Remote Teaching and E-learning Cloud Infrastructure and Support Guidelines for KENET Educational Member Institutions

Author

KENET Team

Kenya Education Network

P.O. Box 30244 -0010

Nairobi, Kenya

JULY 2020

TABLE OF CONTENTS

LIST OF TABLES

Executive Summary

KENET member universities and other educational institutions were closed in the week of March 16-20, 2020 because of the COVID-19 pandemic and subsequent cessation of movement. Some universities migrated their face-to-face campus-based classes to what was called **emergency remote teaching** supplemented by their existing e-learning platforms. In the period April – June 2020, many universities have requested upgrade of their Learning Management System (LMS) servers' resources and applications that are leased from KENET. A few universities have also moved their campus-hosted LMS servers to KENET data centers to achieve high-levels of uptime, optimal bandwidth and for additional server resources, mainly processing power and RAM.

An increasing number of universities are also using the free KENET web conferencing platform for remote teaching (https://conference.ke). There are some universities that are using other free or licensed web conferencing platforms (e.g., Zoom, Microsoft Teams, WebEx and Google teams). There are also some universities that operate their own instances of the open source web conferencing BigBlueButton (BBB) hosted at their campus server rooms or at KENET data center.

These remote teaching and e-learning guidelines therefore to assist universities and other educational institutions implementing their remote teaching and learning continuity plans that as a minimum require selection and/or setting the following ICT infrastructures and training the users (faculty and students)

1. **Selection of remote teaching platform** – universities need to make a decision on the preferred web conferencing to be used for remote teaching and budget for the associated costs if any (e.g., the shared KENET web conferencing platform is free).
2. **Upgrade and hosting of learning management systems (LMS) servers**: Many universities and educational institutions had low-capacity installations of their LMSes (e.g., Moodle) and in most cases these were hosted at their respective campus server rooms. The increased number of concurrent users of the LMSes means upgrade of the servers was necessary. With campuses closed, it might also be necessary for some institutions to collocate their physical servers at KENET data centers or to lease larger virtual servers from KENET.
3. **Setting up content development and testing environments and the associated remote teaching classrooms at their campuses**. All faculty shall be required to develop and curate

high-quality e-learning content to supplement remote teaching (i.e., it is a blended learning environment) . The home environments of the faculty might not be appropriate for content development and educational institutions are therefore expected to setup the content development environments at their campuses. *These guidelines assist the ICT and online learning support teams to setup or expand the environments.*

4. **Selection of off-campus or home Internet access options for students and faculty**. Some universities have chosen to sponsor the off-campus Internet. In all cases, there is a need to support the students and faculty with secure off-campus Internet access and inform the students and faculty about the negotiated discounted bundles and the associated costs.

5. **Faculty training on remote teaching platform, LMSes and associated support tools** (e.g., remote proctoring and anti-plagiarism tools). The faculty would also need online teaching assistants and/or instructional designers during content development.

Each of the above areas have budgetary implications and universities and educational institutions will need to make decisions in a timely fashion to adopt remote teaching and e-learning practices for up to 90% of their students.

In developing these guidelines, KENET has assumed that most of the students shall be taking blended courses that combine both remote teaching and e-learning in the AY 2020/2021 and beyond. Many of the changes shall therefore be permanent because of the social distancing requirements for the on-campus students and faculty.

The KENET remote teaching and learning team is available to support the educational institutions seeking solutions in all or some of the five areas listed above.

1. Introduction

The use of technology to deliver remote teaching to students in the education institutions is growing and we are witnessing a complete shift from the traditional face to face learning to the use of remote teaching and e-learning platforms which could be considered virtual classrooms. Migrating physical classrooms to the online or virtual classrooms requires as a minimum remote teaching platform (e.g., web conferencing platform) that is optionally supplemented with a learning management system that hosts the e-learning content.

KENET educational member institutions were closed abruptly by the government in the week of March 16-20, 2020 as way of containing the COVID-19 pandemic. This resulted in majority of learning institutions moving classes online. The large number of concurrent users accessing the learning platforms means that educational institutions must upgrade their physical or virtual server infrastructure. These servers supporting the remote teaching or LMSes are often virtual servers hosted by campus-based private cloud, KENET community cloud, or the public cloud (e.g., Zoom, Microsoft Azure or even Amazon Web Services).

Many of the educational institutions that are leasing Virtual servers from KENET have requested for upgrades especially in terms of more RAM and number of CPUs. KENET has also upgraded its free web conference (based on BigBlueButton) by close to 18 times to cope with the increased number of concurrent users as more universities started to use the platform for remote teaching.

KENET has therefore developed guidelines that will help ICT directors and technical staff at universities to dimension the following components of virtual classrooms and the associated costs:

1) The remote teaching platform based on instances of open source BigBlueButton or other commercial web conferencing platforms like Zoom or Microsoft Teams.
2) Learning Management System based widely on the adopted open source Moodle platform. The LMS can include plug-ins for anti-plagiarism and remote proctoring tools.
3) Off-campus Internet Access
4) E-learning Content Development environments
5) Faculty support and training

2. Remote Teaching Platforms (Virtual Classrooms Platform)

A remote teaching platform allows for live and synchronous interaction between the teacher and the learners as they are participating in learning activities. In other words, the virtual classroom is a shared online space where the learners and the teacher work together simultaneously. Virtual Classrooms enhance the online learning experience of students through lecturing, polls, one on one interactions, breakout rooms/ group discussions which are all done online.

KENET has setup an open source web conferencing tool https://conference.ke/ for virtual classroom training for use by the KENET member institutions.

The are several virtual classroom solutions available in the market. Before choosing one, it is recommended you consider the following:

1. **Ease of use of a platform** – This depends on which solutions the lecturer/faculty are familiar with, their peer preference and how easy the solution is in administering online teaching. Most lecturers will be influenced by what they have used before and what their peers are currently using.

2. **Size of Institution** – This will inform the number of concurrent class sessions. Small and medium institutions with about <2000 concurrent participants/learners can either use KENET Web Conferencing Platform or their own version of KENET BBB as it will demand lesser compute infrastructure resources. Larger institutions will demand huge server infrastructure resources to have an efficient and productive virtual Classroom. The huge resources can either be leased from public cloud providers or optionally directly use other available video conference solutions e.g. Zoom, Microsoft Teams, Google Classrooms.

3. **Cost** – license and infrastructure. Larger institutions will demand huge infrastructure to setup and host their own virtual classroom platform. Besides, the cost of licenses will be dependent on the number of hosts (number of faculty) and sizes of concurrent classes.

4. **Availability of internal technical capacity** – Lack of technical skill set within the institution is a factor in identifying which solution is ideal for an institution. Setting up own web conference platform requires technical skills in administering and supporting the platform. Institutions without the skillset will prefer to use other readily available solutions.

Table 1 below shows the recommended options on virtual classrooms dependent on the institution size.

Table 1 Virtual Classroom Options

	Web Conference Options	Minimum Requirements	Estimated Costs
1	Use KENET Web Conference platform	N/A	FREE membership service
2	Set up private web-conference platform	Lease KENET VPS infrastructure	Refer to Table 2 below
		Lease commercial cloud infrastructure	Upwards of monthly cost of $3,500 depending on server specs
		Use own infrastructure - Physical server	Minimum of USD 50,000 Physical Server Specs & Cost
3	Procure commercial Video Conferencing Solutions – (Zoom, Microsoft Teams, G-Suite)	Minimum of 500 aggregated licenses to allow joint procurement by KENET	Available from the websites of the providers (e.g., Zoom licenses range from annual fees $180 per host for up to 10 lecturers, $90 per host for up to 100 lecturers and $25 per host for 500+ lecturers).

KENET has setup BigBlueButton (BBB) and recommends it as a virtual classroom solution for the member institutions. The customized KENET web conferencing solution for any institution will require varying server specifications depending on the number of concurrent classes, participants per concurrent session and what media users are sharing in a session. KENET web conferencing is based on BigBlueButton, an open source web conferencing system for online learning. Institutions who will prefer to setup BBB on their own physical servers are encouraged to collocate their servers at KENET Data Centers to guarantee availability and have sufficient bandwidth for all their systems always.

Table 2 below shows the recommended Virtual Private Server specifications for various sizes of institutions.

Table 2 BBB recommended specifications

	Student Population	Estimated concurrent participants	Recommended Solution	Minimum Server Spec's
Very small Institutions	<=1,000	<=500	KENET BBB or Own version of BBB	2VMs each of 8vCPU, 16GB RAM, 1TB storage
Small Institutions	1,000 - 5,000	<=3000	KENET BBB or Own version of BBB	9VMs each of 8vCPU, 16GB RAM, 1TB storage
Medium Institutions	5,001 – 20,000	<= 5000	KENET BBB or Own version of BBB	12-15VMs each of 8vCPU, 16GB RAM, 1TB storage
	20,001 – 50,000	>=10000	Own Version of BBB + Zoom Cloud or Teams	+30VMs each of 8vCPU, 16GB RAM, 1TB storage
Large Institutions		>=20,000	Own Version of BBB + Zoom Cloud or Teams	60VMs each of 8vCPU, 16GB RAM, 1TB storage
Very large institutions	>50,000 students	>=25000	Own Version of BBB + Zoom Cloud or Teams	75VMs each of 8vCPU, 16GB RAM, 1TB storage

NB:

1. *All the above Server Specifications include 1 Load Balancer (1vCPU, 8gbRAM, 100GB HDD), 1 Front-End Server (2vCPU, 4GB RAM, 50GB HDD) and shared 1TB Storage for recordings.*
2. *For private version of BBB, each institution will have to invest in a skilled System administrator who will administer and support the web conference platform.*

Alternative Remote Teaching Options:

Apart from the KENET Web-conferencing platform, which is based on the open source BigBlueButton, there are many other licensed or free web conferencing solutions that can also support remote teaching. These solutions include Zoom, Microsoft Teams and Google Classrooms among others. However, it we recommend that the institution has platforms that are well supported by the ICT teams. Since some of the popular web conferencing platforms such as Zoom or Microsoft Teams are not free, there is a need to calculate the annual costs for the licenses.

Zoom offers an Education solution which is equivalent in features to their commercial Zoom Business version. This solution supports up to 300 concurrent participants and pricing depends on the number

of licenses. The cloud-based Zoom licenses are ideal for institutions with very high number of concurrent classes (+5000 participants) and a large number of faculty. Note that Zoom licenses are host-only licenses given to faculty members. **This means that you are required to purchase a license for each faculty member**. The students/participants do not need to have a zoom licensed account.

Apart from the cloud-based Zoom, it is also possible to localize Zoom in an institutions data center by providing the necessary virtual servers, like the BBB instances. This localized solution reduces the latency and improves the performance, but an institution would then need similar virtual servers to the BBB instances.

Microsoft Teams is packaged in with the Office 365 suite and syncs up well with other Microsoft technologies such as Sharepoint and Onedrive. It is convenient for the institution that already has Office 365 licenses for faculty and students.

Other licensed products include the Cisco WebEx, Amazon Chime and BlueJeans. License costs are available from the respective websites.

Universities on Google suite could use the license-free Google Meet or Google Classrooms that offer a remote teaching platform. However, it is still necessary to train faculty on the use of the tools and how to integrate them with the local Learning Management Systems. The ICT directorates should develop appropriate policies on remote teaching platforms that they support.

Should you require any of the above licenses, kindly reach out to KENET via support@kenet.or.ke.

3. Sizing Learning Management Systems Servers (LMSs)

This section will provide technical specifications on the recommended specifications for the virtual servers required to host a learning management system. The critical factor to consider when developing the specifications of the LMS virtual private server (VPS) is the number of concurrent connections expected on the server. Concurrent connections are defined as the total number of students/participants accessing a resource/activity on the Moodle LMS at the same time. Thereafter it is recommended to monitor usage patterns on the VPS and observe the trends during peak sessions, either from web logs or database logs.

To determine the number of concurrent connections, the educational institution should use its timetable/roster to obtain actual number of students who will be accessing the LMS.

The rule of thumb for a single server is that the approximate max concurrent users = RAM (GB) * 50 concurrent connections and the approximate maximum browsing users = Approximate maximum concurrent users * 5. Table 3 below indicates the recommended VPS specifications and associated costs dependant on the number of students and estimated number of concurrent connections.

Note that the specifications indicated in table 3 below, refer to the RAM (memory), vCPU (processor) and HDD (hard disk storage) of the virtual server environment. The server specifications are critical for optimal performance and the optimization of the applications supporting the Moodle set-up needs to be done to ensure optimal performance. KENET can assist with the optimization of existing LMSs.

Table 3 Moodle VPS specifications

Institution	Student Population	Estimated concurrent participants	Recommended Solution	Minimum Server Spec's
Very Small Institutions	<=1,000	<=500	Moodle on Linux Operating System	1VM with 6vCPUs, 10GB RAM & 0.2TB storage
Small Institutions	1000-5000	<=3000	Moodle on Linux Operating System	1VM with 12vCPUs, 60GB RAM & 0.5TB storage
Medium Institutions	5,001 – 20,000	<= 5,000	Moodle on Linux Operating System	1VM with 18vCPUs, 100GB RAM & 1TB storage
Large Institutions	20,001 – 50,000	>=10,000	Moodle on Linux Operating System	1VM with 24vCPUs, 200GB RAM & 1TB storage
		>=20,000	Moodle on Linux Operating System	1VM with 30vCPUs, 400GB RAM & 1TB storage
Very large institutions	>50,000 students	>=25,000	Moodle on Linux Operating System	1VM with 36vCPUs, 500GB RAM & 2TB storage

4. E-learning content development environments

Content development is a crucial step in having a good eLearning course as it involves making use of documented information, videos, images, narrations and presentations. It is therefore necessary for institutions to invest highly in setting up eLearning production studio that will have the responsibility of creating numerous educational modules. The on-campus studio can be used to:

- Shoot and edit videos for eLearning modules.
- Record and edit voice for voice over activities.
- Create 2D or 3D animation just for illustration purpose.
- Create, edit visual graphics for illustrative purpose. For example, Infographics and Posters
- Be the place to create, edit, research, and all activity of e-Learning modules development.

Each institution is required to have a on campus studio that is accessible by the faculty to facilitate online content creation. KENET recommends that each campus setup a multimedia content development studio. Table 4 below shows the minimum requirements to set up the studio.

Table 4 Institution on campus studio

	Equipment list	Approximate Cost KES
1	Desktop PC (i5 / i7 CPU)	135,000
2	Professional audio mixer	200,000
3	Microphone and headphone	55,000
4	Webcam or conference camera for video shooting	140,000
5	Video prompter and HD professional Camera	50,000
6	Studio Monitor and stand	25,000
7	Studio Lighting	50,000
8	Audio Recorder	8,000
9	Tie clip microphones	6,000
10	Tripods	8,000
11	Hard Drives	8,000

The multimedia content development Studio needs to also have the following:

- Backup power supply.

- Wi-Fi or structured cabling with network points.

- Appropriate lighting.

- Good acoustics and sound proofing

The educational institution needs to also employ a team of skilled video editors and graphic designers who will be tasked to assist the lecturers in editing their videos.

It is also recommended that the faculty also setup home studios for use during live virtual classes and when they are recording content. The faculty can set aside an office corner at their homes to also serve as a studio for courseware or multimedia production. To cut cost as well as create quality content, one can utilize on easily available hardware tools.

Table 5 Home Studio equipment list

	Hardware list	Approximate Cost in KES
1.	Laptop or Desktop with web cam PC (i5 / i7 CPU), RAM at least 8GB,	90,000
2.	Headset	3,000
3.	Webcam/Phone with camera 48mps	15,000
4	Ring Light	7,000
5	External hard disk for storage 1TB	8,000

KENET recommends the following basic software and tools for online content creation, refer to Table 6. These offer same results as the expensive license software/tools and are a good starting point for faculty to use in creating their own multimedia content for e-learning.

Please see summary on software for eLearning:

Table 6 Recommended Software/tools for basic multimedia content creation

Microsoft Powerpoint, Libre Presentation	Create presentations and screencast as video presentations	https://www.libreoffice.org/, https://www.microsoft.com/en-us/microsoft-365/free-office-online-for-the-web
eXeLearning	Create computer generated course file for eLearning production in form of SCORM Packages.	https://exelearning.net/en/
OBS Studio	Perform screen capture with narration.	https://obsproject.com/
OpenShot	Audio recording and editing software.	https://www.openshot.org/
	A simple video editing software, with basic editing function and subtitle, animation, narration, music control.	
Handbrake	Convert video file to different format.	https://handbrake.fr/
	Compress video file to a smaller size	

5. Off-campus or home Internet access for students and faculty

Off campus or home Internet access is essential for supporting remote teaching. However, not all students are privileged to have Internet access at home. Majority of faculty and students who live in or around urban centres are privileged to have Internet at home, including home fiber in Nairobi and Mombasa. However, the majority of students do not live in or around urban centres and rely on mobile data bundles for Internet access. This presents an additional cost to ensure that students and faculty have Internet at home. The cost of home fiber Internet ranges from KES 2,500 per month for 5Mbps and prices increase based on required bandwidth. The mobile Internet costs for a 10GB monthly bundle range from KES 1,500 to KES 2500.

Educational institutions need to decide on whether they will pay for the off-campus Mobile Internet bundles or require the student and faculty meet this cost.

As part of KENET mandate to promote use of ICT in teaching and learning through strategic partnerships, KENET was able to negotiate discounted data bundle rates with the major mobile data providers as follows:

1) Pre-paid Safaricom discounted bundles at KES 500 per month per 10GB which was launched on May 12, 2020. A monthly 10GB bundle costs between KES 1,500 and 2,000 without discount.
2) KENET sponsored TKL SIM cards limited to 30GB per month (data bundles are consumed at 1GB per day). KENET issued up to 4,500 SIM cards, mainly to faculty.
3) Airtel Networks - 12GB/month data bundle at KES 500

Table 7 KENET negotiated off campus Data Bundles

Provider	Data Bundle	Comparative Normal Rate	KENET negotiated discounted Rate
Safaricom	10GB	15GB at KES 2000 per month	KES 500 per month
Telkom	10GB	12GB at KES 999 per month	KES 499 per month
Airtel	12GB	KES 1,00 per month	KES 500 per month

These data bundles are only for use to access whitelisted educational resources or URLs that include web-conferencing platforms, Google suite, and e-learning sites. They do not allow access to other social media or entertainment sites.

The monthly 10GB bundles can support remote teaching and access to e-learning sites but would not be adequate for unlimited access to video content. Additional data bundles will be required for students attending extended virtual classes every day. Thus, it is important to ensure the learning institution whitelist the e-learning resources by providing the list of resources been accessed by students and faculty. This ensures that the data bundles are used only for facilitating online learning. The students and faculty will be required to purchase additional data bundles if they want to access social sites.

To use the bundles the educational institution needs to "whitelist" sites used for institutional educational resources. This includes LMS, virtual classroom, digital repositories and email. Whitelisting is important as it ensures the data bundles are only used for access to educational resources. The students and faculty who need to use the data bundles also need to register their mobile number as this goes through a pre-approval process. Registration is ongoing and can be done at https://registration.kenet.or.ke/

Educational institutions need to ensure that their resources are hosted locally either on campus or with a local provider like KENET. Hosting abroad adds cost and latency to downloads. The loading time for websites increases dramatically, often going from several milliseconds to half a second for a very simple page. This would adversely affect the teaching and learning experience of the faculty and students. A poor experience would lead to disinterest from the faculty and students.

Remote teaching and working are achieved securely by using KENET eduroam and eduVPN services. eduroam https://www.eduroam.ac.ke/ is a secure wireless roaming service that enables students and faculty get access to secure WiFi when they visit participating institutions. eduroam is the secure, world-wide roaming access service developed for the international research and education community.

eduVPN is a VPN service provided by KENET that provides access from the Internet to educational institutions networks that enables users to access internal resources within the internal network of their institution securely.

6. Faculty Support and Training

As more educational institutions move online and require the faculty to teach online and the respective students to learn online, each institution needs to take stock of the number of devices available to the faculty and students. Institutions would provide some devices in the computer labs and offices on campus, but what about off campus? Do the Faculty have a laptop/desktop at home? Are these laptops installed with the latest appropriate software and tools for online learning? Are students equipped with learning devises (Laptops, tablets etc) and do they have access to affordable and reliable internet connectivity? These are some of the critical questions that each institution needs to ask.

The educational institutions need to ensure the students and faculty have appropriate laptops for online learning and teaching. The educational institutions could investigate procuring the laptops for the faculty and/or negotiate subsidised purchase of laptops for the students. A laptop with the required features and specifications for use by Faculty and students will cost from KES 90,000. Table 8 below shows the recommended laptop specifications. Please note it is not just about having a laptop, but one with the required features and specifications.

Table 8 Recommended laptop specifications

Description	Specification
Display	15.6" display features a 16:9 resolution of 1920 x 1080
Visuals	integrated Intel HD 520 chipset
External display	HDMI or VGA ports at resolutions up to 4096 x 2160 @ 24 Hz
Storage	At least 0.5TB(500GB) 5400 rpm hard disk drive with 8Gb cache
RAM	Atleast 8GB of 2133 MHz DDR4 SDRAM
Processor	Atleast 7th generation 2.30GHz Intel Core i5-7200U Dual-Core processor
Webcam	HD camera

As institutions move online, the faculty who do not have access to institution-issued devices will have to use personal devices. This presents a security concern for the Institution as the faculty will now download critical student data onto their personal devices. Security training for the faculty is essential. KENET has developed an online cyber security training that the Faculty, Staff and Students can

undertake as part of their security awareness training. Registration is ongoing and can be accessed here: https://www.kenet.or.ke/content/cyber-security .

Several faculty and students may not be familiar with the use of technology to develop online courses and access online courses, respectively. This will require the Institution to invest in various trainings to ensure that the faculty and staff are adequately equipped with the necessary skillset.

Recommended training for Faculty and Students:

1) How to access and navigate the Learning management system.
2) How to access and navigate the virtual classroom.
3) How to undertake online exams.
4) Online collaboration tools.
5) Online communication including email, chats.
6) How to create online content (specifically for Faculty).
7) Online Security Awareness.

The misconception with online learning content is that a lecturer can just upload their documents and the students can download and read. This is a false misconception about online learning. Online learning needs to be interactive to achieve the best learning experience. Interactive learning could be in the form of video, audio, Q & A sessions, break-out rooms amongst others.

Faculty training needs to be conducted periodically to ensure the faculty and students are comfortable to use the online learning environment. KENET has developed an online training titled Moodle for Instructors. This online course offers training to faculty on how to create courses and upload content to Moodle. Registration is ongoing and available here: https://www.kenet.or.ke/content/kenet-online-courses

While some virtual classroom vendors offer training and support services with the subscription packages, others charge extra fee. Therefore, every time you schedule a training you will need to pay for the time spent and number of participants to be trained. It is best to choose a virtual classroom tool that offers you the specific level of training and support that you need at a price you can afford. Keep in mind that most virtual classrooms have online communities and/or help pages that cover basic troubleshooting topics. Research the web conferencing software provider in advance to verify whether they have an active online community that you can use and what subjects are usually covered.

Recommended training for LMS and virtual classroom System Administrators:

1) Management and administration of learning management system, virtual classrooms, exam proctoring software
2) Monitoring and troubleshooting of learning management systems and virtual classrooms.

The System Administrators are tasked to ensure that online learning systems are running effectively, end-user issues are addressed, and that system resources are scaled up as demand arises.

Table 9 below shows the recommended number of staff versus the number of students and faculty.

Table 9 Cost of Support Staff for online learning

	System Administrators with 4+ years' experience	Multimedia Content Developers	End User Support Staff
Estimated monthly salary per staff KES	120,000	100,000	80,000
Recommended Number of Staff	2 per university per 5,000 student university	at least 2 per 200 faculty members;	5 per 5,000 students + 300 faculty members (full-time + part-time)