas they ensured content validity by checking that the questionnaire covered the required content and that all the correct operational measures were adequately covered. Additionally, they checked construct validity by determining that the questionnaire covered the constructs of the conceptual model, whereas they checked criterion validity through the correlation of the constructs. After ensuring validity, the authors tested the questionnaire on the staff of a department that was not going to participate in the major survey. In all, 20 staff participated in the pilot study; the researchers used the results to test the reliability of the questionnaire using the Cronbach's alpha coefficient. The overall reliability of the questionnaire was .764. Individual constructs showed reliability above 0.6. The authors deemed the questionnaire fit for further analysis since each construct had fewer than five measuring items.

Population and Sampling

Participants in the study included lecturers and instructors at a university and a technical and vocational education and training (TVET) in Limpopo Province, South Africa. A total of 220 staff was eligible for participation in the study. Hence, by using Krejcie and Morgan's (1970) tool for determining a sample size for a finite population, the researchers selected 140 respondents. Of the distributed and returned questionnaires, 136 documents were usable, four having incomplete data. They analyzed data using the statistical package for social scientists (SPSS) v 25, which included descriptive statistics, correlation, and regression analysis.

RESULTS

Tables 2 and 3 present the results of the analysis of the collected data. Table 2 presents the frequencies of the respondents' demographics.

Most of the respondents were males, with a 53.7% (n = 73) response rate compared with that of females at 46.3% (n = 63). This implies that, if MOOCs are to be implemented, these young people with the desire to use technology will find few challenges in place. The majority of the respondents were those who had never used any MOOCs platform before, with 89.7% (n = 122), a small number

Table 2. Frequencies of demographic and situation variables of respondents

Moderating Factor		Item	Frequency	Per Cent	Validity per Cent	Cumulative Per Cent
Gender	Valid	Male	73	53.7	53.7	53.7
		Female	63	46.3	46.3	100.0
		Total	136	100.0	100.0	
Role	Valid	Student	108	79.4	79.4	79.4
		Lecturer	16	11.8	11.8	91.2
		IT Industry Specialist	6	4.4	4.4	95.6
		Administrator	6	4.4	4.4	100.0
		Total	136	100.0	100.0	
Previously used MOOCSs platform	Valid	None	122	89.7	89.7	89.7
		Coursera	8	5.9	5.9	95.6
		FutureLearn	1	.7	.7	96.3
		Edx	5	3.7	3.7	100.0
		Total	136	100.0	100.0	
Previous online learning experience	Valid	None	3	2.2	2.2	2.2
		Not very good	16	11.8	11.8	14.0
		Good	82	60.3	60.3	74.3
		Very good	35	25.7	25.7	100.0
		Total	136	100.0	100.0	
Internet usage frequency	Valid	Never	2	1.5	1.5	1.5
		Less often	42	30.9	30.9	32.4
		Often	61	44.9	44.9	77.2
		More often	31	22.8	22.8	100.0
		Total	136	100.0	100.0	

Table 3. Constructs coefficients of regression analysis

Model		Unstandardized Coefficients		Standardized Coefficients	T	Sig.
		B	Std. Error	Beta		
1	(Constant)	3.804	0.665		5.720	.000
	Organizational	.027	.013	.108	2.082	.048
	Technological	.054	.025	.201	2.157	.045
	Environmental	.520	.149	.345	3.490	.005
	Individual	.438	.107	.374	4.095	.000
	Open Learning	.401	.106	.372	3.777	.001
	Learning Community	.365	.113	.322	3.232	.017
	Distributed Learning	.621	.188	.328	3.304	.012

a. Dependent Variable: Implementation

of respondents 10.3% (n=14) indicating that they had previously used MOOCs platforms such as Coursera, Edx, and FutureLearn.

Results also indicated that a good number of respondents (60.3%, n = 82) had had vast experience in using online learning platforms. This was true, as the majority of the respondents were college students. Prior knowledge of technology usage has been attributed to increased self-efficacy, which, in turn, improves usage (Oyo & Kalema, 2014). This number was reasonably good compared with those with no experience at all (2.2%, n = 3). Since MOOCs are an online platform, this study also investigated the respondents' use of the Internet. Results indicated that 44.9% (n = 61) of respondents often used the Internet, whereas 30.9% (n = 42) used it less often, 22.8% (n = 31) used it more often, and 1.5% indicated that they had never used it before.

Regression Analysis

The authors also carried out multiple regression to determine the prediction of the constructs. Table 3 illustrates constructs coefficients of regression analysis.

Organizational, technological, environmental, individual, open learning, learning community, and distributed learning factors were all significant for MOOCs implementation, with the values below 0.05 all at a 0.005 level of significance. The researchers found individual characteristics to be a highly contributing factor to the implementation of MOOCs, having 37.4% (β= 0.374) with p = .000, implying that, to participate in online activities including learning, an individual's self-efficacy, "learnability," experience with technology, attitude towards technology, as well as skills play an important role. In the same manner, factors that also indicated a highly significant contribution, such as open learning and environmental factors, could be seen as crucial to increasing the efficiency of distance and online learning.

Testing the Hypotheses

Hypothesis testing is key to deciding whether the suggested effects have actually occurred, whether the given treatments have effects, whether the conceptual framework constructs differ from one another, and whether one construct predicts another. Table 4 shows the significance of the hypotheses relationship, and whether they were supported or not, based on their p values at 0.05 level of significance.

Table 4. Hypothesis testing

Suggested Hypotheses	Significant P	Comment
Hypothesis One: Individual factors influence MOOCs implementation in low bandwidth areas.	P = 0.000 < 0.05	Supported
Hypothesis Two: Organizational factors influence MOOCs implementation in low bandwidth areas.	P = 0.048 < 0.05	Supported
Hypothesis Three: Technological factors influence MOOCs implementation in low bandwidth area.	P = 0.045 < 0.05	Supported
Hypothesis Four: Environmental factors influence MOOCs implementation in low bandwidth areas.	P = 0.005 < 0.05	Supported
Hypothesis Five: Open learning factors influence MOOCs implementation in low bandwidth areas.	P = 0.001 < 0.05	Supported
Hypothesis Six: Learning communities factors influence MOOCs implementation in low bandwidth areas.	P = 0.017 < 0.05	Supported
Hypothesis Seven: Distributed learning factors influence MOOCs implementation in low bandwidth areas.	P = 0.012 < 0.05	Supported

The results in Table 4 confirmed that all the theorized relationships were significant. This implies that the conceptual model could be based on developing an artefact for a MOOCs platform, once the designed MOOCs model fully supports implementation in areas of low bandwidth.

DISCUSSION

The Covid-19 pandemic enlightened educational authorities and provided the various perspectives on how learners in different parts of the world experience educational challenges. The pandemic also acted as an eye-opener for higher institutions on the need to have a paradigm shift from face-to-face teaching to online or blended learning in order to maintain sustainable practices for education delivery. The desire to sustain education delivery amidst health challenges of Covid-19 that required social distancing deepened the social inequalities between developed and developing countries and between the urban wealthy and the rural indigent. The need to leverage online learning approaches and tools such as MOOCs became prevalent and thus the desire to make MOOCs benefit all learners, regardless of their geographical locations or socioeconomic status (Alamri, 2022).

In this study, the authors reviewed literature relating to online learning in higher institutions of learning by leveraging approaches and tools such as MOOCs. The review of the literature, together with the underpinning theories, led to the development of the conceptual model for MOOCs' implementation in areas of low bandwidth. Results revealed that ICT usage in developing countries is still a huge challenge due to lack of resources such as reliable bandwidth, computers, high-speed networks, and electricity supply. This was also explained by the fact that, during the height of Covid-19, many higher learning institutions tried to change to online learning; however, many failed to achieve their desired goal due to these challenges. Results also indicated that other factors, such as individual characteristics ranging from attitude, to awareness, acceptance, and resistance to innovations, in addition to organization and pedagogical factors, are key to the successful implementation of MOOCs in areas of low bandwidth. The findings of this study are in agreement with those of previous researchers (Alamri, 2022Marques & Azevedo, 2017; McGill et al., 2014), who also observed that, besides technological issues, individual behaviors and factors leading to them play a major role in successful technology implementation.

The developed MOOCs model resulted in an abstract architectural design for the artefact of the MOOCs platform for low bandwidth areas. After the development of the artefact, the researchers tested the platform in both low bandwidth and offline environments for the delivery of the content. It was evaluated by learners of both a university and a TVET college. In the testing, the authors used various types of file media that allow full access to the content videos, documents as well as audios.

ARTEFACT DEVELOPMENT

The authors conceived the development of the artefact to construct a MOOCs platform that could allow automatic shrinking of the file on detection that the bandwidth was very low. In MOOCs there are resources, interactions, identity assessments, analytics certification, and events. These should work in areas where the bandwidth is lower than in those of high bandwidth. The researchers empowered the MOOCs platform to enable the automatic optimization of files of various formats, such as text, graphics, video, and audio, to be accessed in areas of low width, exactly as they are accessed in those areas of relatively high bandwidth. Hence, to achieve this, the authors had to include, but governed by the quality of service rules, a sequence of processes that have inputs and outputs, along with network and multimedia optimization which are the major players. In this case, the inputs to optimization states of network and multimedia processes are their preoptimization states, the postoptimization states are the outputs. These optimized states of network and multimedia provided a high-performing multimedia learning content suitable for MOOCs platform usage in areas of low bandwidth.

Technical/Nonfunctional Requirements

Technical requirements, also known as nonfunctional requirements, refer to the technical aspects that a system must satisfy, such as execution-related issues, unwavering quality issues, and accessibility issues (Johansson & Lahtinen, 2013). The technical requirements of the system that the authors considered included authorization for uploading videos of learning materials, performance (also in uploading and processing videos), allowing a nontechnical user to upload and download videos of learning contents; and also to allow optimization such that a user in a low bandwidth area would be able to watch the videos as clearly as anyone in a high bandwidth area.

Functional Requirements

According to Johansson and Lahtinen (2013), functional requirements are the statements of service that the system should provide. They also show how the system should react to particular inputs and also in certain situations. The authors considered some functional requirements of the MOOCs platform and placed them in two different categories, namely, the administrative category, which included instructors and technical personnel, and the learners, who use the system to study and upload assignments and course work.

From the administrative side, the authors developed the system in such a way that it supports a number of standard roles (e.g., administrator, instructors, and learners). The system allows instructors to have different rights from those of learners (e.g., uploading and modifying the online learning contents and coursework). This would allow the creation of user groups to collaborate, communicate, and share content and allow administrators to establish specific settings for the rights of users based on user roles. The system would also enable the monitoring of visits and other statistics of the platform, as well as allowing learners' activities in the system (i.e., login tracking). At the learners' end, the authors developed the system to enable learners to search for specific courses on the platform, even before registration. This would allow learners to register before accessing the system, accessing additional features after logging in and to create accounts with the same name or registration number.

Layers of Interaction

The researchers divided the developed MOOCs platform into three layers, namely, Web layer, business-logic layer, and data-access layer.

The Web layer is the front-end layer in the three-tier system. This layer consists of the user interface accessible through a Web browser or Web-based application, which displays content and information useful to an end user. All the users, namely, administrator, instructor, and learners, access the system via this layer, which gives them access to Bootstrap: CSS, JavaScript, jQuery, ReactJS, a JavaScript framework for front-end development, and Shaka Player. A media player offers built-in JavaScript for adaptive media streaming. The business-logic layer, on the other hand, drives the core capabilities of an application because it contains the functional business logic. When the user clicks on the login button, the business-logic layer interacts with the database layer. The business-logic layer sends the required information to the presentation layer, and is responsible for performing detailed processing. In this layer, a process of mediation between Web and the database layer is performed.

In this case, the researchers used five developmen: ExpressJS, which is a server framework written in NodeJS (JavaScript); FFMpeg, which provides a media transcoding tool and is written in C++; Shaka Packager, which allows the media packaging tool also written in C++; Multer and GridFS which is the library used for database management that helps perform functions such as the CRUD. The last one was the JSON Web Tokens that is used for user authentication. Lastly, there is the data-access layer, which communicates with the business-logic layer to retrieve data. This layer is responsible for data manipulation such as insertion, updating, and deletion. This layer uses two databases, namely MongoDB and Amazon S3. The MongoDB connects the server to the MongoDB database for text files, whereas the Amazon S3 is used for media files.
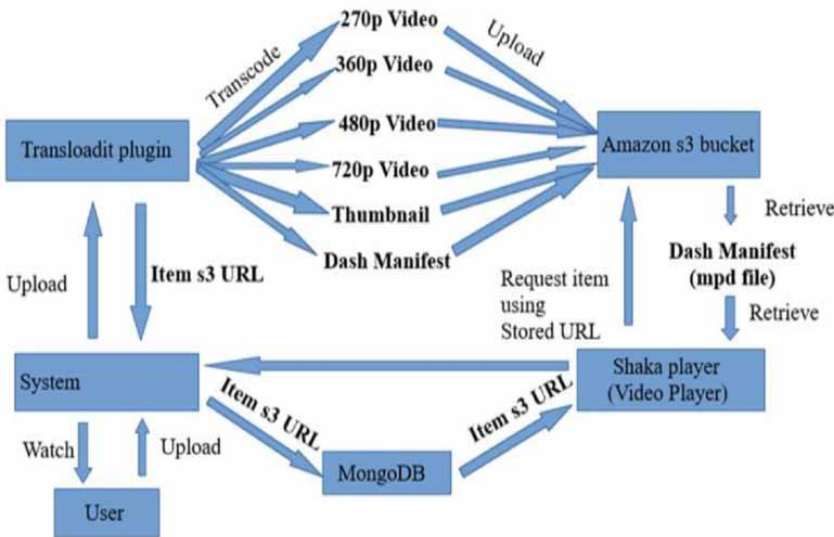
File Conversion

The file conversion process was the major aspect of this study. For the MOOCs platform to operate in areas of low bandwidth, it should have the capacity to optimize files of any kind such that they may be accessed in required format, depending on the available bandwidth (Figure 2). The Transloadit processes images, videos, and audio. It resizes and optimizes images, extracting thumbnails from videos or converting files from one format to another. The various quality files are run, and then the derivatives are saved to an Amazon S3 bucket. The results of these processes are then used to notify the application about the newly generated files, so that the database is updated accordingly. The type of compressed file to display will then depend on the available bandwidth. The conversion of files into different formats is conducted using the MongoDB and the Amazon S3 databases (Figure 2).

Artefact Evaluation

After the development of the artefact, the researchers populated the platform with four courses, namely, two for the university and other two for the TVET. Thereafter, the authors deployed the artefact at two higher institutions−a university and a TVET in Limpopo Province, South Africa. Participating learners from the two institutions were allowed to use the platform for one term, which is a period of two and half months, and thereafter requested to evaluate the system. Learners were asked to give their feedback on the platform's performance, based on a closed-ended questionnaire employing a Likert scale of five. On this scale, 1 and 5 represented "strongly disagree" and "strongly agree," respectively; 3 represented "not sure," whereas 2 and 4 were the respective mid-values. The researchers evaluated the platform on its relevancy to the students' activities, usability, ease of use, ease to navigate and access the learning content, as well as on its responsiveness. They also asked the learners whether they had any recommendation for improvement. The authors used a quantitative approach for evaluation; the findings helped to carry out a step-wise refinement that allowed an iterative process of development, evaluation, and further suggestion.

Figure 2. Video conversion using Transloadit plugin

CONCLUSION

During the current wave of the worldwide pandemic of Covid-19, learners can no longer converge in lecture rooms or campuses. A MOOC is one of the revolutionary online learning applications that must be leveraged. By using MOOCs, ICTs connect the world and bring academicians in various universities closer to autonomous individuals in remote areas worldwide who are trying to study on their own. This trend is likely to spread over the globe for quite some period of time. Therefore, the current MOOCs platforms must be reevaluated and restructured to cover all areas, whether the urban wealthy or the rural indigent. This implies that MOOCs, as one of the most popular online education platforms, should be redesigned and regulated to meet the needs of those learners in the rural settings. From this understanding, researchers and policymakers must join hands to solve the challenges of online education in rural settings both academically and practically.

The authors conducted this study at the peak of Covid-19, when pressure to use technological innovation such as online learning tools was great. Much as the conceptual model was designed and the developed artefact evaluated, the findings of this study do not guarantee continued usage of the artefact, especially after the Covid-19 pressure has lifted. This is mainly because factors that influence continued usage such as exerted pressure, satisfaction, as well as intention for further use were out of the scope of this study. Furthermore, the authors believe that some factors that informed the designing of the conceptual model may cease to be influencing the artefact usage, while others become salient, rendering the artefact less effective. Therefore, the authors recommend that future research either consider a longitudinal survey and/or a test for continuance usage.

The realization of many benefits associated with technological innovation related to online learning such as MOOCs necessitates the accommodation of learners in developing countries that are ever challenged by intermittent networks, irregular power supply, and low bandwidth. Implementation of MOOCs must be guided by empirically tested models which are developed for evolving countries, to be applied in areas of low bandwidth. The MOOCs platform artefact the authors developed in this study can be seen as a cornerstone of increasing opportunities for self-directed and open-ended learning learners need to access higher education.

Lastly, the identified challenges to online education, especially to MOOCs in developing countries, include lack of ICT skills, high implementation cost, lack of support, poor electricity supply, lack of a national accredited MOOCs curriculum, and lack of electronic content development suitable to the learner. A central e-learning platform must be designed to deal with uniformity and cross-cutting modules, establishment and funding of MOOCs coordination units at public higher education institutions, as well as establishment of MOOCs access hubs at strategic locations, also referred to as e-learning satellite centers. Some of these challenges have been handled at national level in improving responses to the pandemics in the post Covid-19 disaster preparedness planning and coordination efforts (Palinkas et al., 2021). Challenges have included access to teaching and learning, improving rural electrification, strengthening ICT infrastructure, and supporting projects that embrace digital skills development and empowerment (World Bank Group, 2022). This study has contributed to developing a MOOCs platform to be used in areas of low bandwidth. The authors therefore recommend that future research expand the developed artefacts and also concentrate on developing electronic MOOCs content that cuts across the various curricula.

ACKNOWLEDGMENT

REFERENCES

Al-Rahmi, W., Aldraiweesh, A., Yahaya, N., Kamin, Y. B., & Zeki, A. M. (2019). Massive open online courses (MOOCs): Data on higher education. *Data in Brief*, *22*, 118–125. doi:10.1016/j.dib.2018.11.139 PMID:30581914

Alamri, M. M. (2022). Investigating students' adoption of MOOCs during COVID-19 pandemic: Students' academic self-efficacy, learning engagement, and learning persistence. *Sustainability*, *14*(2), 714. doi:10.3390/su14020714

Ali, S., Uppal, M. A., & Gulliver, S. R. (2018). A conceptual framework highlighting e-learning implementation barriers. *Information Technology & People*, *31*(1), 156–180. doi:10.1108/ITP-10-2016-0246

Botha, P. A., & Swanepoel, S. (2015). Allocation of Academic workloads in the Faculty of Human and Social Sciences at a South African university. *Africa Education Review*, *12*(3), 398–414. doi:10.1080/18146627.2015.1110902

De Pietro, R., Wiarda, E., & Fleischer, M. (1990). The context for change: Organization, technology, and environment. In L. G. Tornatzky & M. Fleischer (Eds.), *The processes of technological innovation* (pp. 151–175). Lexington Books.

Deng, R., & Benckendorff, P. (2021). What are the key themes associated with the positive learning experience in MOOCs? An empirical investigation of learners' ratings and reviews. *International Journal of Educational Technology in Higher Education*, *18*(1), 1–28. doi:10.1186/s41239-021-00244-3

Ghavifekr, S., Kunjappan, T., Ramasamy, L., & Anthony, A. (2016). Teaching and learning with ICT tools: Issues and challenges from teachers' perceptions. *Malaysian Online Journal of Educational Technology*, *4*, 38–57.

Johansson, B., & Lahtinen, M. (2013). Getting the balance right between functional and non-functional requirements: The case of requirement specification in IT procurement. *International Journal of Information Systems and Project Management*, *1*(1), 5–16. doi:10.12821/ijispm010101

Jouicha, A. I., Berrada, K., Bendaoud, R., Machwate, S., Miraoui, A., & Burgos, D. (2020). Starting MOOCSs in African University: The experience of Cadi Ayyad University, process, review, recommendations, and prospects. *IEEE Access: Practical Innovations, Open Solutions*, *8*, 17477–17488. doi:10.1109/ACCESS.2020.2966762

Khan, B. H. (2001). A framework for web-based learning. In B. H. Khan (Ed.), *Web-based training* (pp. 42–51). Educational Technology Publications.

Krejcie, R. V., & Morgan, D. W. (1970). Determining sample size for research activities. *Educational and Psychological Measurement*, *30*(3), 607–610. doi:10.1177/001316447003000308

Kwon, T. H., & Zmud, R. W. (1987). Unifying the fragmented models of information systems implementation. In R. J. Boland & R. A. Hirschheim (Eds.), *Critical issues in information systems research* (pp. 227–251). John Wiley & Sons.

Li, B., Wang, X., & Tan, S. C. (2018). What makes MOOCs users persist in completing MOOCs? A perspective from network externalities and human factors. *Computers in Human Behavior*, *85*, 385–395. doi:10.1016/j.chb.2018.04.028

Lin, H. C., & Hwang, G. J. (2018). Research trends of flipped classroom studies for medical courses: A review of journal publications from 2008 to 2017 based on the technology-enhanced learning model. *Interactive Learning Environments*, *27*(8), 1011–1027. doi:10.1080/10494820.2018.1467462

Liyanagunawardena, T. R., Parslow, P., & Williams, S. A. (2017). Exploring "success" in MOOCs. In R. Bennett & M. Kent (Eds.), Massive open online courses and higher education: What went right, what went wrong and where to next? (pp. 212 -229). Routledge. doi:10.4324/9781315594248-7

Liyanagunawardena, T. R., Williams, S., & Adams, A. A. (2013). The impact and reach of MOOCs: A developing countries' perspective. *eLearning Papers*, (33), 38-46.

Macdonald, C. J., Stodel, E. J., Farres, L. G., Breithaupt, K., & Gabriel, M. A. (2001). The demand-driven learning model: A framework for web-based learning. *The Internet and Higher Education*, *4*(1), 9–30. doi:10.1016/S1096-7516(01)00045-8

Marques, M., & Azevedo, J. (2017). MOOCs success factors: Proposal of an analysis framework. *Journal of Information Technology Education: Innovations in Practice*, *16*, 233–251. doi:10.28945/3861

Mcgill, T. J., Klobas, J. E., & Renzi, S. (2014). Critical success factors for the continuation of e-learning initiatives. *The Internet and Higher Education*, *22*, 24–36. doi:10.1016/j.iheduc.2014.04.001

O'Connor, K. (2014). MOOCs, institutional policy and change dynamics in higher education. *Higher Education*, *68*(5), 623–635. doi:10.1007/s10734-014-9735-z

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

Oyo, B., Kalema, B. M., & Byabazaire, J. (2017). MOOCs for practicing teachers: The case of Uganda and the lessons for Africa. *Revista Española de Pedagogía*, *75*(266), 121–141. doi:10.22550/REP75-1-2017-07

Palinkas, L. A., Springgate, B. F., Sugarman, O. K., Hancock, J., Wennerstrom, A., Haywood, C., Meyers, D., Johnson, A., Polk, M., Pesson, C. L., Seay, J. E., Stallard, C. N., & Wells, K. B. (2021). A rapid assessment of disaster preparedness needs and resources during the COVID-19 pandemic. *International Journal of Environmental Research and Public Health*, *18*(2), 425. doi:10.3390/ijerph18020425 PMID:33430355

Picciano, A. G. (2017). Theories and frameworks for online education: Seeking an integrated model. *Online Learning*, *21*(3), 166–190. doi:10.24059/olj.v21i3.1225

Rogers, E. M. (2003). *Diffusion of innovations*. Free Press.

Siemens, G. (2005). Connectivism: A learning theory for the digital age. *International Journal of Instructional Technology & Distance Learning*, *2*(1), 3–10.

Sigama, K., & Kalema, B. M. (2020). The potential of MOOCs towards student access to higher education in developing countries. In *Proceedings of the International Conference on Teaching, Assessment and Learning in digital age* (vol. 2, pp.365-375). Durban, South Africa.

Stracke, C. M., & Trisolini, G. (2021). A systematic literature review on the quality of MOOCs. *Sustainability*, *13*(11), 5817. doi:10.3390/su13115817

Traxler, J. M. (2018). Learning with mobiles in developing countries: Technology, language, and literacy. In I. Management Association (Eds.), Information and technology literacy: Concepts, methodologies, tools, and applications, (pp. 774-790). IGI Global. doi:10.4018/978-1-5225-3417-4.ch041

World Bank Group. (2022, July 15). Operational response to COVID-19 (coronavirus): Projects list.

Zajda, J., & Rust, V. (2016). Research in globalisation and higher education reforms. In J. Zajda & V. Rust (Eds.), *Globalisation and higher education reforms* (pp. 179–187). Springer., doi:10.1007/978-3-319-28191-9_12

Zakariah, Z., Janom, N., & Arshad, N. H. (2016). Crowdsourcing to uplift the lifestyle of low income community. *Advanced Science Letters*, *22*(5-6), 1658–1661. doi:10.1166/asl.2016.6719

Zakharova, U., & Tanasenko, K. (2019). MOOCs in higher education: Advantages and pitfalls for instructors. *Educational Studies Moscow*, *2019*(3), 176–202. doi:10.17323/1814-9545-2019-3-176-202

Zhao, L., Ao, Y., Wang, Y., & Wang, T. (2022). Impact of home-based learning experience during COVID-19 on future intentions to study online: A Chinese university perspective. *Frontiers in Psychology*, *13*(862965), 1–14. doi:10.3389/fpsyg.2022.862965 PMID:35401360

Zhu, M., & Bonk, C. J. (2019). Designing MOOCs to facilitate participant self-monitoring for self-directed learning. *Online Learning*, *23*(4), 106–134. doi:10.24059/olj.v23i4.2037

Zhu, M., Bonk, C. J., & Sari, A. R. (2018). Instructor experiences designing MOOCs in higher education: Pedagogical, resource, and logistical considerations and challenges. *Online Learning*, *22*(4), 203–241. doi:10.24059/olj.v22i4.1495

Khuliso Sigama is an information systems researcher; he obtained his doctorate in the field of information systems in 2021. He has spoken in doctoral symposiums and has a record of publications in peer reviewed journals.

Billy Mathias Kalema is a researcher in the field of information systems, with an extensive practical and research experience in ICT4Business Enhancement, ICT4Education including m-learning, e-learning, and open and distance education such as MOOCs, big data, and the statistical methods for data analysis.