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# Comparative Analyses of Learning Management Systems, 2019

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# Comparative Analyses of Learning Management Systems, 2019

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An abstract submitted to the Faculty of Rolling School of Public Health of Emory University in partial fulfillment of the requirement for the degree of
Master of Public Health
in Hubert Department of Global Health
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# Abstract

**Comparative Analyses of Learning Management Systems, 2019**
Grace Ngobia

**Introduction**
Africa bears a heavy disease burden, both communicable and non-communicable. Paired with shortages of well-trained, healthcare personnel caused the African Union (AU) to establish the Africa Centres for Disease Control (Africa CDC). A newly created institution, Africa CDC has the mission to serve and protect African citizens from communicable and non-communicable diseases by strengthening the capacities of National Public Health Institutes (NPHIs). To improve the public health workforce across the continent, Africa CDC proposed an innovative strategy and established an Institute for Workforce Development (IWD). In cooperation with Emory University, Africa CDC has conceived and implemented this IWD. This work compares learning management systems (LMS) to best inform the Africa CDC's IWD.

**Methods**
Peer-reviewed and gray literature were reviewed using data searches with keywords refined by inclusion and exclusion criteria and informal meetings with project managers. Conducted to inform the selection processes and criteria, quantitative scaling and weighing evaluated a select group of LMS for recommendation.

**Results**
Canvas received a perfect total score of 60 and weighted total of six. Totara followed with a score of 58 and weighted score of 5.8. Open eDX received a score of 52 and weighted score of 5.2; Blackboard™ a score of 48 and weighted score of 4.8; Moodle received a score of 46 and weighted score of 4.6; and Sakai received a score of 42 and weighted score of 4.2.

**Discussion**
Outcomes of this comparative analyses revealed that Canvas directly addressed the prioritized and selected criteria. With this, the choice to incorporate Canvas as the LMS in the Africa CDC IWD would bring alignment with other global and esteemed academic institutions. Therefore, we recommend Canvas for the Africa CDC IWD.

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Psalm 100: 1-5

## Table of Contents

## Abbreviations

Africa Centres for Disease Control (Africa CDC)

African Union (AU)

Institute for Workforce Development (IWD)

Institutional Review Board (IRB)

Learning Management System (LMS)

Member States (MS)

Non-communicable diseases (NCDs)

National Public Health Institutes (NPHIs)

Shareable Content Object Reference Model (SCORM)

## Chapter 1- Introduction

The Africa Centres for Disease Control (Africa CDC) is a newly established organization that provides support for Member States (MS) of the African Union (AU) to improve the public's health. As stated on its website, the mission of the Africa CDC is to "strengthen Africa's public health institutions and its capabilities." [2] One of Africa CDC's primary objectives is public health workforce development. In collaboration with Emory University, Africa CDC will implement an Institute for Workforce Development (IWD). With the implementation of this IWD, there are two important questions: what education content will be delivered and how should it be delivered (i.e., what Learning Management System [LMS]).

The comparative analyses will allow the Africa CDC (and the Emory team) to choose an LMS and maintain a robust, world-class, learning environment and platform accessible to the continent. Regardless of geographic location, the proposed LMS will promote Africa CDC and its efforts to strengthen healthcare workforce development. Therefore, the objective of this study is to provide evidence comparing LMS and to make a recommendation to the Africa CDC-IWD. By conducting the analyses, we can offer a thoughtful, objective recommendation for decision makers.

# Chapter 2- Literature Review

## I. African Disease Burden and Emergence of Non-Communicable Diseases (NCDs)

Africa has the highest burden of disease of any continent, and it faces the double burden of chronic and infectious diseases. While 69% of deaths are due to infectious diseases, age-specific mortality rates from chronic diseases are greater in Africa than other regions of the world [9]. This includes both men and women. African health systems are often weak; infectious and parasitic diseases are prioritized by national investments in healthcare training and service delivery [9]. Over the next decade, WHO projects that the continent will experience the largest increase in death rates from non-communicable diseases (NCDs) (e.g., cardiovascular disease, diabetes, and respiratory disease) [9]. According to the Global Health Council, Sierra Leone has both the highest proportion of active tuberculosis (TB) cases and the sixth highest death rate for cardiovascular disease [30]. In Ethiopia, approximately the same number die from cancer as malaria each year. Risk factors for NCDs (e.g., smoking and obesity) continue to increase; those with NCDs in Africa die more quickly than those in other countries [30].

Various factors contribute to the growth of NCDs in Africa and the (re)-emergence of infectious diseases [35], including the lack of training for healthcare providers and the public health workforce [12]. Alongside the lack of a trained healthcare workforce, other factors contribute to the rise of both NCDs and infectious diseases (e.g., increased life expectancy, changing lifestyle practices, poverty, and urbanization) [11], the lack of infrastructure, weakened ministries of health, and the lack of support and efforts to harmonize collaborations among stakeholders [13].

## II. Africa's Healthcare Workforce

The shortage of healthcare workers is more prevalent in developing countries contributes to the limited achievements in health-related Sustainable Development Goals (SDGs) [18]. Africa, in particular, is burdened with insufficiently trained public health assets, including those trained in public health surveillance, laboratory systems, and a skilled managers and leaders [21]. The World Health Organization (WHO) estimates that Africa faces a shortage of 4.3 million healthcare professionals required to deliver essential services. There are currently 55 countries on the continent of Africa with a critical shortage of healthcare workers; WHO estimates an additional 2.4 million will be needed to meet the Sustainable Development Goals [36]. The ratio of health workers to population illustrates the disequilibrium: the United States has an average of 24.8 health workers per 1,000 people, while in Africa the ratio is 2.3 per 1,000. Only 1.3% of the world's health workers for a continent that experiences 25% of the global disease burden.

The shortages in Africa's healthcare workforce derives from many causes, include the lack of funding and resources for proper training to increase health worker densities, migration to other international countries for better pay, and career changes [28]. Poor staff welfare, salary and leadership/management and governmental inability to implement fair agreements results in healthcare worker strikes in many African countries resulting in the disruption of service delivery and training programs, and further increases morbidity and mortality rates of patients needing care [22]. With this, and despite the lopsided ratio of health care workers to population size, WHO estimates that around 60 million healthcare workers migrate to other countries. The AU estimates that about 70,000 skilled professionals emigrate from Africa every year, and that in many Africa countries over 50% of healthcare workers intend to migrate from their home country once trained. This migration of healthcare workers (brain drain) is defined as "the

movement of health personnel in search of a better standard of living and life quality, higher salaries, access to advanced technology and more stable political conditions in different places worldwide." [17] The migration of healthcare workers from developing countries such as those in sub-Saharan Africa to developed countries has proved detrimental to healthcare delivery. Inadequate health systems of Africa have been badly damaged by the emigration of health professionals [20], as this shortage constitutes a major barrier to the provisions of essential health services [10].

## III. Africa CDC and the Institute for Workforce Development

### Africa CDC

The Ebola outbreak, which destabilized the healthcare systems and economies of West African nations, exposed the weaknesses in public health preparedness of the affected countries [37]. Recognizing the critical need to unify African countries around improving workforce development and effective response to outbreaks, heads of states and governments of the AU officially launched the Africa Centres for Disease Control (Africa CDC) in Addis Ababa, Ethiopia on January 31, 2017. Africa CDC is a *specialised technical institution of the African Union that serves as a platform for Member States to Share Knowledge, exchange lessons learnt, build capacity, and provide technical assistance to each other*. [2] Its mission is to "strengthen the capabilities of African public health institutions to detect and respond effectively to disease threats and outbreaks, based on science, policy, and data-driven interventions and programs." [2] It also has a vision for "a safer, healthier, integrated, and prosperous Africa, in which member states can efficiently prevent disease transmission, implement surveillance and detection, and always be prepared to respond effectively to health threats and outbreaks." [2] This African

owned institution is guided by principles of leadership, credibility, ownership, delegated authority, timely dissemination of information, transparency, accountability and value addition is set to support all member states (MS) of the AU to improve public health surveillance, prevention of infectious diseases and emergency response. This involves addressing man-made and natural disasters, outbreaks, and public health events of regional and international concern. It further seeks to build the capacity to reduce disease burden on the continent [2].

*Africa CDC Five Pillars*

Africa CDC has a strategic focus in five key areas: National Public Health Institutes (NPHIs) and Public Health Research; Laboratory Systems and Networks; Information Systems; Emergency Preparedness and Response; and Surveillance and Disease Intelligence. Healthcare Workforce Development is housed under the NPHI and Public Health Research pillar [2].


Figure 1. Five Africa CDC Strategic Pillars

*Africa CDC Structure*

Africa CDC incorporates the secretariat, led by the Executive Director of Africa CDC, at its headquarter in Addis Ababa, Ethiopia. Its responsibilities and functions include supporting MS to develop and strengthen already existing public health mechanisms such as policies, programs, systems, and structures [2]. In the five AU regions, Regional Collaborating Centres (RCCs) serve as the technical support institutions for the Africa CDC. They serve as links between the secretariat and the MS by promoting regional collaboration, networking, and integration [2]. The National Public Health Institutes (NPHIs) science-based, governmental organizations serve as focal points for a country's public health efforts, as well as a critical component of global disease prevention and response system [11]. They collaborate with Africa CDC and the RCCs in cross-border and regional health issues, and with academia across the continent to strengthen in workforce development and research [2].

Figure 2. Five Africa CDC Regional Collaborating Centers

*Institute for Workforce Development*

Africa CDC's mission is to "strengthen Africa's public health institutions' capabilities to detect and respond quickly and effectively to disease outbreaks and other health burdens through an integrated network of continent-wide preparedness, response, public health surveillance (PHS), laboratory, and research programs." [2] If Africa CDC fulfills its mission to strengthen healthcare networks, it has the potential strengthen the capacity of the health professionals who are responsible for addressing 25% of the world's burden of disease [19]. To improve the public health workforce capacity across the continent, Africa CDC has proposed an innovative strategy and established an Institute for Workforce Development (IWD) [21].

Africa has the highest burden of disease of any continent, but the lowest ratio of trained healthcare workers per the population. Furthermore, a workforce development training program through a continental health organization had yet been established. These factors have created suitable conditions for the growth of non-communicable diseases, the emergence of infectious diseases, and increased levels of maternal and child mortality rates [35].

Public health workforce development is an integral component of Africa CDC's mission, as it will benefit MS by increasing their ability and knowledge to prevent, detect, and respond to the spread of disease within their borders. Recognizing the critical need to unify African nations around public health preparedness and a necessity to increase the number of skilled health workers Africa CDC in cooperation with Rollins School of Public Health (RSPH) and the AU is piloting an innovative and comprehensive IWD for health care workers. Public health workforce development is an integral component of Africa CDC's mission and will benefit MS by

increasing their ability and knowledge to prevent, detect, and respond to the spread of disease within their borders.

Africa CDC, its RCCS, and RSPH will develop and deploy training through the NPHIs of AU member states. Initial training is set to target persisting critical vulnerabilities in areas of public health such as antimicrobial resistance (AMR) and public health surveillance (PHS), together with technical training in leadership and management and proposal writing.

As the IWD will be the foundation to maximize resources, establish an effective e-learning training environment, and design training courses, RSPH together with Africa CDC have acknowledged a LMS to be an integral component of success. The establishment of world-class e-learning pedagogy is a main objective of the IWD; it will aid in the training administration, documentation, tracking, reporting, and overall course delivery. The LMS will provide a web-based platform for e-learning, reducing resources, and saving time and travel; identifying the best one is crucial.

## IV. e-Learning

e-learning occurs when digitized training content is provided to learners through the internet (online), and learners are provided with pedagogic options (meaning the ability to access learning resources anywhere and anytime-regardless of geographical borders). It emerged as a result of developments in economics, social and cultural life, and technology in educational systems. e-Learning is classified and characterized into two types: synchronous and asynchronous. In synchronous e-Learning, learners experience the process in a physical environment that is virtual. Through the LMS, the learning process is conducted through live chat apps and video conferencing systems. The learning activities are pre-scheduled and the

online presence is necessary at the same time; the instructor acts as the active party. Asynchronous e-Learning is a type in which the learners are the active party. The instructors present the learners with access to digitized training content (i.e., course materials, videos, e-tests/quizzes), and the content is updated based on need [32].

With this, e-Learning provides the ability for independence in terms of time and space, with continuous accessibility, time and cost savings, the ability for many participants to benefit from same training, and the ability to virtualize classical and traditional learning styles. e-Learning has proven a successful model, and is becoming preferred for many organizations and academic institutions [34].

## V. Learning Management Systems

Learning Management Systems (LMS) also referred to as Virtual Learning Environments, Digital Learning Environments, Course Management Systems or Electronic Learning Environments are web based applications, running on a server and accessible with a web browser from any place with an internet connection [32].

LMS gives educators tools to create and offer online courses and provide access to learning materials and the ability to administer, document, track, report, and deliver courses or training programs [8]. They are greatly used by educational institutions to enhance and support classroom teaching and offer courses to a larger population across geographical borders [3]. There are several advantages and benefits to using an LMS. These include:

- Organize e-Learning content into one location
- Provide unlimited access to e-Learning materials
- Track learner progress and performance

- Reduce learning and development costs and time
- Keep organizations up-to-date with compliance regulations
- Quickly and conveniently expand e-Learning courses
- Integrate social-learning experiences

There are various types of LMS. They are primarily differentiated by two main criteria: licensing and deployment types. For licensing types, there are two types: proprietary and open source. Proprietary LMS are licensed under legal right, restricted from modification and distribution, and with license costs per user. Such LMS are cost-based and distributed on a paid basis; they are easy to implement as the company offers technical support. Customization within a proprietary LMS is limited as users are not the decision makers; vendors are. The other type of licensing is open-source. LMS that are open-source operate under the general public license; the intention is to guarantee freedom to share and customize the program, while ensuring that it is free or affordable for users [14].

From the deployment perspective, there are two types: on premise or in-house and hosted. On-premise LMS are primarily hosted in house by the organization or academia using the LMS. A website domain for the LMS is required for implementation. It requires a dedicated internal IT team. Due to this, their maintenance costs are higher, as the customer will be responsible for IT infrastructure and ongoing management. Hosted LMSs are either hosted on the internet and accessed by logging on to the vendors' site. Therefore, an independent website is not required and neither is an internal IT team, as the vendor's IT handles activities. Low cost subscriptions are purchased for the hosting, making management costs also lower [14].

As times and technology progress and the global expansion of continuing education, the need for the best automated and predetermined system becomes key in the decision-making for institutions; a system that will improve the overall results of students or trainees, by providing instant access to material, and instantaneously track performances in a centralized data storage.

## VI. LMS and e-Learning in Africa

The use of e-Learning has major impact on Africa's education sector. This impact however has challenges due to certain limitations in most African countries. Key constraints and impediments in the implementation and development of e-Learning include internet connectivity and the lack of relevant digital content that is compatible to the rapidly changing technology. It is estimated that 1/250 people have access to internet in Africa as compared to the global average of 1/15. Online learning poses as an overall challenge, as these various dynamics involved in implementing e-Learning within the Africa context are complex [5]. Although e-Learning is still in its infancy across most of the continent, various technological advancements have taken place in Africa to support online education. An example of such a measure includes the incorporation of tele-centers, which are public sites that offer internet access for a fee. These are becoming more popular and common in many countries, and are being used to expand access to e-Learning [4].

Institutions incorporating e-Learning have gradually penetrated the African education sector with a wide range of programs and projects being implemented and supported. Some of these include NEPAD e-Schools initiative, an initiative focused on networking African schools and universities such as the Africa Virtual University (AVU) and collaborate learning projects that directly involve learners and instructors from several African countries [4]. Furthermore, within

low-resource areas and countries that are undergoing the shortage and lack of healthcare workers, e-Learning has been seen as a revolutionary force for healthcare education. Technology has grown, and computers are widely available in many forms such as tablets, mobile phones, and laptops. In addition, developing African countries have significantly progressed within the past few years in mobile connectivity and internet access. This progress therefore breeds ground for healthcare e-Learning, which included advantages of time efficiency, flexibility in learning, and overall lower costs [6]. To further echo this, an article illustrating the perspectives of distance learning in various African countries states that, "trends in online education stand to have profound impacts on employment, culture, communication and class around the world. The rapid global expansion in online education resources will make learning opportunities more abundant, cheaper and more accessible. Increased value placed on lifelong learning and the recognition of non-formal and informal learning will change the nature of recruitment, and equalize employment opportunities in a number of ways." [5]

## VII. Comparative Analyses

In conclusion, Africa CDC, in collaboration with the Emory team, is dedicated to providing healthcare professionals within the AU MS with public health educational courses, aimed to expand and strengthen workforce capacity. With this, Africa CDC and Emory needs an LMS to aid in the e-Learning environment and work towards healthcare workforce development.

# Chapter 3 - Manuscript

## I. Abstract

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Grace Ngobia

**Introduction**
Africa bears a heavy disease burden, both communicable and non-communicable. Paired with shortages of well-trained, healthcare personnel caused the African Union (AU) to establish the Africa Centres for Disease Control (Africa CDC). A newly created institution, Africa CDC has the mission to serve and protect African citizens from communicable and non-communicable diseases by strengthening the capacities of National Public Health Institutes (NPHIs). To improve the public health workforce across the continent, Africa CDC proposed an innovative strategy and established an Institute for Workforce Development (IWD). In cooperation with Emory University, Africa CDC has conceived and implemented this IWD. This work compares learning management systems (LMS) to best inform the Africa CDC's IWD.
**Methods**
Peer-reviewed and gray literature were reviewed using data searches with keywords refined by inclusion and exclusion criteria and informal meetings with project managers. Conducted to inform the selection processes and criteria, quantitative scaling and weighing evaluated a select group of LMS for recommendation.
**Results**
Canvas received a perfect total score of 60 and weighted total of six. Totara followed with a score of 58 and weighted score of 5.8. Open eDX received a score of 52 and weighted score of 5.2; Blackboard™ a score of 48 and weighted score of 4.8; Moodle received a score of 46 and weighted score of 4.6; and Sakai received a score of 42 and weighted score of 4.2.
**Discussion**
Outcomes of this comparative analyses revealed that Canvas directly addressed the prioritized and selected criteria. With this, the choice to incorporate Canvas as the LMS in the Africa CDC IWD would bring alignment with other global and esteemed academic institutions. Therefore, we recommend Canvas for the Africa CDC IWD.

## II. Introduction

Although dramatic progress has been made in reducing the loss of life caused by disease, they still account for most health loss on the African continent; communicable, maternal and child, and nutritional disease continue to be prevalent, contributing to at-least 69% of deaths on the African continent [27]. Additionally, Africa faces the double burden of both communicable and non-communicable diseases (NCDs), as age specific mortality rates in both men and women from chronic diseases are higher in the region, compared to other regions across the world. WHO projects that over the next decade, the largest increase in death rates from various NCDs such as diabetes and cardiovascular disease will be within the African continent [9]. Even though Africa has the greatest disease burden, it has the lowest ratio of healthcare workers per population. Intra-Health in collaboration with WHO calculated that the global shortage of health workers will expand from 12 million to 18 million by 2030. With this, Africa is challenged to train health workers and encourage them to stay and work in the region [31].

Africa Centers for Disease Control (Africa CDC) is a newly established organization under the AU. With the mission to strengthen Africa's public health institutions and their capabilities, it has the objective to strengthen healthcare workforce development. To do so Africa CDC in collaboration with Emory University, is piloting an Institute for Workforce Development (IWD) is set to train the healthcare workforce on continent. To facilitate this learning institute, e-Learning will be utilized. Therefore, Africa CDC and Emory must select a Learning Management System (LMS) to aid in the e-Learning environment, and work towards healthcare workforce development.

The establishment of an e-Learning pedagogy with a LMS, is a main objective in the establishment of the IWD to aid in training administration, documentation, tracking, reporting,

and overall course delivery. The LMS will provide a web-based platform for e-Learning, reducing resources, reduce time and effort, and money, ideally increasing both number of individuals trained and the amount of training individuals can obtain.

The comparative analyses will allow Africa CDC and Emory to pick a LMS, that will create and maintain an active e-Learning environment accessible to all willing to take courses through IWD.

The selected LMSs were compared in the analyses by a given criteria, and weighed against each other. Based on the results, the highest scoring LMS will be recommended for use in the IWD.

## III. Methods

*Sample*

The particular LMS were chosen for this comparative study due to their usage in Africa by Academia, and their ability to fit the comparative criteria. These LMS and their forms of deliver are:

- **Canvas**- launched in 2011, and is being used in more than 3,000 universities and institutions worldwide [1]. It is a proprietary and a cloud-based hosted LMS [14].
- **Totara**- released in the global market in 2011, it is an open sourced and cloud-based hosted tool [23].
- **Open eDX**- an open-source system used globally, it can be installed on premise or by leveraging cloud infrastructure service providers for hosting and management [16].
- **Blackboard**- created and founded in 1997, it has come to be used by more than 70% of universities and colleges in the United States [7]. It is a proprietary-based, managed system [38].

- **Moodle**- launched in 2002, it has garnered more than 60 million users, with more than 50 thousand sites operating globally, making it the most used system globally [29]. It is an open sourced, on premise web system [26].
- **Sakai**- an open-source software supporting over 4 million educational users globally [24], its primary mode of delivery is on premise/in-house [25].

Data of each LMS were collected via a literature search, using as keywords such as "Learning Management Systems" "Comparative Analysis of LMS" "LMS" and names of selected LMS. The inclusion criteria for where data was searched were created (peer reviewed articles, websites of chosen LMSs, other websites pertaining selected keywords and pertinent information) and an exclusion criteria as well (articles and websites which don't include keywords listed). Data were extracted by reading the abstracts of all articles, reading websites retrieved during the initial search, and then narrowing by keywords. Once focus was narrowed, relevant information was retrieved from the full text and synthesized to summarize the comparison between the selected LMS. A summary of findings table was made to aid in the extraction of information from the literature.

*Comparative Analysis*

The comparative criteria were chosen by holding informal interviews with the Primary Investigator and Project Manager of the Emory-Africa CDC team that are leading the ongoing project of implementing the IWD at Africa CDC. After several meetings, we established the list of seven criteria in which the LMSs would be compared, together with the percentage priority status for each criterion. These criteria and their percentage priority status were:

- Pricing - 20%
- User-friendliness - 15%

- Shareable Content Object Reference Model (SCORM) Compliance - 15%
    - SCORM enables the sharing of content from one system to another [33].
- Learning Tools Interoperability (LTI) Compliance - 10%
    - LTI enables the integration of external tools and features into an LMS [15].
- AU languages - 10%
    - Portuguese, French, English, Arabic
- Long-term management - 30%

This quantitative scale was used to assist in the calculations and the recommendations. Furthermore, for data representation of the comparative analyses, tables were created as visual displays for each criterion. Lastly, an evidence table was created with references inputted to illustrate reasoning for the scoring process (c.f., Appendix).

*Quantitative Analysis*

A quantitative scale was created to compare the systems. Different criteria were scored on a scale of 0-10, with 10 being the highest attained. Additionally, the different criteria were weighted by percentages based on priority given by the Emory-Africa CDC team. Each LMS was scored according to the previously established and prioritized criteria. The scores of each LMS were multiplied by the given weighted percentages of each criteria. Final scores were combined into one comprehensive table. The highest scoring LMS was proposed for recommendation to be used for the pilot of the learning institute. The selected ratings are below:

- **Price - 20%:** A score of 10 was given to the LMS with annual price lower than $10,000. If over, a gradient by $5,000 was used (e.g., $10,000 - $15,000 = 8; $15,000 - $20,000 = 6; $20,000 - $25,000 = 4; and <$30,000 = 2).

- **User-friendliness - 15%:** A score of 10 was given to the LMS with inclusion of four selected features (i.e., streamlined navigation, browser compatibility, mobile device accessibility, services).
- **SCORM Compliance - 15%:** A score of 10 was given to the LMS with this feature.
- **LTI Compliance - 10%:** A score of 10 was given to LMS with this feature.
- **AU Languages - 10%:** A score of 10 was given to LMS with inclusion of all four AU languages (i.e., English, Portuguese, Arabic, and French).
- **Long-term Management - 30%:** A score of 10 was given to LMS which is open sourced and cloud based or proprietary and cloud based.

*Ethical Considerations*

An application was sent it to Emory's Institutional Review Board (IRB) and was determined that this work did not require IRB review and was exempt as it did not meet the definition of "research" with "human subjects," or the definition of "clinical investigation" as set forth by Emory in their IRB procedures and policies.

## IV. Results

**SCORM Compliance.**

All selected LMS scored the same; they all received the highest score of 10--and received the quantitative score of 1.5 when weighted by 15%. (Table 1)

**African Union Languages**

All selected LMS scored the same; they all received the highest score of 10 and a total of 1 when weighted by 10%. (Table 1)

**Pricing**

Canvas and Totara were the only systems to receive a score of 10 and a weighted total by 20%. (Table 1) Moodle, Sakai, and Open eDX received a score of six and a weighted total of 1.2 as their overall cost was approximated to be within $15,000 - $20,000. Blackboard received the lowest score of two and a weighted total of 0.04, as it proved to be the most expensive LMS of the selected systems.

**Long-term Management**

With a high priority set by the implementation team for sustainable, long-term management of LMSs, Canvas, Blackboard, and Open eDX received a scores of 10 and a weighted total by 30% of three. (Table 1). They all have cloud-based and hosted options for management. Moodle and Sakai received scores of 0 and a similar weighted total, as majority of evidence showed that their primary form of delivery is in-premise/in-house without a cloud-based option.

**LTI Compliance**

All selected LMS received the highest score of 10, and all received the same quantitative score of 1 when weighted by 10%. (Table 1)

**User-friendliness**

Canvas and Moodle received the highest score of 10 and a score of 1.5 when weighted by 15% (Table 1); Totara received a scaled score of eight and a weighted score of 1.2 as was available only in web-based form with a lack of accessibility to a mobile app on both iOS and android platforms, and Sakai, Blackboard, and Open eDX received a scaled score of six and a weighted score of 0.9. Sakai received this score due to its limitations on browser compatibility, as it is primarily recommended to use of Google Chrome, Mozilla Firefox, and Internet Explorer for best performance. Additionally, Sakai mainly support web-based devices. Blackboard received a

similar score due to its difficult usability and navigation, and also because it only provides on-the-phone support services. Open eDX received a score of 6 and a weighted score of 0.9 as research conducted showed it only supports email-based support services, and its web browser compatibility is limited to Google Chrome and Firefox for best performance.

**Total**

The highest total score a system could receive was 60, and a weighted total of six by 100%. When all scaled totals were summed, Canvas received a perfect score of 60, and a weighted total of 6. (Table 2) Moodle received a score of 46 and a weighted total of 4.6, as it missed points in the criteria of pricing, long-term management, and African Union languages. Its lowest criteria score was within long-term management. Totara scored a total of 58 and a weighted total of 5.8, as it missed points in the criteria of user-friendliness. Sakai received a score of 42 and a weighted total of 4.2, as it missed points in the criteria of pricing, long-term management, and user-friendliness. Its lowest criteria score was within long-term management. Blackboard received a total scaled score of 48 and a total weighted score of 4.8, as it missed points in the criteria of pricing and user-friendliness. It received the lowest score within the pricing criteria. Open eDX received a total scaled score of 52 and a weighted total score of 5.2. It missed points in the criteria of pricing and user-friendliness.

**Table 1**. Evaluation of Learning Management Systems, by Various Criteria, 2019

| Learning Management System | SCORM Compliance | | African Union Language | | Pricing | | Long-term Management | | LTI Compliance | | User-friendliness | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Total | Weighted* | Total | Weighted* | Total | Weighted* | Total | Weighted* | Total | Weighted* | Total | Weighted* |
| Canvas | 10 | 1.5 | 10 | 1 | 10 | 2 | 10 | 3 | 10 | 1 | 10 | 1.5 |
| Totara | 10 | 1.5 | 10 | 1 | 10 | 2 | 10 | 3 | 10 | 1 | 8 | 1.2 |
| Open eDX | 10 | 1.5 | 10 | 1 | 6 | 1.2 | 10 | 3 | 10 | 1 | 6 | 0.9 |
| Blackboard™ | 10 | 1.5 | 10 | 1 | 2 | 0.04 | 10 | 3 | 10 | 1 | 6 | 0.9 |
| Moodle | 10 | 1.5 | 10 | 1 | 6 | 1.2 | 0 | 0 | 10 | 1 | 10 | 1.5 |
| Sakai | 10 | 1.5 | 10 | 1 | 6 | 1.2 | 0 | 0 | 10 | 1 | 6 | 0.9 |

Weighted by: SCORM Compliance-10%*, African Union language-10%* (Portuguese, French, Arabic, English), Pricing-20%*, Long-term Management-30%*, LTI Compliance-10%*, User-friendliness-15%*.

SCORM Compliance is defined as the ability to share content from one system to another
LTI Compliance is defined as the ability to integrate external tools and features.

**Table 2**. Overall Evaluation of Learning Management Systems, 2019

| Learning Management System | Total | Weighted* |
|---|---|---|
| Canvas | 60 | 6 |
| Totara | 58 | 5.8 |
| Open eDX | 52 | 5.2 |
| Blackboard™ | 48 | 4.8 |
| Moodle | 46 | 4.6 |
| Sakai | 42 | 4.2 |

Weighted by 100%*

## V. Discussion and Recommendation

Comparative analyses of LMS provided the Africa CDC's IWD implementation team with a reviewed report of selected LMS options. These analyses were specific to the needs and priorities of the Africa CDC's IWD. We conducted extensive research into the LMS, and included other resources found of LMS analysis conducted by other academic institutions, in order to determine how to score the LMSs by the selected criteria.

Canvas scored the highest with a perfect score in the comparative analyses. It was recommended that on the basis of this evaluation. Africa CDC's IWD will adopt Canvas as its LMS during the immediate implementation phase. This recommendation was attributed to its capacity in all selected criteria, particularly in its cloud-based and managed delivery to ensure resourceful long-term management, its pricing being within the established budget, and incorporating all of the user-friendliness measures. We also recommended that a thorough follow-up impact evaluation be conducted after the first year of operation. A post-impact evaluation should include surveys gathered from both instructors of courses and students who used it. This follow-up evaluation should gather data, from students and instructors, to see how effective the LMS was, and whether a switch to another LMS is needed.

Canvas is an affordable, cloud-based LMS. The comparative analyses showed that it directly addressed the prioritized criteria, especially the highly prioritized criteria of long-term management and pricing. The choice to incorporate Canvas as the LMS within Africa CDC

implementation of the IWD would bring the Africa CDC on par with other global and esteemed academic institutions, and with the emerging industry standard LMS platform.

## VI. Limitations and Conclusions

The immediate implications of the comparative analyses will be to the Africa CDC and the implementation of the IWD. However, one limitation includes the fact that the methods heavily rely on internet research; the sample evaluated was small. Additionally, with some of the data coming from websites of the LMS, self-reporting could contain potential biases. Given the time frame of this project, there were resources outside of internet sites that were examined. But a more comprehensive assessment should include interviews with technical members of each selected LMS, together with technical members of various universities who participated in the process of LMS analysis for their own institutions. This would provide a thorough qualitative analyses of experiences using the various LMS and resolutions about features from technical personnel of the LMS, as they have a better understanding. Lastly, with the analyses being exclusive to the Africa CDC IWD needs and priorities, other organizations may not be able to utilize this work as the findings are not necessarily generalizable.

With the mission to "strengthen Africa's public health institutions' capabilities to detect and respond quickly and effectively to disease outbreaks and other health burdens through an integrated network of continent-wide preparedness, response, public health surveillance, laboratory, and research programs" [2], Africa CDC is a growing organization that is set to implement the IWD. The institute will train public health personnel and ultimately work to strengthen the healthcare workforce throughout Africa. In order for this to be implemented and beneficial, a LMS will be set up to support the pedagogical environment. Therefore, the need to

establish an LMS that correlates with the priorities of the Africa CDC IWD implementation was imperative. With the analyses of LMSs, we hope that the offered recommendation is considered, and further commits to incorporating Canvas as the LMS for the IWD.

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## VIII. Appendix

### Evidence Table

| Learning Management System | SCORM Compliance | Africa Union Language | Pricing | Long-term Management | LTI Compliance | User-friendliness |
|---|---|---|---|---|---|---|
| Canvas | **10** [22] [27] | **10** [47] | **10** [offer] | **10** [36] [5] | **10** [6] | **10** [10] [31] [46] [55] |
| Totara | **10** [44] [20] | **10** [51] | **10** [1] | **10** [1] | **10** [17] | **8** [52] [53] [48] [13] |
| Open eDX | **10** [3] [21] | **10** [49] | **6** [19] | **10** [11] | **10** [37] | **6** [16] |
| Blackboard™ | **10** [14] [45 | **10** [26] | **2** [15] [4] | **10** [23] | **10** [28] | **6** [4] [12] [38] [33] |
| Moodle | **10** [9] [24] | **10** [25] | **6** [50] | **0** [2] | **10** [30] | **10** [32] [54] [7] [34] [35] |
| Sakai | **10** [24] [42] | **10** [43] [18] | **6** [50] | **0** [41] | **10** [40] | **6** [29] [8] [39] |

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