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Case of Contingent Digital Practices and Attendant Asset-Based Risk Mitigation Framework for Learning and Assessment during the COVID-19 Pandemic

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Abstract

Universities world-wide faced unprecedented disruption to teaching and learning as a result of the COVID-19 pandemic. Whereas the shift to remote learning might have been smooth, despite the lack of preparedness of some institutions, the conduct of online examinations has remained a severe challenge and most limiting in the capacity of digital space. Remote learning was contingent on the availability and use of tools or systems in a manner hardly classifiable as meeting the norms of digital pedagogy. The aim of this paper is to develop an asset-based risk mitigating framework for the challenges of conducting examinations online in order to maintain the momentum of the academic calendar year and preclude prolonged delay in the completion of studies. This case study draws from international and national sources, and internal data sampled from a public university in Kenya. An initial pilot with a relatively smaller cohort of final year students, concerned with graduation, had challenges, but not to the extent of those challenges faced with the rest of the cohorts with regard to the online examinations. A detailed asset-based risk framework is developed to mitigate the risks, from an institutional, human resource and technical perspective, for the medium to long term. This will help the institution move towards digital pedagogy rather than simply enhanced digital practices. For the short-term case, a 3D risk-based decision tool is derived taking into account whether; areas are locked down or not spatially; exams should be conducted physically or online; and devices to access the Moodle (LMS) platform should be restricted to minimum specification

levels or not (i.e., use of android-based smart phones). The compulsory use of minimum specification devices such as laptops and/or PCs with web-cams by students that can be used with browser-locks and proctoring software, duly integrated with the LMS, thus increasing the level of success in rolling out online examinations is not a feasible option. In public institutions therefore, given the varied socio-economic students' background country wide, inclusivity is a key policy issue in the implementation of higher levels of technology mediation in the conduct of online examinations.

Keywords

Remote Learning, Digital Practices, Online Examinations, Asset-Based Analysis

1. Introduction: Educational Background World-Wide

The educational sector worldwide has been seriously affected by the COVID-19 pandemic. According to UNESCO (2021), close to half the world's students are still affected by partial or full school closures, and over 100 million additional children will fall below the minimum proficiency level in reading as a result of the health crisis. Prioritizing education recovery is crucial to avoid a generational catastrophe. Given the cyclical manifestation of the pandemic in waves, peaking in April 2020 while appearing to bottom out 28th April 2021: when 84.3% versus 10% of total enrolled learners were affected with 123 versus 29 country-wide school closures, respectively. The data correspond to number of learners enrolled at pre-primary, primary, lower-secondary, and upper-secondary levels of education [ISCED levels 0 to 3], as well as at tertiary education levels [ISCED levels 5 to 8].

At the tertiary and university level, 175 institutions were closed and over 220 million post-secondary students, 13% of the total number of students affected, have had their studies ended or significantly disrupted (World Bank, 2020). The ad hoc nature of these closures has affected students, faculty, university management and government officials due to the effect on teaching, learning, research, innovation and education outcomes. Despite challenges with regard to equity, infrastructure, broadband capacity, and pedagogic capacity the immediate response to campus closures as a contingency, was to move to remote learning to maintain education momentum. However, the impact on the quality and integrity of educational outcomes is still being assessed. The short- and long-term challenges facing tertiary education systems and institutions are inter alia: diminished resources for institutions, personal and academic hurdles for institutions and students, demand for improved infrastructure to support continued distance and blended learning models, and reduced mobility thus pressurizing the need to improve further higher learning institutional capabilities.

This case study highlights the challenges faced by a tertiary institution of learning in a developing country which prioritized business continuity in teaching and learning during the state prescribed restrictions on teachers and learn-

ers' movement during the pandemic. This resulted in the adoption of digital tools and practices in the digital space that was the only choice to mitigate against closure. Clearly this mode of delivery necessarily implied pedagogical risks, see Murty & Rao, 2019. In addition, this paper develops an asset-based risk mitigating framework for the challenges encountered while conducting examinations online in order to maintain the momentum of the academic calendar year and preclude prolonged delay in the completion of studies.

2. Digital Pedagogy

While many universities have moved to the provision of online platforms, these are often used simply as a more efficient mode of delivery for offline content rather than to explore new and creative pedagogical approaches to teaching and learning. For online learning to be effective, it is necessary to move beyond copy/paste approaches that basically seek to replicate offline approaches in online environments (Blewett, 2016). Ironically, when the term "eLearning" had been coined in 1998 (Linder, 2006), it initially had stood for an explicit counter draft to the static, restricted and overly formalized "computer-based training". Now the term has come to mean the storage and transfer of precast content through online delivery channels.

Whilst the immediate rapid response to the COVID-19 pandemic "made-do" with "what is possible", this contingency provision is not a basis for teaching and learning in the medium-term. The main issue, see Anderson, 2020, is: What is a meaningful digitally enabled pedagogy to encourage and facilitate novel and opportune approaches for academic practices? Pedagogy refers to the interaction between learning and teaching practice and underlying beliefs and values about how learning can, should, and does occur, rather than simply the deployment of learning techniques and methods, see Kreber, 2010. Likewise, "digital pedagogy" should not be conflated with the deployment of digital tools. Rather the term refers to learning-focused values that are of relevance not only for subject-specific education, but also for personal and social processes and relationships and systems intrinsic to the learning process (James and Pollard, 2011).

Effective pedagogy: equips learners for life by developing their intellectual, personal, and social skills; encourages learner engagement with valued forms of knowledge, ideas, and forums of discourse; builds on learners' prior experience and learning vide the personal and cultural experiences of different groups of learners; provides structures and processes of intellectual, social, and emotional support to enable learners move forward in their learning; uses formative and summative assessment, effectively aligned with learning outcomes, to advance learning and determine the extent to which learning has occurred; encourages strategies and practices that promotes learners' independence and autonomy; and promotes the social processes of relationship—building, communication and advocacy for learning purposes (James and Pollard, 2011).

Bloom et al. (1956) well known model of learning or instructional design still stands the test of time for digital pedagogy as well. There are six levels of learning: Knowledge (remembering), Comprehension/understanding, Application

(problem solving), Analysis, Synthesis/creating, and Evaluation (judgement).

Online and remote teaching and learning and academic assessments are feasible and valid, with sufficient pedagogical and technical expertise and preparation. However, technology in itself is no panacea or silver bullet. It is important to re-evaluate online and remote teaching and learning and assessment thoroughly to obtain pedagogical outcomes solutions. Some institutions and faculty are now moving along this difficult but also more sustainable path, see Blundell, Lee, & Nykvist, 2015; Murty & Rao, 2019; Nanjundaswamy, Baskaran, & Leela, 2021; Lederman, 2020 and Chatterjee et al., 2023.

3. Contingent Digital Practices: Tertiary Institutions World-Wide

A poll involving EDUCAUSE community group respondents representing 312 institutions, predominantly in the USA with others from Australia, Canada, China (Hong Kong), Finland, Ireland, Saint Lucia, and Trinidad and Tobago, was conducted to understand the prevailing global digital pedagogical practices in tertiary institutions (Grajek, 2020). Most respondents (294) represented US institutions. Higher education institutions are adapting grading and assessment policies and are deploying technologies to adjust grading and proctoring to the special circumstances of the pandemic. Over 75% of institutions may use online or remote proctoring for exams. Many of their product choices meet accessibility standards, but quite a few do not.

On making the initial transition to remote teaching and learning, colleges and universities are trying to maintain continuity of the entire educational process, see Grajek, 2020. In particular, grading disrupted courses and proctoring exams taken remotely present the following challenges: deterrence of online exams cheating; students perform under stressful and less-than-ideal conditions; students without adequate bandwidth or equipment may be unfairly disadvantaged; support for students with accessibility needs; administration of exams taken remotely, and as many students and faculty are new to remote learning, remote assessment exacerbates the situation.

Adapting course grading. Only 14% of institutions are not making changes, while 77% have made changes, while another 9% are still considering changes. For those making changes, the most common change is adopting pass/fail or credit/no credit instead of grading courses.

Flexible grading. Many institutions are making grading as flexible as possible, for example, by: offering more lenient criteria for grades of "Incomplete"; extending the dates for final grade submission; allowing for much later withdrawal from courses; reweighting assessment and assignment grades within a course; and allowing students to see their grades and then letting them decide whether the grade or a pass/fail will be recorded.

Broad changes to assessment. Exams, though common, are only one way to assess learning. The pandemic provides 31% of institutions the opportunity to

consider more authentic demonstrations of knowledge and skills. It is generally faculty rather than the institution that makes the decision to move away from exams. Changes under consideration include basing assessments on multiple methods including: projects, discussions, simulations, videos, podcasts, and essays. A few institutions are opting not to make any assessments immediately.

Online or Remote Proctoring. Over 75% of institutions may use online or remote proctoring for exams during the pandemic. Institutions currently using online or remote proctoring services are 54%, while another 23% are planning or considering using them. There are basically four types of proctoring: 1) passive monitoring of software on students' computers (by tracking applications run on students "computers and whether they switch to another application while taking an exam); 2) active restriction of software on students" computers (by using a "lockdown browser" application that blocks access to other applications during exams); 3) passive video surveillance of students (by using software that accesses a student's webcam to directly monitor them); and 4) active video surveillance of students (by using a method similar to 3) immediately above but adding real-time monitoring by live proctors).

All four types of proctoring are commonly used. Active restriction of software and passive video surveillance are the most widespread. Most institutions (80%) that adopt online proctoring use more than one type, and 18% use all four.

For the types of proctoring software used and challenges faced by tertiary institutions worldwide see Table 1 and Table 2 respectively below.

Promising Practices include: Exams are either "open resource" or are assignment/projects; Faculty are required to offer asynchronous "open-book" take home exams, final papers, final projects, or a series of lower stake assessments in lieu of final exams; Incorporation of problem-based assessment in courses; Faculty are moving to project-based assessment; Students participate in discussions about and demonstration of their knowledge; Assessments may be: project-based, discussion-based, reflective assignments, videos or podcasts; Adapting assignments based on students' resources (e.g., video presentations, handwritten papers); and Bring more simulation-based assessment online.

Table 3 gives a brief summary of the status of e-learning/blended learning in selected public and private universities in Kenya. It is noted from the limited sample in Table 3 that private universities are relatively better equipped for online exams than public universities. It may also be the case that satisfactory outcomes in online learning and assessment are contingent upon the fact that

Table 1. Proctoring software used by tertiary institutions world-wide.

Type	Percent
Respondus Monitor and/or LockDown Browser	65%
Proctor U	23%
Proctorio	17%
Zoom (active video exam)	7%

(Source: Grajek, 2020).

Table 2. Tertiary institutional challenges with remote proctoring world-wide.

Challenges	Percent
Financial	58%
Students' privacy concerns	51%
Product's functionality	41%
Accessibility of available tools	35%
Unfamiliarity with best tools or practices	33%
Faculty buy-in	32%
Digital divide students' technical limitations	14%
Lack of leadership support	9%
Approach incompatible with culture	7%
Other technical	5%
Miscellaneous other	5%

(Source: Grajek, 2020).

Table 3. E_Learning platforms: Teaching and examinations in Kenyan universities.

	E- or Blended-Learning	Platform LMS	Conducting On-line Exams	Proctor	Remarks/Challenges
Public					
1	Both	Moodle	No	None	Relatively stable
2	Both	Moodle	No	No	Low Content development uptake
3	Both	Moodle	Yes	SEB; Moodle	Quite Stable
4	Neither	N/A	N/A	N/A	Faculty resistance
5	Both	Moodle	Yes	Respondus Monitor	Well configured
6	Both	Moodle	Yes	Yes	Students' Devices & Bundles
7	Both	Moodle	No	SEB	No online exam
Private					
1	Both	Moodle	Yes	Respondus Monitor	Satisfactory thus far
2	Both	Moodle	Yes	Respondus Monitor	Satisfactory
3	Both	Blackboard	Yes	Respondus Monitor	Quite Satisfactory
4*	Both	Moodle	Yes	SEB & OBE	Students' Devices & Bundles

*Open Book Exam also implemented.

full fee-paying students may be better positioned, relatively, to afford laptops and other high-end devices to access the respective LMS.

4. Institutional Context

4.1. LMS Implementation and the Transition to Remote Learning

In 2016, the University Council advised that e-learning be fast-tracked due to the

increased enrollment resulting from clearing the back log of qualified Kenya Certificate of Secondary Education (KCSE) students eligible for entry to the university. Consequently, a Project Implementation Committee was set up under the Chairmanship of the Deputy-Vice Chancellor (Academic Affairs) with the Dean, School of Informatics and Innovative Systems (SIIS) as the Project Leader. In due course: two laboratories were equipped in a thin client-server configuration and seven dedicated staff were hired i.e., instructional designer, system administrator, graphics designer, media specialist, and laboratory technician. The Learning Management System (LMS) was Open-source MOODLE 3.7 in keeping with policy.

For several years, the LMS was piloted for Diploma and Certificate students from the Nairobi campus graduating in 2018. Although faculty had been trained on developing content for the LMS, the up-take was rather poor, and as a result, e-learning was far from being mainstreamed as an alternative mode of delivery for even a single undergraduate unit.

In mid-March 2020, when the COVID-19 pandemic reached Kenya, all learning institutions were closed and students sent home. The Commission for University Education (CUE), the regulatory quality assurance body, temporarily waived the requirement that only institution accredited for Open Distance and Electronic Learning could conduct teaching and learning online. The University Senate made a decision to allow courses to continue remotely mediated by technology. Most meetings were conducted virtually through ZOOM. Other video conferencing options including the open-source Big Blue Button (BBB) availed vide the Kenya Education Network Trust (KENET) were used for remote learning.

In mid-April 2020, Senate approved the following online support for teaching and learning through Remote Teaching: Online classes conducted using Skype, Google Classroom, Microsoft Teams and Zoom, BBB; Sharing educational materials with the students through use of SMS or WhatsApp messages by the lecturers; Uploading notes and other materials vide WhatsApp, email, the JOOUST website, or YouTube among other modes; Use of JOOUST E-learning platform. The variety of tools used may be referred to as altered digital practices.

With the move to remote learning, the university MOODLE 3.7 LMS hosted at the KENET Data Centre was upgraded in April 2020 from a Virtual Private Server (VPS): 1vCPU, 4 GB RAM, 100GB HDD to VPS: 16vCPU, 40 GB RAM, 1TB HDD, thereby increasing the performance, configuration issues notwithstanding, from 25 to 2000 concurrent users. In August 2020, the University procured ZOOM Business Plan Option with 10 licenses each accommodating 300 attendees. As the procured ZOOM licenses introduced greater versatility, eight of these licenses were used for remote teaching as well as for meetings. Later, ZOOM WEBINAR was procured for large groups (1500) and used for virtual graduation and the Vice-Chancellor's address.

4.2. Online Examinations

By all accounts, teaching and learning from of the perspective of both students

and staff appeared to progress smoothly. Meanwhile, Senate, in August 2020 had agreed that preparation for online examinations for the end of year examinations commence. This involved uploading the exam papers to the LMS by the Examination Office, students accessing the said papers from the LMS using a variety of devices including android-based smart mobile phones, and the use of ZOOM as an active video proctor. Those who had laptops logged into the system and submitted their answers through the system online and in synchronous mode, whereas those with mobile devices used a quasi-asynchronous mode that entailed answering the questions they had accessed online, on paper then scanned and then submitted the same on completion by uploading it, during the specified exam duration, to the LMS in the first instance or a designated email if the upload was not successful as back-up measure.

Priority was given to the final 4th year students who undertook their exams in September 2020 and due to technical challenges, that is, unable to upload successfully, or uploaded successfully but their answers were not immediately traceable on the LMS or just had inadequate or reliable bandwidth among other reasons. The results for such cases were deferred and exams were reset and undertaken two more times to reduce the number of such deferred cases. Despite the said challenges, a review by an ad hoc committee of Senate of the consolidated marks after normalization found that there was no discernable difference between the performance of the online 4th year 2nd semester examinations and the earlier semester exams conducted physically, in-person, and invigilated in-person by staff for this cohort.

The pilot experience with the graduating cohort encouraged the Senate to move ahead with the 1st, 2nd, and 3rd year examinations in a similar "online" manner. These examinations were held during 14th to 23rd of December 2020 for the 2nd and 3rd year cohorts and between 11th to 22nd January 2021 for the 1st year cohort after the nation-wide lock-down was lifted. Greater challenges, both technical and with exam integrity, were experienced. The technical difficulties with uploads not being unsuccessful or being successful but scripts not easily located on the system by relevant examiners were exacerbated by the larger numbers due to system scalability and configuration issues with the performance of MOODLE 3.7. vis-à-vis the hosting server. Furthermore, other integrity issues were noted, such as students colluding in groups having by now discovered weaknesses in the ZOOM proctoring by simply turning it off or not positioning the device, especially mobiles, so that their respective images were not visible in real-time for active real-time proctoring. The results eventually were availed to the Senate on 10th March 2021 where an unacceptable number of cases, 52% of approximately 4000, were deferred for technical reasons. Further mopping up was advised, especially with regard to scripts unmarked but submitted to the LMS system or vide a fallback designated email address.

The above demonstrates that remote learning was contingent on the availability and use of tools or systems in a manner hardly classifiable as meeting the norms of digital pedagogies as conceptualized for example by the Väätäjä & Ru-

okamo (2021), three-dimensional model: pedagogical orientation; pedagogical practices; and the digital pedagogical competencies it provides for the teacher.

In the next section, we detail the review of the online examination process initiated by the Senate to mitigate against the risk of having an unacceptable number of failures or deferred examination cases due to technology-related proctoring lapses or inadequacies.

5. Asset-Based Risk Mitigation Framework for Online Exams

The University Senate then, on the 10th March 2021, set up an ad hoc technical committee to review the situation and make recommendations for improving the quality and integrity of on-line examinations given the adverse impact of the recent results as highlighted in the previous section. The three-level asset-based risk mitigation framework in Table 4 was adopted and applied in three stages as set out below:

Stage One: From Table 4, for the Institutional, Human Resource and Technical Levels respectively, and for each asset identified therein, a detailed online examination process risk matrix was developed to assist with understanding the potential risks and possible mitigation measures by: Identifying the university assets at risk; Identifying the possible threats to the assets; Identifying the vulnerabilities associated with the assets; Determining the possible risks associated with identified assets i.e., High, Moderate, Low, Very Low; and Proposing measures to mitigate these risks. It is noted that risk and integrity of exams are inversely related (i.e., high risk implies low integrity and vice-versa).

Stage Two: The e-Learning technical team was requested to demonstrate: Efforts made towards addressing the recommended configurations and integration issues; Possible available cost-effective solutions to integrating Specialized software for technical courses (Engineering, Mathematics, Chemistry and Special Needs Education Students) into the LMS; Possible customizations of LMS for ease of use; Segmentation/grouping of students according to their units and lecturers; and Configuration of LMS to align with proposed exam structure including updating to the latest stable version.

Stage Three: Deans of three schools were consulted to identify their specific needs and to demonstrate the capabilities of the improved LMS platform.

Structural Framework for the Assets Identified by Level:

Table 4. Online examination process asset-based risk mitigation framework.

Level	Risk Matrix				
	Identify Assets	Possible Threats	Possible Vulnerabilities	Risks	Mitigation
1. Institutional					
2. Human Resource					
3. Technical					

The Institutional Level assets: Governance Structure, E-learning (CEL) Board, CEL establishment, CEL Budget vote head; Policies and Procedures governing Examinations including online exams, E-learning Policy, Procedures for OnlineExaminations, Rules and Regulations Governing Online examinations, The Examination Administration, Examination Preparation, Assessment (Formative, Summative); Structure (Present, Proposed); Examination (Setting, Moderation).

The Human Resource Level assets: Examination Officers; CEL Technical Staff; Faculty; Students.

The Technical Level assets: Server hosting MOODLE 3.7 platform; Back-up Server; MOODLE platform; Internet Connectivity: University, KENET host, Student (personal mobile): Online Examinations; Devices; Laptop, Desktop, Tablet, Phones. Power Conditioning; KENET, University. Proctoring Solutions Online Examinations: ZOOM not integrated (active); Safe Browser (SEB) Integrated with MOODLE; MOODLE Proctor integrated (passive); Respondus Monitor etc, integrated (passive); Controlled environment i.e. in-person invigilators.

6. Attendant Actions to Improve LMS by Level

Institutional: E-learning board should meet regularly to review activities of the Centre and make decisions to be implemented by technical team within the centre; CEL should be fully established and operationalized. (Staff still report to Dean, SIIS while there is no budget allocation for the directorate). The Centre should be fully operationalized: Staff in the Centre should report directly to the Director of CEL; The Directorate should be allocated a budget. Review of relevant University Statutes, Examination Policies, Rules & Regulations. Enforcement of relevant University Statutes, Examination Policies, Rules and Regulations.

Human Resources: Targeted training based on the needs of the staff and students; Adherence to relevant University Statutes, Examination's policy, Procedures, Rules and Regulations (section on examination processes).

Technical: LMS Integration; Integrate Specialized software for technical courses (Engineering, Mathematics, Chemistry and Special Needs Education Students) into the LMS. Integrate proctoring software and ERP with LMS. LMS configurations: Improve customization for ease of use; Segmentation/grouping of students according to their units and lecturer; Update the existing LMS to the latest stable version bundled with proctoring software; Configure LMS to align with the proposed exam structure. Devices/Failed uploads: Use devices that conform to minimum specifications. Android phones and other devices are exclusive with regard to Browser lock software; Students are advised follow guidelines as contained in the Moodle user guide.

7. Technical Solutions

The following technical solutions to the existing LMS platform were proposed to

address the identified risks: LMS will continue to integrate specialized software for technical courses (Engineering, Mathematics, and Chemistry). For mathematics the following software plugins have already been added to the system: Latex; Stack; Simple Calculator; WileyPLUS—to enter and edit math expressions; MathType—to prepare complex equations; equation editor—to prepare complex equations and comes with the upgraded system; Further user training was needed on these add-on applications. Further consultation was required with other schools on the appropriate software appropriate for their needs.

LMS has been configured for ease of use and integrity of online exams—The technical staff at CEL worked closely with the hosting organization towards improvement of the platform. These technical improvements included: Upgrade Moodle from the current LMS (v3.7) to the latest stable version (v3.10) which is bundled with SAFE EXAM BROWSER LOCK software and Moodle Proctoring software. The functionality of each software was tested; Seamless integration of Safe Exam Browser and Moodle Proctor with LMS which should be tested and configured appropriately; Optimization of Apache, PHP, MySQL as per the recommendation guidelines; The safe browser lock can accommodate up-to 4000 users with proper configuration of resource usage; and Although Safe Exam Browser Lock is available for both windows, IOS and *Android mobile platforms*, *the latter is not stable* and hence *not advisable to use for now*. The best low-cost option is to keep the Safe Exam Browser Lock.

Devices/Failed uploads—A set of minimum standards required for students to access an online exam were developed. Thus: Students must use ONLY devices that conform to minimum specifications). Android phones and other devices are, excluded from this category because of compatibility issues; and students are advised to follow guidelines as contained in the Moodle user guide.

8. Recommendations Medium to Long Term by Level

8.1. Institutional

1) Review the assessment structure to align with the proposed revised examination structure, see 8.2.5 below. Ratios of Formative (F i.e., Cats 1, 2) to Summative (S i.e., Examination) to be revised from current 30-40:70-60 to 60-70:40-30 to emphasise the need for the assessment of complex/more technical issues at the formative as opposed to the summative stage, thereby reducing the attendant risk;

2) Build capacity of lecturers, students, CEL technical staff, and examination officers to use the online examination system efficiently and effectively;

3) Roll out the online examination process in phases for effective user acceptance for the following categories of students:

a) Special needs examination;

b) Using specialized tools/software, for example, in Mathematics, Spatial, Engineering, and Chemistry exams; and

c) Other examinations.

8.2. Human Resource

1) Strict adherence/enforcement of exam policies, procedures, rules and regulations will reduce risks associated with exam integrity and malpractice;

2) Training of users on the use of specialized software for both exams and teaching should begin immediately;

3) Logistics—to avoid scalability issues linked to server capacity of 2000, concurrent users sitting for an exam should be limited to not more than 1500 to give the system some slack. Timetabling coordinator should take cognizant of this limitation;

4) Groups/students taking exams on campus should be supervised in a controlled environment; and

5) Develop exam structure that is aligned with an online examination process. Exam setting should be done in tandem with blooms taxonomy.

8.3. Technical

1) CEL technical staff MUST prepare a user guide (both staff and students) for Safe Exam Browser that describes how to complete the test remotely;

2) SEB is available for Windows PC, Mac, or iOS. SEB will not work on an Android phone or tablet;

3) Use the existing cost-effective Safe Exam Browser (SEB) and Moodle proctor embedded in the latest and stable Moodle version 3.10 to reduce risks associated with exam integrity and malpractice provided that SEB and Moodle proctor are seemingly integrated;

4) Use devices that conform to specified minimum specifications to reduce other risk such as "failed uploads"; and

5) All Personal computers (including 200 PCs in the computer labs) should be fitted with webcams for access to exams.

From a detailed analysis of the online examination process risk matrix, technical solutions proposed and recommendations above the technical risk quantification (likely percentage risk) of the current system under different possible scenarios has been derived (aggregated), and summarized in Table 5, due to the far-reaching consequences, as will be shown in the next section, involving the digital divide and attendant inclusivity issues:

Table 5. Technical risk quantification.

S/No	Scenario	Risk (Percent)
1	Current LMS (Moodle v3.7) as is	80%
2	Moodle Proctor alone (Without SEB)	65%
3	Safe Exam Browser alone (v3.9)	50%
4	Safe Exam Browser and Moodle Proctor integrated seamlessly with LMS	20%
5	As in 4 above and specialized software/tools integrated with LMS	10%

Caveat

To mitigate further the residual risk arising from institutional, human resource, technical levels considered above, the ultimate fallback position is to carry out online examinations on campus, in a controlled environment with in-person invigilation.

9. Examination Scenarios under Lockdown

The following question regarding the imminent examinations due to commence in May 2021 both regular and special (deferred cases) was raised: Given the overarching goal of preserving the integrity of the examination process what is the appropriate mode of delivery of the imminent examinations given that five counties (that are contiguous) out of forty-seven were in a lockdown to contain the on-going pandemic?

Pursuant to the earlier sections above, the underpinning issues, are presented as a 3-D Asset-based Risk Decision Tool in Figure 1 encompassing:

1) Prevailing lockdown conditions;

2) Mode of delivery of examinations online or physical; and

3) Devices used by students to access exams be restricted (to minimum specification to enhance online exam integrity) or not restricted.

For possible mode of examination scenarios with attendant technical enhancements or conditions to ensure the integrity of examinations, estimated as a percentage risk, see Table 6. It should be noted that risk and integrity are inversely related.

We now map these various scenarios and attendant risks, where applicable, onto the 3-D asset-based risk decision tool shown in Figure 1. This enables decision making for the various scenarios giving, where applicable, the risk to the integrity of examinations is conducted: Physically or Online (x-horizontal axis); under possible Lockdown conditions or Not (y-vertical axis); and whether Devices (z-third axis) to access and carry out examinations online are Restricted to minimum specifications (running Windows, iOS etc.) or Any not so restricted (that include Android OS smart phones).

The 3-D asset-based risk decision tool can be used to trade off the degree of

Table 6. Possible scenarios for conducting examinations.

Option: Mode of Exam	Browser Lock	Proctor	Location	Risk (Exam Integrity)
1. Physical	N/A	In-person invigilation	campus	Very Low = 5%
2. Online	SEB	MOODLE proctor	anywhere	Very Low = 10%
3. Online	SEB	ZOOM	anywhere	Moderate = 50%
4. Online	none	MOODLE Proctor	anywhere	Moderate = 55%
5. Online	SEB	none	anywhere	High = 75%
6. Online	none	ZOOM	Anywhere	Very High = 85%

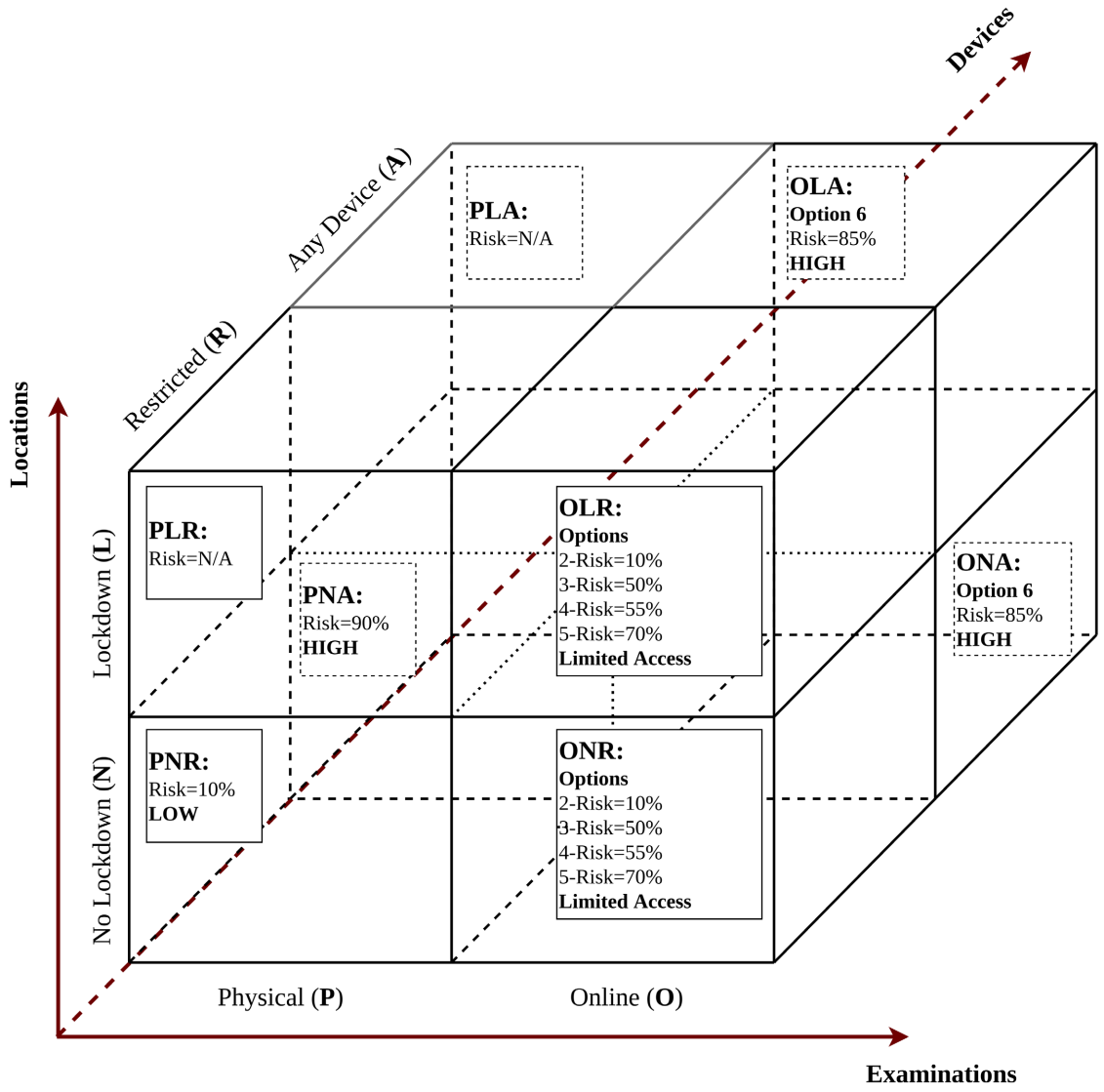

Figure 1. 3D asset-based risk decision tool.

enhancement of *exam integrity* (expressed inversely as a percentage risk), institutional financial constraints notwithstanding, by using various proctoring solutions vis-à-vis *students' access to online examinations* which, due to the digital divide underpinned by socio-economic issues:

1) is largely through the use of mobile phones (android OS) which increases access but is a liability when it comes to integrity of examinations since technical enhancements to the e-learning platform such as Safe browser, Proctoring software are not yet configured for such access devices; rather than

2) more commonly acceptable minimum specification devices for online examinations such laptops, PCs with web-cams, tablets (running Windows, iOS, Mac) that enhance online examination integrity since technical enhancements such as Safe browser and Proctoring Software are configurable but restrict access vide android OS mobile phones.

It should be carefully noted that access through Android browsers vis-à-vis

Windows, iOS, Mac browsers in 1) and 2) above are mutually exclusive on the given Moodle platforms currently available.

10. Short Term Recommendations

1) In the Lockdown areas, students will undertake the examinations in on-line mode using the upgraded Moodle Platform 3.8.10 but without the SEB enabled or Moodle Proctor plugin. ZOOM will be used as before to proctor the student's environment as a contingency measure. This enhances access to the examinations but sacrifices examination integrity with attendant risk of 85% since:

a) ZOOM is not integrated with the MOODLE platform and

b) The integrated SEB and Moodle proctor are not configurable at present with the mobile phone's Android Operating System.

2) In the No-Lockdown areas, there are two feasible options with attendant risks and logistical considerations:

a) Examinations may be conducted online using any device for greater access; however, integrity of examinations must be enhanced by in-person attendance on the campus or designated site and in-person invigilation which provides a controlled environment to reduce the risk to 10%.

b) Examinations may be conducted purely physically i.e., in-person attendance on preprinted stationery invigilated in person. No access to any communication devices will be allowed. This will reduce the risk even further to 5%.

3) Logistical Preparations:

a) Scheduling of examinations at the same time irrespective of the mode of delivery, in total numbers not exceeding 1500 students at any one session for online exam mode;

b) for physical exams; availability of examination materials; adequate physical space suitably distanced for both physical and for online but in a controlled environment;

c) adequate and effective data bundles for students in lockdown areas;

d) adequate and effective data bundles for online exams conducted on campus supplemented by enhanced wifi access, Lan access for online exams on campus by students with webcams (KShs 1000 each) compatible with laboratory PCs; and

e) adequate and effective in person invigilation for exams on campus in physical or online controlled environment.

4) Other information necessary for Logistical preparations such as a survey of the devices available to students and with minimum specifications above and those without.

11. Conclusion

The detailed asset-based risk framework developed to mitigate the risks for online examinations from institutional, human resource and technical levels for the medium- to long-term, will assist the institution move towards digital pedagogy.

Case-based scenarios for decision making purposes with attendant risks are given vide the 3D tool which takes into account: whether physical or online examinations ought to be conducted (under prevailing circumstances); whether spatial locations are under lockdown or not; and whether restricted or unrestricted devices are used by students to access to the LMS with various technical enhancements to enhance the integrity of online examinations.

Online exams present a great tension between the integrity of the said examinations from a public institutional perspective and the access to the same by the majority of students who, due to the prevailing digital divide underpinned by their respective socio-economic status, can only afford entry level android smart phones. With such entry level mobile devices exams are accessed from the LMS (MOODLE platform) online but carried out quasi asynchronously offline uploading the scanned handwritten solutions on completion, to the LMS within the prescribed duration for the said examination.

The compulsory use of minimum specification devices, such as laptops and/or PC's with web-cams, that can be used with browser-locks, and the proctoring software duly integrated with the LMS to enhance the integrity of online examination is currently not a feasible option. In public institutions, therefore, given the varied socio-economic background of students' country wide, inclusivity with respect to the digital divide is a key policy issue in the implementation of higher levels of technology mediation in the conduct of online examinations.

It is important, nonetheless, for institutions to comprehensively re-assess online/remote teaching and assessment practices with a view to attaining robust, scalable and effective technology mediated solutions in order to attain digital pedagogy, going forward.

Conflicts of Interest

The authors declare no conflicts of interest regarding the publication of this paper.

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