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INTEGRATING EDUCATIONAL TECHNOLOGY IN EAST AFRICA: ONE SIZE DOES NOT FIT ALL

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Abstract. Globalization and the post-industrial economy, combined with a growing number of the youth, has increased the demand for higher education in Africa. Online learning breaks down temporal and geographic barriers creating a digital learning community that offers an opportunity to expand access and meet skills and training demands. Deployment of technology is a principal consideration in implementing an online learning programme, given its centrality in the teaching and learning process. The integration of technology requires a decision-making matrix that provides a phased review of the suitability of solution as well as locally placed contemplation of relevance and user accessibility. Higher education institutions in low connectivity areas

ИНТЕГРАЦИЯ ОБРАЗОВАТЕЛЬНЫХ ТЕХНОЛОГИЙ В ВОСТОЧНОЙ АФРИКЕ: ОДИН РАЗМЕР НЕ ПОДХОДИТ ВСЕМ

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Аннотация. Глобализация и постиндустриальная экономика в сочетании с ростом численности молодежи увеличили спрос на высшее образование в Африке. Онлайн-обучение устраняет временные и географические барьеры: создавая сообщество цифрового обучения, оно дает возможность расширить доступ и удовлетворить потребности в навыках и обучении. Распространение технологий, с учетом их центральной роли в процессе преподавания и обучения, является основным фактором при реализации программ онлайн-обучения. Для интеграции технологий необходима матрица принятия решений, обеспечивающая поэтапный анализ его пригодности, а также актуальности и доступности для пользователей в локальных условиях. Высшие

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need to be deliberative and innovative in selecting which technology best fits their environment and accommodates their students' limitations. This paper discusses the decision-making process of integrating technology for an online learning pilot project analysed through Rogers' Diffusion of Innovation (DOI) theory applied to educational technological adoption. The approach of the project considered local infrastructure, university ICT capacity, and user Internet accessibility in the selection of online learning solutions. The process provides insights and understanding of the decision matrix, not only on online learning solutions but also in the broader issue of integrating technology into brick and mortar institutions.

Keywords: educational technology, low connectivity, Africa, online learning, internet access

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учебные заведения в районах с низким качеством интернет-связи должны одновременно проявлять осмотрительность и новаторство при выборе технологии, которая лучше всего подходит для их среды и учитывает ограничения студентов. В этой статье обсуждается процесс принятия решений об интеграции технологии для пилотного проекта онлайн-обучения. В основу анализа легла теория диффузии инноваций Эверетта Роджерса в приложении к внедрению технологий в образовании. Предложенный аналитический подход учитывает местную инфраструктуру, возможности университетов в области ИКТ и доступность интернета для пользователей при выборе решений для онлайн-обучения. Полученные результаты касаются матрицы решений и аргументов не только в отношении онлайн-обучения, но и в отношении более широкой области интеграции технологий в обычных учебных заведениях.

Ключевые слова: образовательные технологии, Африка, онлайн-образование, доступ в интернет, ограниченный доступ в интернет

Благодарность. Работа основана на опыте реализации программы онлайн-обучения в Восточной Африке в рамках партнерства университетов США и Восточной Африки, финансируемого правительством США.

Introduction

This article examines the decision-making process of adapting Education Technology (EdTech) for online learning within the context of low connectivity environments. Integration of technology is influenced by several factors, from organizational capacity to user readiness. This study focuses primarily on deliberations on infrastructure challenges, notably, capacity, access, and affordability of Internet connection, central to

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facilitating online learning. Rogers' [2003] Diffusion of Innovation (DOI) theory provides a framework for analysing the decision-making process in selecting an online learning platform that addresses the challenges in low connectivity environments.

Online learning has the potential to break down barriers such as time and space through the creation of digital learning community facilitated by technology. The ability to access the online community is vital for the success of any online learning initiatives. Technological resources are the scaffolding on which online instruction is constructed and they are essential for delivering online learning. *Afrobarometer*, in *Africa's Digital Divide and the Promise of eLearning*, found 'a substantial digital divide both across and within [African] countries, reflected in uneven access to resources'[1]. Access to these digital resources determine the ability of learners to access and participate in online programmes.

A study on connectivity in African higher education concluded that the state of Internet connection in African institutions was 'too little, too expensive, and poorly managed' [Gaiko, 2006]. The survey found that of the institutions planning to launch digital initiatives such as online learning, only 39% had a written ITC strategy, while of institutions who had mounted online learning applications, 50% had no written policy [ibid.]. Of those that have selected and installed an online learning platform, 22% chose Moodle, 12% Blackboard, 15% Kewi, 12% WEBCT, 8% Caroline, while 12% selected other applications and 19% opted for Distance education [ibid.]. It is important to note, though open to modification, of the package solution chosen, 81% were developed externally. Additionally, although these solutions may appear to be convenient, the potential of customised solution to be responsive to the local context, its long-term affordability, and potential scaling to accommodate programme expansion come with a premium.

Technology serves as the foundation for online learning and communication, and unencumbered access to the Learning Management System (LMS) is critical for the success of the online learning programme and positive student learning outcome. Therefore, deployment of technology is a principal consideration in implementing an online learning programme, given its centrality in the teaching and learning process. This is especially true in low connectivity areas where access to the Internet is limited and fee-based. In low connectivity areas, implementing online learning programmes requires extensive planning and assessments to determine the appropriateness and relevance of components, especially the integration of technology [Moore, 2012]. However, higher education institutions in Africa have been adopting systems without long-term strategy, planning, or reflection on infrastructure and connectivity challenges [Gaiko, 2006; Njenga, 2011][2].

Background

The public higher education landscape in Africa has attempted to keep abreast of the changes in the labour market and respond to the demands of the new economy focused on service and technology. Although still in the early days, Information and

[1] Krönke M. (2020) Africa's Digital Divide and the Promise of E-Learning. *Afrobarometer Policy Paper No. 66*. P. 1. URL: https://afrobarometer.org/sites/default/files/publications/Policy%20papers/pp66-africas_digital_divide_and_the_promise_of_e-learning-afrobarometer_policy_paper-14june20.pdf (accessed: 20.02.2021).

[2] Additionally, see Twinomugisha A., Magochi J., Aluoch S. (2004) *Investigation of Bandwidth Consolidation for Partnership Universities*. African Virtual University. URL: http://www.foundation-partnership.org/pubs/pdf/bandwidth_consolidation.pdf (accessed: 20.02.2021).

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Communication Technology (ICT) appears to be central in expanding access and meeting new skills and training demands [Altbach et al., 2009]. In many economies across Africa, where increasing infrastructure and teaching staff are prohibitively expensive, technologies offer the key for increasing access to higher education [ibid.]. However, a wholesale adaptation of educational technology may be challenging and even detrimental. Therefore, there is a need for higher education institutions in Africa to be deliberative and innovative in selecting which technology best fits their environment and accommodates their students' limitations.

Educational technology

EdTech is the intersection of technology and education where innovations and advances in technology are integrated to support, supplement, customize, personalize, and diversify instruction [3]. It is a relatively new area with varying definitions depending on orientation: technological or educational. Within the technical field, EdTech denotes the development and application of tools such as hardware, software, and processes that enhance and promote education [4]. Within education, it is the 'study and ethical practice for facilitating learning and improving performance by creating, using and managing appropriate technological processes and resources' [5].

There is no limit or strict definition of which technologies are suitable for inclusion in EdTech. In the early days, many of the software and hardware systems widely used in EdTech were initially developed for enterprise-level application in the private sector [6]. Today, there are several Fortune 500 Companies solely devoted to developing technology exclusively for classrooms and learning. However, there are foundational technologies, software, hardware, and interactive media, that are common to the EdTech eco-system.

EdTech software consists of solutions initially developed for business as well as those specifically designed for education. Early EdTech consisted of adapting enterprise-level software to support education. However, growth in the field has led to a sector solely devoted to the development of EdTech technology and training, raising a total of $962 million in 2019, of which $383 million was for software exclusively designed for learning such as learning platform and classroom management tools [7].

Management Information System (MIS) serves as a central data repository that collects, organizes, stores, processes, and analyses data [8]. A version of MIS for institutions is called Education Management Information System (EMIS). It is specifically

[3] See Edtech 2.0 (2017) The Ultimate Guide to Edtech. *Medium.* June 5th. URL: https://medium.com/@edtech2/the-ultimate-guide-to-edtech-88b9f984ada0 (accessed: 20.02.2021).

[4] Lazaro H. (2020) What is EdTech and Why Should it Matter to You? *General Assembly Blog.* May 24th. URL: https://generalassemb.ly/blog/what-is-edtech/ (accessed: 20.02.2021).

[5] See post *What is EdTEch?* (2013) *EdTechReview.* February 15th. URL: https://edtechreview.in/dictionary/119-what-is-edtech (accessed: 20.02.2021).

[6] Perry Y. (2018) Could Computing in Education with Cloud Volumes ONTAP. *NetApp Blog.* November 8th. URL: https://cloud.netapp.com/blog/cloud-computing-in-education-trends-and-challenges (accessed: 20.02.2021).

[7] Wan T., Millward T. (2019) US Edtech Funding Already Nears $ 1 Billion in First Half of 2019. *EdSurge Newsletter.* August 7th. URL: https://www.edsurge.com/news/2019-08-07-us-edtech-funding-already-nears-1-billion-in-first-half-of-2019 (accessed: 20.02.2021).

[8] Korde B. (2020) Role of Management Information Systems (MIS) in Education Sector. *MasterSoft.* December 25th. URL: https://www.iitms.co.in/blog/role-of-management-information-system-in-education.html (accessed: 20.02.2021).

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designed for educational institutions and is central to management and instructional operations. EMIS is used to collect and store student data, including personal data, exam records, and can also include housing and library information[9]. At the institutional level, it includes HR and financial management systems, as well as specialised MIS systems such as learning management systems (LMS). Popular programmes in LMS include Blackboard Learning System, Share-Point LMS, and Moodle[10]. LMS combines online course management, communication, and collaboration tools which can include a discussion forum, file exchange, real-time chat, interactive whiteboards, group work, registration integration, quizzes/surveys, grade book, student tracking, and content sharing[11].

With the advancement in software, hardware requirements for EdTech have expanded from simply computers to include interactive displays, broadband connectivity and support devices such as routers and servers. More powerful computers, as well as personal computers and other devices have led to increased accessibility of instruction and learning. Laptops, desktops, and tablets allow students to experience the full scope of applied technology from fundamental keyboarding to advanced drafting and programming[12]. Interactive technology is another driver of EdTech which allows instructors and students to visualize and connect with materials directly. Touch-responsive multimedia displays provide an opportunity to pull limitless resources into the classroom with a tap or swipe of a screen. The goal of each innovation in EdTech is to create a learning environment that diminishes the distance between instructor and student as well as the student and the material.

Online learning

Online learning is a component of Distance Learning (DL), an education process where the learner and instructor are physically separated, and interaction takes place through telecommunication systems [Moore, 2012]. DL has evolved in line with technological innovations over the last three centuries, from postal based to today leveraging ICT [Kentnor, 2015]. Innovations in technology have unleased DL and given rise to a new component of DL, online learning. Online learning employs computers and the Internet as a delivery mechanism for courses and instruction. An online course can be taught entirely online over the Internet or in a hybrid or blended format, which uses a combination of online and face-to-face interaction [Nguyen, 2015].

The temporal and geographic limitations of classroom instruction mean that a potentially large number of students are left behind [Asunka, 2008]. Not every student seeking an education can travel, relocate or devote full-time to schoolwork, many have family and professional obligations that limit mobility and flexibility. In many cases, those unable to make this accommodation are female students with

[9] Davis B., Carmean C., Wagner E. D. (2009) The Evolution of the LMS: From Management to Learning. *The Learning Guild*. October 15th. URL: https://www.learningguild.com/insights/137/the-evolution-of-the-lms-from-management-to-learning/ (accessed: 20.02.2021).

[10] Ibidem.

[11] See post by Balram Korde mentioned above.

[12] Lazaro H. (2020) What is EdTech and Why Should it Matter to You? *General Assembly Blog*. May 24th. URL: https://generalassemb.ly/blog/what-is-edtech/ (accessed: 20.02.2021).

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responsibilities and commitments that prevent them from entering a traditional learning classroom [13]. Hence, online instruction creates a classroom without walls and enrollment limits, accessible to previously excluded populations. As long as students have a proper device and Internet connection, they can participate in the digital learning environment.

Since the introduction of online learning, the number of free and fee-based online programmes available has exponentially increased. However, critics of online learning question its appropriateness for instruction at the college level [14]. Foundational to this position is the role classroom education plays in socialising students and the intangible benefits of interaction with classmates, professors, and materials that challenge a student's beliefs and perspectives. In campus-based instruction, students are 'taught by expert educators about how to access, analyze, criticize, synthesize, and communicate knowledge from multiple perspectives and disciplines' [15]. Although these learning objectives can be accomplished in online learning, there are questions of their suitability for certain disciplines that require hands-on training and students who might not learn and flourish in the isolated, individualised online learning environment.

Literature and studies of US-based online programmes indicate preconditions, such as quality of early learning, digital literacy, technical capacity, etc., strongly determine success in distance learning programmes [Henschke, 2014; Nguyen, 2015; Kauffman, 2015]. Studies have examined 'test scores, student engagement with the class material, improved perception of learning and the online format, stronger sense of community among students, and reduction in withdrawal or failure' [Nguyen, 2015: 310]. The technical elements of online instruction, such as the ability to pause, rewind, and review lectures at will, and flexibility and convivence of attending class, have been attributed to increased learning and engagement of learners in online mode. However, individual learning outcome is primarily determined by learners' motivation and self-directness [Henschke, 2014].

In many developing countries, online learning is controversial and divisive, and this is the case across Africa. Some view it as an 'inferior form of education providing an isolated learning experience <…> [and] a harbinger of global, Western-dominated educational homogenization' [16]. Best practices in online learning from the U.S. and the West often 'embed deep political, epistemological, and cultural assumptions that may be incongruent with the cultural knowledge of users in many communities in Africa' [Mawere, Stam, 2019: 421].

The ongoing COVID-19 crisis that led to school closures has highlighted the importance of connectivity for success in online learning. In the U.S., where Internet access

[13] Trines S. (2018) The Rise of Online Education in Sub-Saharan Africa and South Asia. *WENR: World Education News + Reviews*. August 14th. URL: https://wenr.wes.org/2018/08/educating-the-masses-the-rise-of-online-education (accessed: 20.02.2021).

[14] Samuels B. (2013) Being Present. *Inside Higher Education*. January 24th. URL: https://www.insidehighered.com/views/2013/01/24/essay-flaws-distance-education (accessed: 20.02.2021).

[15] Ibid.

[16] Trines S. (2018) The Rise of Online Education in Sub-Saharan Africa and South Asia. *WENR: World Education News + Reviews*. August 14th. URL: https://wenr.wes.org/2018/08/educating-the-masses-the-rise-of-online-education (accessed: 20.02.2021).

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is more readily available than other countries, studies have found that inadequate connectivity has impacted the quality of education[17]. A study by Brookings Institute [2020] found that as many as 30% of students had no Internet access at home. The study acknowledges that structural change to deliver Internet access is a broader issue, therefore, areas with low, and in some cases, no connectivity should consider creative approaches to providing instruction[18]. The report features examples of solutions that leverage appropriate technology to deliver lessons to students in low connectivity environments. Hence, even in the world's largest economy, one size does not fit all in terms of digital delivery of online learning.

Low connectivity environments

The *Global Connectivity Index (GCI)* assesses the expansion of ICT infrastructure across the world. It lists the top 79 countries according to their level of technology infrastructure development. The GCI categorizes countries that score 65—85% and are leading the way in ICT and AI innovation as *Frontrunners*, those in the range of 40—64% indicating quick expansion of digitization into industry and economy as *Adopters*, and those with scores 23—39%, being in the early stage of ICT development and focusing on expanding connectivity to greater populations as *Starters*[19]. The primary metrics for the index are Internet bandwidth and broadband download speed, which are 'Foundation' indicators on which all ICT innovation takes place. The 2019 GCI did not list an African nation in the *Frontrunner* category and only South Africa, with a score of 43%, made it to the *Adopters* list, however, the *Starters* category included Egypt (37%), Morocco (36%), Algeria (31%), Botswana (30%), Ghana (29%), Kenya (29%), Namibia (28%), Nigeria (27%), Tanzania (24%), Uganda (24%), and Ethiopia (23%). The placement of only eleven African countries across 24 available slots is a strong indicator of the emergence of digital technology in Africa. However, the low scores reflect the uneven distribution, where connectivity outside metropolitan areas is still a significant challenge. This finding is consistent with the results of a Pew Research Center study that found, globally, a correlation between national GDP per capita and the proportion of the population online. In the African context, those online are generally young, educated, well-off, and residents of urban centres, who go online for social and entertainment purposes[20].

GCI's methodology points to broadband and bandwidth as the primary measures of connectivity at the national level. Thus, low connectivity environment can be characterised as having inadequate availability of bandwidth, defined by the capacity of the Internet connection, as calculated by the rate of data transfer in uploading and

[17] Kim J.-H. (2020) Lack of Internet Access Continues to Impact Students' Online Learning Experience. *The Cavalier Daily*. September 17th. URL: https://www.cavalierdaily.com/article/2020/09/lack-of-internet-access-continues-to-impact-students-online-learning-experiences (accessed: 20.02.2021).

[18] Opalka A., Gable A., Nicola T., Ash J. (2020) Rural School Districts Can Be Creative in Solving the Internet Connectivity Gap — but They Need Support. *Brookings*. August 10th. URL: https://www.brookings.edu/blog/brown-center-chalkboard/2020/08/10/rural-school-districts-can-be-creative-in-solving-the-internet-connectivity-gap-but-they-need-support/ (accessed: 20.02.2021).

[19] Huawei's Global Connectivity Index 2020. URL: https://www.huawei.com/minisite/gci/en/ (accessed: 20.02.2021).

[20] Silver L., Johnson C. (2018) Internet Connectivity Seen as Having Positive Impact on Life in Sub-Saharan Africa. *Pew Research Center Report*. URL: https://www.pewresearch.org/global/wp-content/uploads/sites/2/2018/10/Pew-Research-Center_Technology-use-in-Sub-Saharan-Africa_2018-10-09.pdf (accessed: 20.02.2021).

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downloading[21]. However, an inclusive and individual-level measure of low connectivity includes 'insufficient bandwidth, inadequate telecommunication infrastructure, irregular power supply, high cost of technology' [Suhail, 2008: 377] as these factors greatly determine a person's ability to access and afford Internet connectivity. *Afrobarometer* found that only 17% of respondents across 34 African countries are prepared to engage in Internet-facilitated remote learning[22]. The study conducted a regression analysis model with device ownership and frequency of mobile phone use and Internet access to develop a digital literacy index. The analysis found that 55% of adult population were completely unprepared, while another 28% would require additional resources to participate in online learning [ibid.]. The study also found significant urban-rural divide in connectivity metrics, such as household device ownership (64% and 29% respectively) and digital literacy (48% and 18%), as well as a positive correlation between reliable electricity and digital literacy.

Technological adaptation

The above-mentioned findings have implications for determining technological adaption for online learning in the African context and other low connectivity environments. Prior to adopting online learning solutions, a deeper understanding of the factors impacting adoption, deployment, and user experience is necessary. In terms of connectivity, much of the LM software for online learning delivery and management were developed for environments with technological infrastructure, large device availability, and strong digital literacy. Therefore, the optimal use of these systems requires a powerful personal device, reliable electricity, and broadband Internet connection as well as digital savviness to navigate lessons. Another potential limitation in the African context is the difficultly in meeting essential technical preconditions for online learning across all population groups.

In low connectivity environments, the cost of Internet connection adds to this burden. In Africa, internet users pay the highest rate in the world as a proportion of personal income, and on average the price of 1GB of data is 7.1% of the average income[23]. To further illustrate this point, the bottom nine countries on the Affordability Drivers Index presented in the *2019 Affordability Report*, which measures the extent of Internet infrastructure and broadband adoption rates, are on the African continent, while top 10 countries are mainly in Latin America and Asia[24].

Theoretical framework

Integration of technology for online learning requires a decision-making matrix that provides phased consideration of the suitability of solution as well as locally placed

[21] Gakio K., Chimwasa G., Nyareza S. (2006) *African Tertiary Institutions Connectivity Survey (ATICS)*. P. 15. URL: https://idl-bnc-idrc.dspacedirect.org/bitstream/handle/10625/50710/IDL-50710.pdf (accessed: 20.02.2021).

[22] Krönke M. (2020) Africa's Digital Divide and the Promise of E-Learning. *Afrobarometer policy paper No. 66*. URL: https://afrobarometer.org/sites/default/files/publications/Policy%20papers/pp66-africas_digital_divide_and_the_promise_of_e-learning-afrobarometer_policy_paper-14june20.pdf (accessed: 20.02.2021).

[23] Alliance for Affordable Internet (2019) *The 2019 Affordability Report*. Washington DC: Web Foundation. URL: https://1e8q3q16vyc81g8l3h3md6q5f5e-wpengine.netdna-ssl.com/wp-content/uploads/2019/10/A4AI_2019_AR_Screen_AW.pdf (accessed: 20.02.2021).

[24] Ibid.

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contemplation of relevance and user accessibility. Rogers' Diffusion of Innovation [2003], a highly influential theory in higher education, is suited as a framework for understanding the process of technological diffusion through a scaffolding approach of the decision-making process. The diffusion of innovation theory (DOI), although developed to explain individual behaviour, applies to group and organizational decision-making, which is ultimately an individual-based participatory process.

Rogers presents four elements in the process of diffusion: *innovation*, the new idea or practice, *communication channels*, the collection and communication of information to form positions and attitudes on the innovation, *time*, the rate of adoption, and *social systems*, defined as 'a set of interrelated units engaged in joint problem solving to accomplish a common goal' [Rogers, 2003: 23]. These components are central in the DOI decision process, characterised as a process motivated by the desire to reduce uncertainty through information gathering and sharing on the benefits and drawbacks of an innovation ultimately leading to a decision to adopt or reject it.

Rogers' theory also articulates a five-step decision-making process consisting of *knowledge*, a cognitive stage creating awareness and in-depth knowledge; *persuasion*, an affective process weighing pros and cons; the *decision* stage of adopting or rejecting the innovation; *implementation*, consisting of technical assistance and reinvention; and the *confirmation* stage, where the decision is reinforced through external support, the absence of which results in replacement or disenchantment [Rogers, 2003]. This process is central to the adoption of online learning technology in Africa, where it illustrates an institutional consultation process. However, as noted in Njenga [2011], the incomplete nature of the knowledge phase is a significant risk for institutions, leading to unsuited technological adoption followed by replacement or disenchantment.

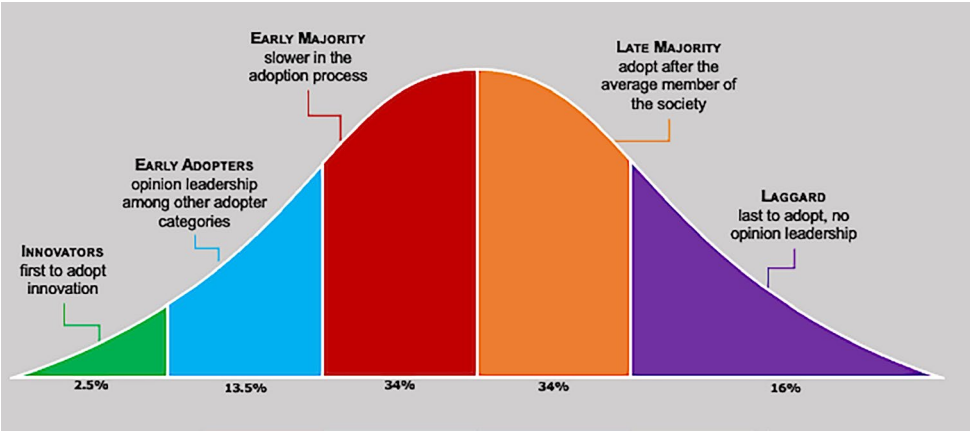

Fig. 1. Rogers' Diffusion of Innovations

An essential component of Rogers' theory is the time-based categorization of adopters charted on a normal distribution curve where those one standard deviation away from the mean are either Early Majority (left) or Late Majority (right), and two standard deviations are Early Adopters (left) or Laggards (right), and finally, those who are in the

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left corner beyond two standard deviations are the Innovators, those who joined the system first (see Fig. 1). The relative risk and reward of adoption are analogous to the timeframe of adoption where those that join earlier are able to withstand greater risk and failure of innovation. However, those that join later, as Late Majority, are more risk averse and relay on network information for adoption.

African institutions engaged in technological adoption at this point in the timeframe of digital innovation fall within the Late Majority category, where networks provide the basis for building knowledge and understanding of systems. The high risk of failure and loss attendant with being innovators present a challenge at the individual and organizational level. The harsh funding climate, faced by many institutions, and the significant peril, associated with failure, render innovation a frontier with considerable consequences.

However, Rogers did not provide a quantifiable definition or standard for diffusion and, lacking consistency and cohesion, the theory rendered stagnant [Greenhalgh et al., 2005]. Criticism of DOI includes the focus on the individual in conceptualising the decision-making process, even though it draws from organizational and rational theories from a wide range of fields and disciplines [Ciborra, 1997]. Some authors have questioned the applicability of DOI theory to the diffusion of IT innovations, in light of the complexity and dynamic nature of IT diffusion on individuals and organizations [Hanseth et al., 1996]. Additionally, others have pointed to the lack of in-depth analysis of social factors in analysing the success or failure of adoption of innovations [Grudin, 1988].

Integration of technology

Background and context

Between 2012—2015, a partnership project, funded by the U.S. government, between a US-based research university and a national university in East Africa implemented a pilot online learning programme [25]. The online learning programme was part of a project to increase equity in terms of providing equal access to the university's programmes across gender groups. The online learning pilot was part of a component aimed at increasing the rate of participation of women in higher education. The process consisted of transforming an existing post-graduate distance learning programme into a hybrid online learning programme to provide a flexible learning environment, thereby increasing access to advanced training for women and others unable to participate in traditional learning programmes.

The post-graduate programme targeted educators, employed in the field, who had previously earned a diploma/degree in education and were pursuing a post-graduate degree to move up in their position. The piloted online programme was a hybrid modality, with lecturers using the online platform to distribute assignments, lecture notes and to conduct online discussions while still maintaining the weekly face-to-face session in the learning centres. However, the length and frequency of face-to-face engagement steadily decreased through the course of the semester. Students use

[25] Here and further in the text, when describing the programme and its outcomes, the authors rely on the materials of the report: Lancaster I., Mirembe J. (2015) Evaluation of HED/USAID Women's Leadership Program — Rwanda (2012—2015). USAID. URL: https://pdf.usaid.gov/pdf_docs/PA00KPDP.pdf (accessed: 20.02.2021).

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the online platform to complete and submit assignments, conduct research, access readings (both mandatory and suggested supplementary), send questions to instructors, and engage in online discussion forums. Developing a mixed instructional model provided the needed flexibility for increasing the capacity of the institution to provide access to the programme and for participants to advance their training.

The pilot online programme enrolment was mainly mature adults employed full-time who, upon completion of the programme, intended to use their new degree to move forward in their careers. The selection of the post-graduate programme was based mainly on the higher rate of enrolment of mature students in the distance learning version of programme and the potential of this student population to adapt to new learning environments. Learning theory suggests that the learning characteristics of adults are best suited for the independent learning environment of online learning as advanced by Knowles [1970] andragogy. It posits that adult learning, *andragogy* (adult-led), is an approach for learners who have experience and some knowledge and can actively participate in the learning process. This learning process entails different underlying factors than child learning, *pedagogy* (child-led), which is well suited for children who lack experience and knowledge and require teacher directed structured instruction [Knowles, 1970].

The project also provided an opportunity to compare learning outcomes between the previously utilised distance education method and the new system using technology. The enrolment for this programme in correspondence distance mode was 50, but for the online programme, it increased to 70 and finally settled at 74. The use of technology did not seem to deter registration but increased participation. The dropout rate for this programme in the past was low with only 2 to 4 students, however, the online pilot did not experience any dropout.

Technological adaptation decision framework

Knowledge and persuasion

The initial steps to mounting the online learning project consisted of expansion of knowledge of the innovation and persuasion of users at all levels. In designing the pilot, the project had to determine the process of gradually introducing technology, to both students and lecturers. To this end, a readiness assessment was conducted to determine the skills and knowledge of participants and design the onboarding process for the online learning programme. The assessment featured a section on Language Readiness, Technology Readiness exploring the level of computer literacy, previous experience with online learning, and familiarity with various digital resources, as well as learning characteristic profile assessment. Result of the assessment was used to design training and roll out of the pilot online learning programme by addressing identified gaps in skills required to participate in the programme successfully. An additional lecturer assessment, consisting of questions to determine their readiness to teach in the online modality, was conducted among instructors.

All participants, students and lecturers, did not have previous experience with the online learning system and a very small number considered themselves computer literate at the start of the programme implementation. The average participant did not own a computer and did not have regular Internet access at home. This aligns with

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findings that indicate that only 28 % of the population in Africa is online and only 20 % of adults have access to a smartphone *and* a computer, however, 50 % can access either a smartphone *or* a laptop [26]. A polling of the 74 pilot programme participants found that students planned to download lessons at work, at the learning centre, and in cyber cafes and then working on their assignments offline. Due to the pervasiveness of low digital literacy among participants, it was necessary to build competency and confidence of users gradually.

The lecturers were also relatively new to online learning and received basic training in uploading their syllabi, tracking student progress, and monitoring assignments. During the pilot, lecturers were trained on the platform and online course delivery, thus gaining familiarity with the e-learning and its functionalities. To fully utilize the system, lecturers were trained in converting their courses into interactive digital lessons and integrate video and other digital media. Once lecturers can deliver their lectures through video (live and pre-recorded), the pilot would go entirely online, and in class lectures would eventually be eliminated.

In selecting the devices for the pilot, functionality and accessibility were two primary considerations. Online learning devices for students were assessed based on usability and price. In line with the *Afrobarometer* study [27], participants owned mobile phones, however, many did not own laptops or tablets. Compatibility and availability of the appropriate device is central to participant success in online learning. Initially, Windows mobile phones were considered, however, the relatively small screen proved challenging during the testing phase for extended reading and writing assignments. The project settled on laptops at the price range of $ 300, which fulfilled accessibility requirement while providing users, of all levels, easy functionality and usability.

The computers selected for the pilot proved to be easy to operate for the students and lecturers. Once they received the necessary training, they were able to utilize the devices not only for the programme but also in other areas of their lives. A number of the participants reported using the computer in their classrooms, which increased their students' interest in the lessons. Others commented on how having a laptop motivated them to conduct online research and explore the other functionalities of the device. Overall, participants reported that they considered themselves computer literate and able to use the computers in both their professional and private lives after the training.

The devices were loaned to the students for the pilot period; however, ownership of the laptop was the goal. Upon gaining experience and familiarity with the computer, participants realised the expanded impact on their lives. Participants were interested in a mechanism that would allow a purchase of a laptop, and lecturers were keen to integrate it into their teaching. They also felt that the online learning programme was

[26] Krönke M. (2020) Africa's Digital Divide and the Promise of E-Learning. *Afrobarometer Policy Paper No. 66*. URL: https://afrobarometer.org/sites/default/files/publications/Policy%20papers/pp66-africas_digital_divide_and_the_promise_of_e-learning-afrobarometer_policy_paper-14june20.pdf (accessed: 20.02.2021); Alliance for Affordable Internet (2019) *The 2019 Affordability Report*. Washington DC: Web Foundation. URL: https://1e8q3q16vyc81g8l3h3md6q5f5e-wpengine.netdna-ssl.com/wp-content/uploads/2019/10/A4AI_2019_AR_Screen_AW.pdf (accessed: 20.02.2021).

[27] Krönke M. (2020) Africa's Digital Divide and the Promise of E-Learning. Afrobarometer Policy Paper No. 66. URL: https://afrobarometer.org/sites/default/files/publications/Policy%20papers/pp66-africas_digital_divide_and_the_promise_of_e-learning-afrobarometer_policy_paper-14june20.pdf (accessed: 20.02.2021).

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more cost effective, in the long run, eliminating expenses such as making copies, transportation to learning centres, and purchasing supplementary readings.

Decision, implementation and confirmation

The DOI theory framed the process of selecting an online learning system where a wide range of factors are considered in a decision-making process to address uncertainty in adopting the innovation. The analysis of the project within the DOI framework considered local infrastructure, university ICT capacity, and user Internet accessibility in the selection of online learning solution. The pilot project faced several decision points in meeting the primary requirements, including:

- Connectivity — the e-learning platform must have an offline capability to address issues of connectivity and availability of the Internet.
- Ease of usability — the system must be easy to learn and navigate for users, lecturers, and administrators. The assessment results indicated that students and lecturers had limited digital literacy, making an easy-to-use system necessary. The system and interface needed to be intuitive, and as much as possible, free from developer assumptions.
- Alteration — the ability to customize, as needed, at any point in the future without additional costs was essential. Flexibility to add features, change visuals, and the interface was important.
- Scalability — ability to scale up or down the platform as needed. In the early days of the programme, it was anticipated that few features would be utilised; however, as users gained proficiency, additional features would be used widely.

Table 1. ***Comparison of solutions***

	Package solution	**Institutionally developed solution**
OWNERSHIP	No institutional ownership	Full ownership by the institution
CUSTOMIZATION	— Requires a programmer with specific knowledge unavailable locally — Expensive, additional fee for customization required	— Fully customizable locally — Additional manipulation and customization at the discretion of the institution without additional costs
SYSTEM SUPPORT	— No dedicated support — Local talent difficult to secure	— Developer support available locally — Institutional capacity developed to serve as the first line of support
OFFLINE CAPABILITY	No offline capacity	Offline option available
LICENSE	Annual license fee	No license fee

As the project was contemplating solutions, there was a national rollout of a top-selling online LMS in various institutions. An informal observation found that the national rollout faced challenges of affordability, capacity to administer the system, and user

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connectivity. Therefore, the project conducted a comparative analysis of using the online platform that was part of the national rollout or developing a system that would be more responsive to the requirements discussed above. The result indicated that the cost of adapting and launching the top-selling LMS solution that was part of the national rollout was cost-prohibitive (*see table 1*). Moreover, the institution undertaking the online programme lacked the ICT infrastructure and personnel capacity to administer the system.

The decision-making process resulted in the project opting to build an online learning platform developed by a local firm, with the leasing of a regionally developed platform as an alternative. The information gathering and persuasion stage consisted of consultation with technology partners and the review and testing of a regionally developed platform customised for the African context. However, closer examination revealed the alternative challenges including:

— the solution turned out to be irreconcilable with the limited infrastructure capacity of the institution and presented a number of financial and organizational concerns;
— although the solution offered a certain level of customization, user adoption to the functionality proved to be a barrier;
— expanding use of the platform for use in other online programmes would be cost-prohibitive which raised issues of sustainability. A study conducted by the institution estimated that the use of a leased online learning platform would result in a 46 % increase in programme fees.

Challenges during the trial phase of the regionally developed solution proved that an initial investment in building an e-learning platform could respond to the requirements and need for sustainability and could have a lasting impact. There was a sustained search that resulted in securing a national technology firm, which was contracted to develop an online learning solution to project specifications and provide training for the project online platform administrators, who will take over the management and maintenance, as well as lecturers and students.

In addition to information and experience gained from a review of the regionally development solution, there were a number of decision points which led to the development of learning platform. An important consideration was user connectivity given the inadequacy of Internet connection, nationwide and in participants' households. Integrating an App for the platform offered offline functionality and access, a vital feature for low connectivity areas. Moreover, the online learning platform, housed in the internal system at each learning centre site, allowed students to access it through an internal network, neutralising issues with connectivity and cost.

Additional advantages that were a consideration for selection of a locally developed online learning solution included:

— building internal capacity, both human and technological, as well as national capacity;
— direct consultation and input from users embedding an understanding of the local context;

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— ability to load the solution locally in satellite learning centres for users to access through the intranet, which allowed to download and upload lessons faster and at no cost;
— increased student enrolment in online programmes at will without additional costs;
— increased number of courses offered at will without additional charges.

Maintenance for the online learning platform was designed at two levels. The institution entered a service contract with the platform developer for secondary level support that would provide institution-based administrators, the first line of support for the platform, with maintenance services. The system was directly housed on the institution's servers which provided IT personnel and the platform administrator with direct access to the solution, where they can assign users and control permissions for levels of access. The fact that the firm was located within a few miles of the institution, facilitated the development of close working relationships, targeted training and support and eliminated the need for additional travel costs to address technical issues with the system.

The final solution for the online learning programme was a customised, scalable online learning platform owned, and not licensed, by the institution, which removed the high cost of leasing with an App functionality for offline use. Eliminating leasing fee for the online learning solution offered the opportunity to re-direct funds allocated for leasing to assist students with payments for computers. A contemplated formula includes allocating a portion of the registration fee towards funding approximately half of the cost of the computer while students would enter a payment schedule for the remaining half of the purchase price.

Conclusion

This pilot study of the integration of EdTech in East Africa provides insights and understanding on the decision matrix and consideration, not only on online learning solutions but also on the broader issue of integrating technology into brick and mortar institutions. It provided an opportunity to explore areas that might require attention and adjustment. The experience of the lecturers and students was critical to understanding the functionality of online learning platforms as a learning environment.

Reducing uncertainty was the driver for the DOI process for the project in light of the limited resources and shortage of institutional and infrastructure capacity. Although the project arrived late in the general context of international development of online learning, nationally, it was innovative and thus, preceded through the DOI steps of building awareness, building consensus, two-step decision, one resulting in discontinuance and one in implementation and confirmation. The complexity of the package system and regionally developed solution previewed were rendered impractical, delivering the relative advantage to the final option of internally developing a customised solution. The ability to create a solution that aligned with requirements and functionality suited to local users offered compatibility, which in DOI is the 'degree to which an innovation is perceived as consistent with the existing values, past experiences, and needs of potential adopters' [Rogers, 2003: 15]. Ultimately, the final decision rested on the solution's relative advantage, compatibility, complexity, and observability.

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